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Notices

of the American Mathematical Society

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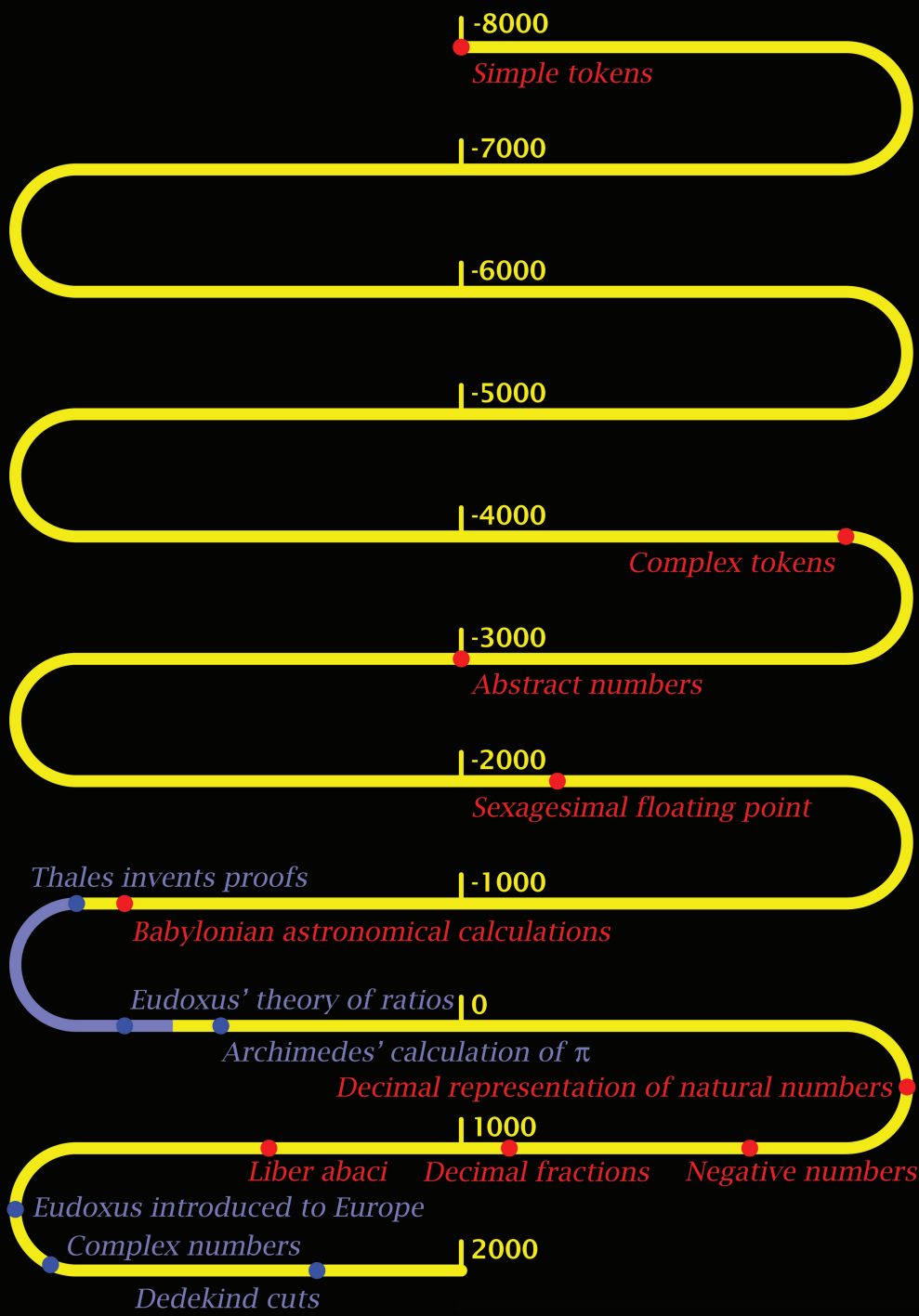

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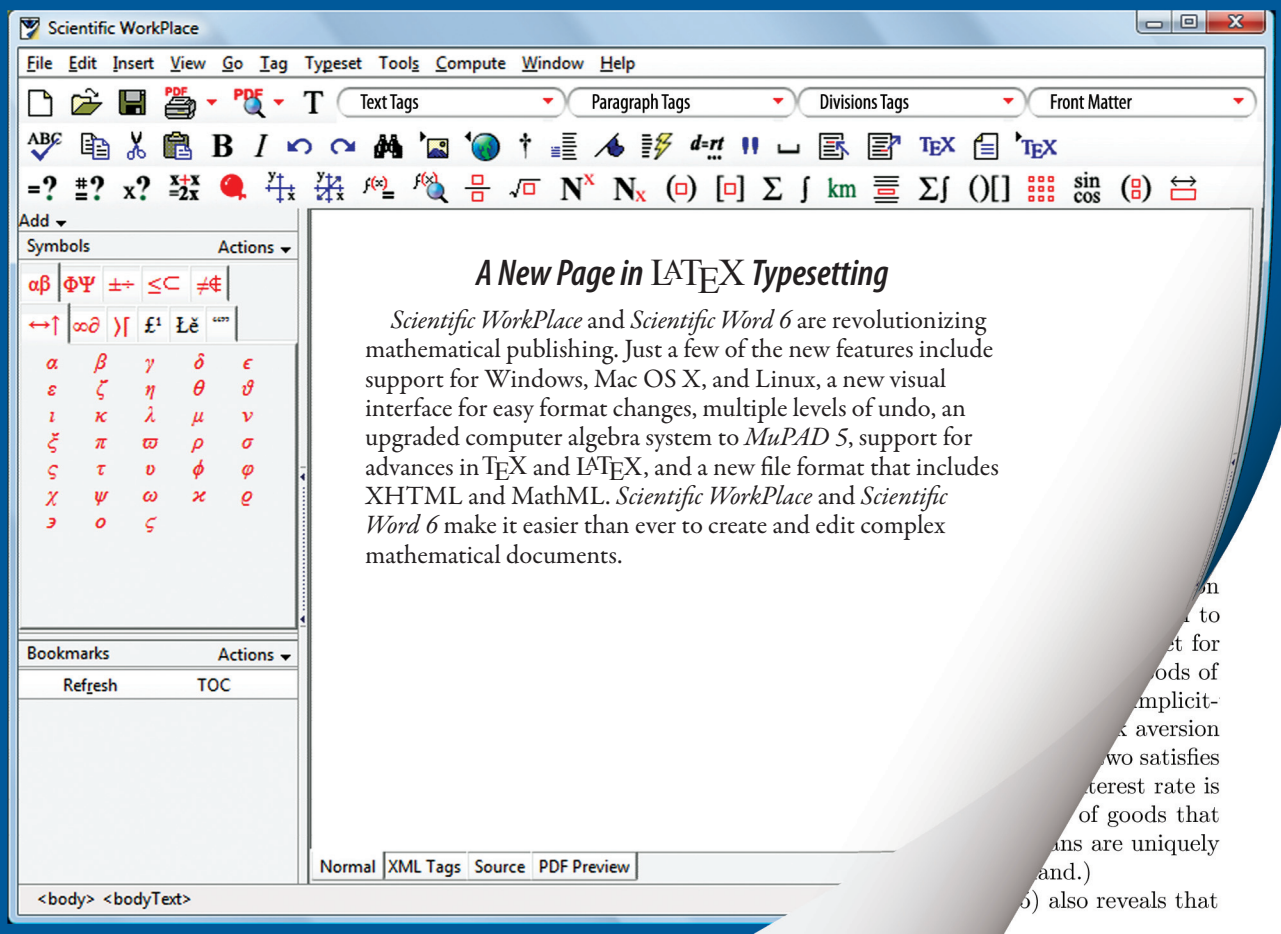

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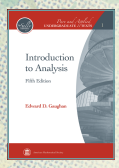


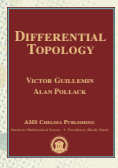
Introduction to Analysis
Fifth Edition

TEXTBOOK

Edward D. Gaughan, *New Mexico State University, Las Cruces, NM*

This book is designed to bridge the gap between the intuitive calculus usually offered at the undergraduate level and the sophisticated analysis encountered at the senior or first-year graduate level. Through its rigorous treatment of standard topics, it offers a deeper understanding of the ideas in the calculus. A series of Projects at the end of each section consist of substantial mathematical problems and the guidance necessary to solve them.

Pure and Applied Undergraduate Texts, Volume 1; 1998; 240 pages; Hardcover; ISBN: 978-0-8218-4787-9; List US$62; AMS members US$49.60; Order code AMSTEXT/1



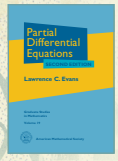
Differential Topology

TEXTBOOK

Victor Guillemin, *Massachusetts Institute of Technology, Cambridge, MA*, and **Alan Pollack**

This introduction to differential topology takes the clever approach of using transversality to avoid advanced methods and demonstrate that mathematics can be done without big machinery. Use of this unifying idea allows for intelligent treatments of important theorems such as the Lefschetz fixed-point theorem and the Poincaré-Hopf index theorem. The 15 to 20 exercises in each section enhance the understanding of the material.

AMS Chelsea Publishing, Volume 370; 1974; 222 pages; Hardcover; ISBN: 978-0-8218-5193-7; List US$40; AMS members US$36; Order code CHEL/370.H



Partial Differential Equations
Second Edition

TEXTBOOK

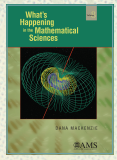
Lawrence C. Evans, *University of California, Berkeley, CA*

This book would be invaluable for a graduate student preparing to do research in PDEs; I wish I had a copy in graduate school.

—MAA Reviews

This second edition of what has been called an essential text for every graduate student in analysis includes an array of new topics in partial differential equations, particularly in a new chapter on nonlinear wave equations. The author offers an unparalleled combination of insight and technical detail. The second edition includes 84 new exercises, many of which are elaborate.

Graduate Studies in Mathematics, Volume 19; 2010; 749 pages; Hardcover; ISBN: 978-0-8218-4974-3; List US$93; AMS members US$74.40; Order code GSM/19.R



What's Happening in the Mathematical Sciences, Volume 8

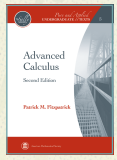
Dana Mackenzie

The author's way of presenting the material is vivid, simple and engaging. The narrative is illustrated [with] beautiful pictures. For those with a mathematical background ...it will make a fascinating read.

—Ilia Rushkin, Plus Magazine

This volume showcases the latest remarkable progress in pure and applied mathematics, written in an engaging style that conveys modern mathematics' thrill of discovery. Among the stories in this volume are several showing mathematics' significant role in current events, from the financial crisis to breast cancer screening. The book chronicles several important conjectures that mathematicians have settled in the past several years.

What's Happening in the Mathematical Sciences, Volume 8; 2011; 129 pages; Softcover; ISBN: 978-0-8218-4999-6; List US$23; AMS members US$18.40; Order code HAPPENING/8



Advanced Calculus
Second Edition

TEXTBOOK

Patrick M. Fitzpatrick, *University of Maryland, College Park, MD*

This book offers a rigorous but clear presentation of the fundamental concepts of mathematical analysis, emphasizing that this subject constitutes a coherent body of knowledge. It offers the reader a genuine understanding of the concepts at the heart of the computational algorithms. The book includes exercises that are challenging and in many cases foreshadow future developments.

Pure and Applied Undergraduate Texts, Volume 5; 2006; 590 pages; Hardcover; ISBN: 978-0-8218-4791-6; List US$82; AMS members US$65.60; Order code AMSTEXT/5

Random Walk and the Heat Equation

Gregory F. Lawler, *University of Chicago, IL*

This book introduces the heat equation and the closely related notion of harmonic functions from a probabilistic perspective. By beginning with the concrete example of random walk, the author builds up a structure that finishes with the powerful notion of Brownian motion. This is the first treatment of the connection between the heat equation and Brownian motion that is geared specifically to undergraduates.

Student Mathematical Library, Volume 55; 2010; 156 pages; Softcover; ISBN: 978-0-8218-4829-6; List US$29; AMS members US$23.20; Order code STML/55

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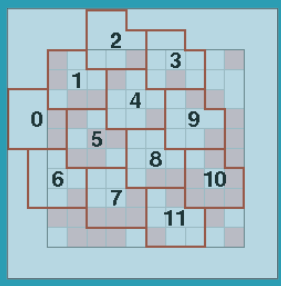

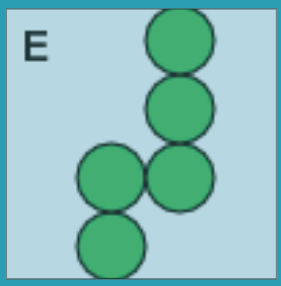

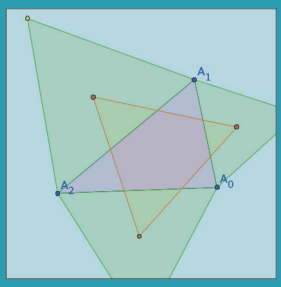

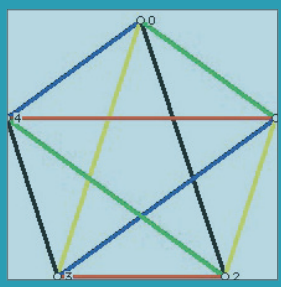

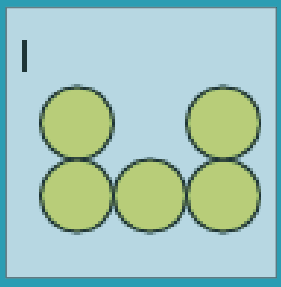

THE FEATURE COLUMN

monthly essays on mathematical topics

www.ams.org/featurecolumn

Each month, the Feature Column provides an online in-depth look at a mathematical topic. Complete with graphics, links, and references, the columns cover a wide spectrum of mathematics and its applications, often including historical figures and their contributions. The authors—David Austin, Bill Casselman, Joe Malkevitch, and Tony Phillips—share their excitement about developments in mathematics.

Recent essays include:

Geometry and the Discrete Fourier Transform

Farey Numbers and the Magnetic Cactus

Who Won!

Multiplication Is Easier When It's Complex

How Did Escher Do It?

From Pascal's Triangle to the Bell-shaped Curve

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of the American Mathematical Society

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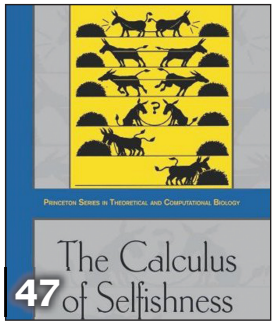

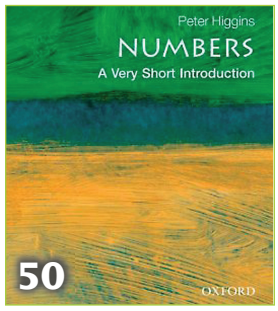

Features

This month's *Notices* contains a potpourri of stimulating mathematical ideas. The topics covered range from gender equity to a hundred-year-old revolution in mathematical thought to the ideas of Wigner about the effectiveness of mathematics. The *Scripta Manent* this month is about university presses and mathematical publishing. The *Doceamus* is about teaching with cognitive-demand tasks. Happy reading!

—Steven G. Krantz, Editor

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Notices

of the American Mathematical Society

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Mathematics of Planet Earth 2013

Mathematics of Planet Earth (MPE) is a worldwide project to be held in 2013. Since its conception in 2010, MPE2013 has become a true world initiative, attracting partners from all over the globe and from all continents, including, in the United States: the AMS, the American Statistical Association, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics. The project has been endorsed by the International Mathematical Union, the International Council of Applied and Industrial Mathematics, and the International Commission of Mathematical Instruction.

The mission of MPE2013 is to increase the engagement of mathematicians, researchers, teachers, students, and the public with the role of mathematics in issues affecting Planet Earth and its future. The strategies are to:

• Encourage research to identify and address fundamental questions about our planet to which mathematics can contribute to a solution, including understanding Earth's climate and environment and addressing its sustainability.

• Encourage mathematics teachers at all levels to communicate issues related to Planet Earth through their instruction and curriculum development.

• Encourage mathematics students and beginning researchers to pursue research areas related to Planet Earth.

• Inform the public about roles that mathematics can play in addressing questions related to Planet Earth.

The MPE theme is interpreted in a very broad sense, which leaves room for many institutes and societies around the world to organize related activities. Earth is a planet with dynamic processes in the mantle, oceans, and atmosphere that create climate, cause natural disasters, and influence fundamental aspects of life and life-supporting systems. In addition to these natural processes, humans have developed systems of great complexity, including economic and financial systems; the World Wide Web; frameworks for resource management, transportation, and health care delivery; and sophisticated social organizations. Human activity has increased to the point where it influences the global climate, impacts the ability of the planet to feed itself, and threatens the stability of these systems. Mathematics is poised to play an essential role in the study of planetary issues, both as a fundamental discipline and as an essential component of multidisciplinary research.

Mathematics of Planet Earth 2013 aims to develop this role for mathematics by providing a platform to showcase the essential relevance of mathematics to planetary problems, to coalesce activities currently dispersed among institutions, and to create a context for mathematical and interdisciplinary developments that will be necessary in order to address a myriad of issues and meet future global challenges. The MPE activities will take place everywhere on the planet. The scientific activities will include thematic terms or semesters on subthemes related to the main theme, workshops, collaborative research groups, summer schools, and special issues of scientific journals. Several learned societies will hold meetings on the theme or will publish related articles in their newsletters. Collaboration and joint activities are much encouraged.

In parallel with the scientific side, outreach activities developing awareness of the role of mathematics in the study of the planet and in planetary issues will be organized worldwide, targeting the public, the media, and the schools. These could include public lectures, panel discussions, radio or television programs, exhibitions, articles in newspapers, etc. School activities will include posters, special issues of magazines, websites, exhibitions, outreach to teachers' organizations, lectures in the schools, classroom projects, etc. International collaboration is encouraged to maximize the visibility of the initiative.

The MPE Workshop Committee is concentrating on identifying the most important themes and ensuring that these are covered in workshops or in thematic programs at mathematics institutes. The committee will also assist proposers in finding funding and venues for the workshops that seem to best fit the MPE ideals. A call for input to the Workshop Committee is posted on the MPE website.

The MPE Museum Committee has launched a competition of virtual modules that could be reproduced and utilized by many users around the world, from science museums to schools. Further information about this competition may be found in an announcement in the "Mathematics Opportunities" section of this issue of the *Notices*.

In North America, the Canadian Mathematical Society (CMS) will launch MPE2013 activities at its winter meeting in Montreal in December 2012; other societies, such as the Canadian Applied and Industrial Mathematical Society, have been invited to participate. MPE2013 activities will also take place at the Joint Mathematics Meetings in January 2013, including at the open house of the mathematics institutes. The first Mathematical Congress of the Americas, which will take place in Guanajuato, Mexico, August 5–9, 2013, will also have an MPE2013 component.

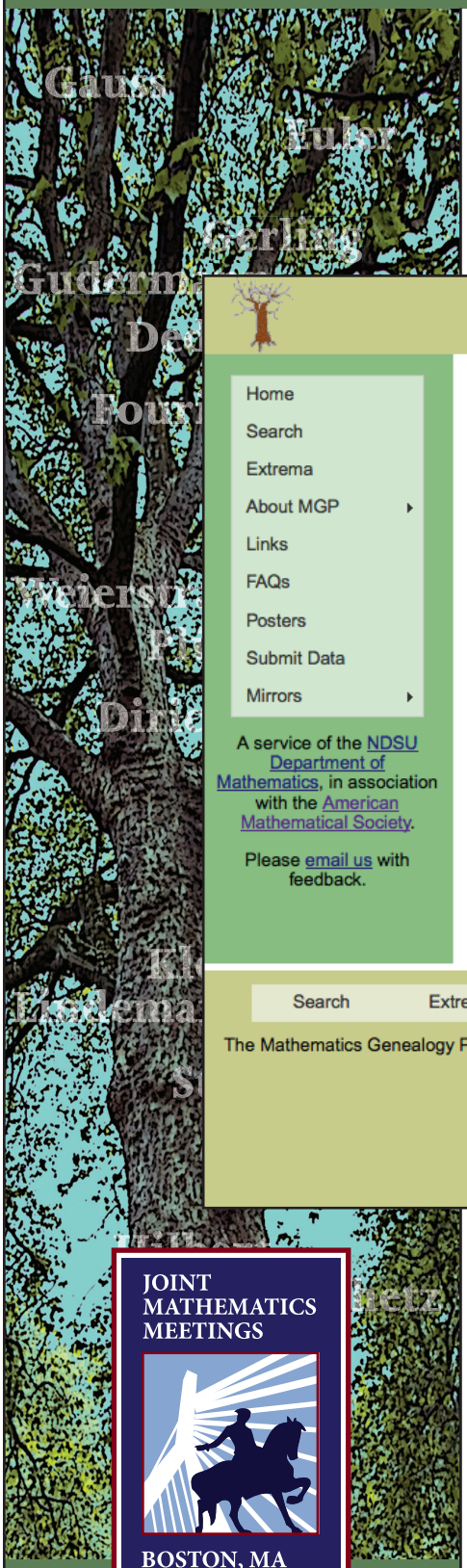
The themes of Mathematics of Planet Earth are so rich and varied that the project allows members of the mathematical community and various organizations to contribute to the initiative in creative ways. We hope to enlist the participation of many mathematicians and organizations as well as their help in promoting the event.

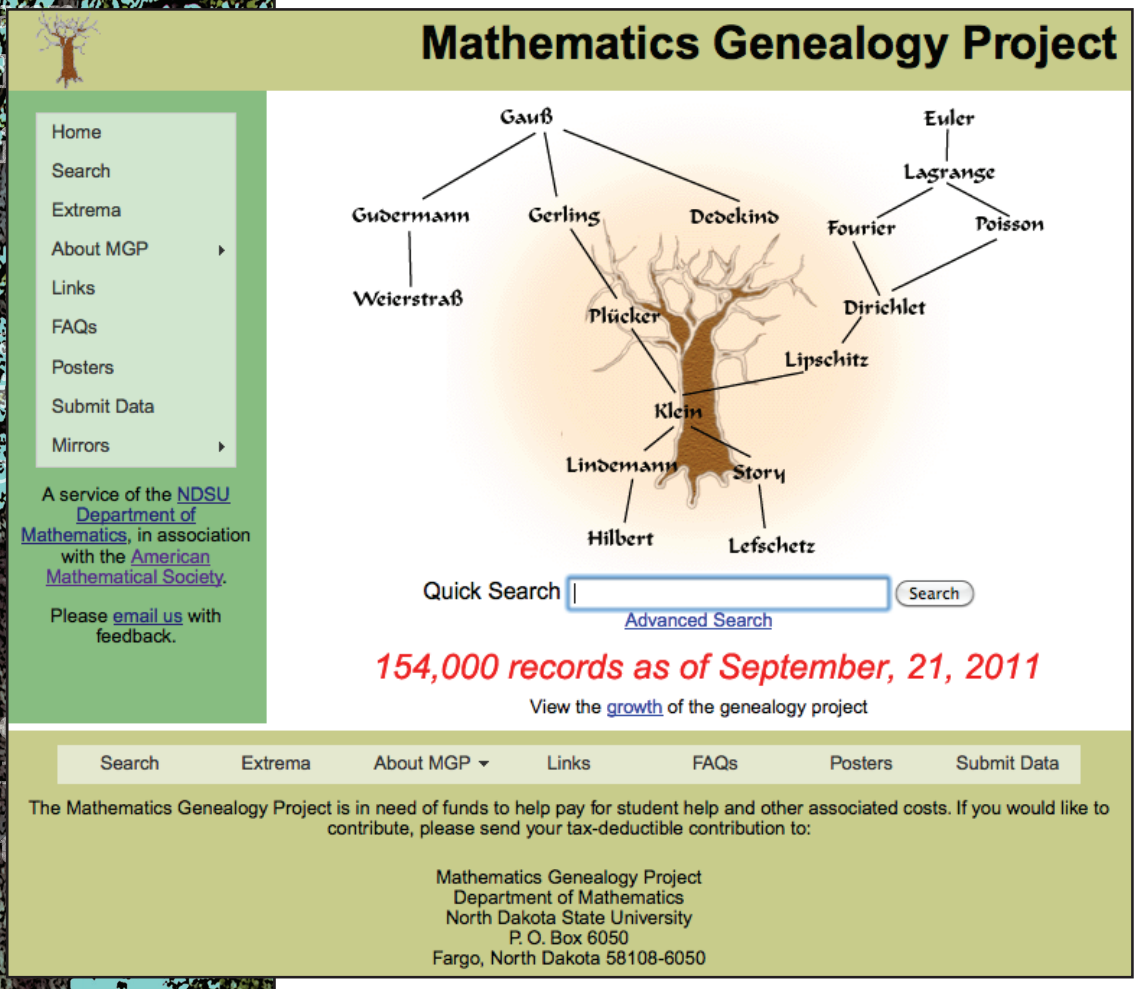
—Christiane Rousseau, Chair
MPE2013 Steering Committee
University of Montreal
rousseac@dms.umontreal.ca
http://www.mpe2013.org

DOI: http://dx.doi.org/10.1090/noti802

AMERICAN MATHEMATICAL SOCIETY

Mathematics Genealogy Project





This searchable database includes over 154,000 records of mathematicians from more than 100 countries, that date back as far as 1363. Entries include the degree recipient, university, name of advisor (linked to a list of his/her other students), dissertation title, year in which the degree was awarded, list of the degree recipient's students (if any), and the MSC code of the thesis.

Submit additions and corrections on the website at

www.genealogy.ams.org

The Mathematics Genealogy Project is a service of North Dakota State University and the American Mathematical Society.

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JOINT MATHEMATICS MEETINGS
BOSTON, MA
JANUARY 4–7, 2012

See a demonstration of the website and submit information at the AMS booth during the Joint Mathematics Meetings.

Letters to the Editor

Response to D. Bondoni

In response to the letter by Davide Bondoni in the June/July 2011 *Notices* about my book *Mathematicians Fleeing from Nazi Germany* (Princeton, 2009), reviewed in the November 2010 *Notices*:

The writer seems to wish I had written a different book. The aims of historical research are many-sided. They certainly include striving for "completeness" of sources and facts in certain areas as far as this can be achieved. For a still underresearched and politically sensitive topic like the effects of Nazi rule on mathematics, this is a particularly relevant goal, as is clearly explained in the book's preface. I agree that qualitative evaluation of events and interpretations are important. I am wondering whether Bondoni has overlooked the many qualitative statements and analyses in my book, not least of which include aiming at exact terminology such as "early" versus "forced" emigration, "persecution" under the Nazis, "losses and gains" of emigration. I have some rather strong claims about periodization and the effects of emigration in my book, for instance about the "late arrival of academic applied mathematics" in the United States and the misidentification of "German" algebra with Noether's particular approach. These claims are based on further and more detailed interpretative publications of mine, of which I take the liberty to quote just a few for further reading:

"Trois phases d'incorporation et legitimation des mathématiques en allemagne fasciste", in *La science sous le Troisième Reich*, J. Olff-Nathan (ed.), Paris, Seuil, 1993, 91–102.

"'Scientific control' in mathematical reviewing and German-U.S.-American relations between the two world wars", *Historia Mathematica* **21** (1994), 306–329.

"Mathematics in Hitler's Germany: Importance, results and open problems of a historical question", *Gazette des Mathématiciens*, No. 75 (Janvier 1998), 35–41.

"The effects of Nazi rule on the international participation of German mathematicians: An overview and two case studies", in *Mathematics Unbound: The Evolution of an International Mathematical Research Community, 1800–1945*, K. H. Parshall and A. Rice, eds., American Mathematical Society and London Mathematical Society, Providence and London, 2002, 335–357.

"The late arrival of academic applied mathematics in the United States: A paradox, theses, and literature", *N.T.M. International Journal of History and Ethics of Natural Sciences, Technology and Medicine* (N.S.) **11** (2003), 116–127.

(With Sandy Zabell) "Richard von Mises and the 'Problem of two races': A statistical satire in 1934", *Historia Mathematica* **34** (2007), 206–220.

"The historiography and history of mathematics in the Third Reich", in *The Oxford Handbook of the History of Mathematics*, Eleanor Robson and Jacqueline Stedall (eds.), Oxford University Press, 2009, pp. 853–879.

—Reinhard Siegmund-Schultze
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(Received July 22, 2011)

No Science Here

I was somewhat taken aback by the prominent inclusion of Frank Quinn's article ("A science-of-learning approach to mathematics education") in the October 2011 *AMS Notices*. Science? There's no science here. This article presents one mathematician's personal experience and opinions, without documentation or references, and fails to even acknowledge the existence of decades, if not centuries, of research into how students learn mathematics at all levels. I will not address specific content except to note that the emphasis on memorized algorithms seems to have little to do with actual learning. Is this really the state of the art in mathematics education? If the editor's purpose in publishing this article was to stimulate discussion, I expect he will have succeeded.

—Tevian Dray
Oregon State University
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(Received October 11, 2011

Correction

The October 2011 issue of the *Notices* carried an article in memory of Shiing-Shen Chern. The article included a piece by F. Hirzebruch in which an error appeared in one of the references. Reference [3], S. S. CHERN, "Characteristic classes of Hermitian manifolds", appeared in the *Annals of Mathematics* **47** (1946), 85–121, not in the *American Journal of Mathematics*.

—Allyn Jackson

Find the derivative of $y = 2\cos(3x - \pi)$ with respect to x.

$$\frac{dy}{dx} = \boxed{6 \cdot \sin 3x}$$

"Sorry, that's not correct."

"That's correct."

TWO ONLINE HOMEWORK SYSTEMS WENT HEAD TO HEAD. ONLY ONE MADE THE GRADE.

What good is an online homework system if it can't recognize right from wrong? Our sentiments exactly. Which is why we decided to compare WebAssign with the other leading homework system for math. The results were surprising. The other system failed to recognize correct answers to free response questions time and time again. That means students who were actually answering correctly were receiving failing grades. WebAssign, on the other hand, was designed to recognize and accept more iterations of a correct answer. In other words, WebAssign grades a lot more like a living, breathing professor and a lot less like, well, that other system.

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Debunking Myths about Gender and Mathematics Performance

Jonathan M. Kane and Janet E. Mertz

Gender differences in mathematics participation rate, mean and high-end performance, and variance in distribution of performance have been reported on numerous occasions. The reasons for these findings have been the subject of much debate. For example, the *greater male variability hypothesis*, originally proposed by Ellis in 1894 [42] and reiterated in 2005 by Lawrence Summers when he was president of Harvard University [48], states that variability in intellectual abilities is intrinsically greater among males. If true, it could account for the fact that all Fields medalists have been male. If gender differences in means and variances are primarily a consequence of innate, biologically determined differences between the sexes, one would expect these differences to be similar among countries regardless of their culture and to remain fairly constant across time. Such a finding would suggest that little can be done to diminish these differences. In support of this hypothesis, Machin and Pekkarinen [26] claimed that greater male variance in mathematics performance was a "robust phenomenon", that is, observed among fifteen-year-olds in thirty-five out of the forty countries that participated in the 2003 Programme for International Student Assessment (PISA). In addition, women's nature might include a tendency to prefer the more nurturing fields, such as nursing and teaching young children, to the more quantitative ones, such as mathematics, physics, and engineering. If so, it might not make sense to encourage and direct any but the unusual female toward studying and seeking employment in these latter fields. This viewpoint has led some folks to propose that it may be a waste of time and money to expend resources directed toward trying to increase participation of women in these mathematics-intensive fields (e.g., [5], [6], [46], [49], [50]).

Alternatively, boys and girls may be born similar in their innate intellectual potential but end up displaying differences due to a variety of sociocultural factors present in their environment, for example, gender-stratification ([2]). If true, one might see differences among countries and changes over time in mathematics variances and mean performances. This *gender-stratified hypothesis* is consistent with several recent findings. For example, Hyde and collaborators ([20], [25]) reported that girls have now reached parity with boys in mean mathematics performance in the United States, even in high school, where a significant gap in mean performance existed in the 1970s. Likewise, both Brody and Mills ([3]) and Wai et al. ([51]) noted a drop in nonrandom samples of students under thirteen years of age, from 13:1 in the 1970s down to approximately 3:1 by the 1990s in the ratio of U.S. boys to girls scoring above 700 on the quantitative section of the college-entrance SAT examination. The percentage of Ph.D.'s in the mathematical sciences awarded to U.S. citizens who are women has increased from 6 percent in the 1960s to 30 percent in the past decade ([4], [9]). Sociocultural, legal, and educational changes that took place during this time span may account for these dramatic improvements in mathematics performance and participation by U.S. females.

Gender differences in opportunities and outcomes within countries have been quantified by a variety of measures. The Gender Gap Index (GGI) is a composite, weighted measure of the gap

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between men and women with respect to economic participation, educational attainment, political empowerment, and health. Looking across countries, Guiso et al. ([16]) reported that the GGI negatively correlates with both the gap in mean mathematics performance between boys and girls and the ratio of boys to girls scoring above the 95th percentile on the 2003 PISA; the gap and 95th percentile ratio were essentially zero and unity, respectively, in some countries with high GGI indexes. Even considering the extreme right side of the distribution, one notes that the percentage of worldwide participants who are girls in the International Mathematical Olympiad (IMO), an extremely difficult, proof-based, essay-style examination in mathematical problem solving, has increased from approximately 2½ percent in the 1970s to 10 percent in recent years ([22]). In addition, we ([1], [21]) reported that a positive correlation also exists between GGI and identification of girls with profound mathematical talent as measured by percentage of girls who participated in the IMO as members of high-ranked teams. These findings are consistent with the idea that the gap between boys' and girls' mathematics performance is due to differences in opportunities available to males versus females, which we will call here the *gap due to inequity hypothesis*. If either the gap due to inequity hypothesis or the gender-stratified hypothesis is true, it would suggest that a variety of actions could be taken to increase both average and high-end mathematics performance of females and participation rates by women in science, technology, engineering, and mathematics (STEM) fields.

Of course, outcome could be the end result of complex interplay between nature and nurture (for examples, see [43]). In this case, it would still make sense to devote resources toward increasing participation and performance of females in the mathematical sciences given that they make up half of the population and that U.S. STEM workers will likely be in short supply in the future.

However, Fryer and Levitt ([14]) and Ellison and Swanson ([10]) recently suggested a *Muslim culture hypothesis* given their finding that these above-mentioned correlations disappear when the samples include predominately Muslim countries with very low GGIs where most children attend single-gender schools. The Fryer-Levitt findings were based on data from eighth graders who participated in the 2003 Trends in International Mathematics and Science Study (TIMSS). They found that "in countries like Bahrain, which are among the worst in terms of gender equality, girls are actually outperforming boys on math". Alternatively, they propose a *single-gender classroom hypothesis* that "mixed-gender classrooms are a necessary component for gender inequality to translate into poor female math performance, although it is difficult to distinguish single-gender classrooms from Islamic religion."

In this article, we tested each of these above-stated hypotheses by analyzing data from the 2007 TIMSS, 2009 PISA, and 2001–2010 IMOs, which included more countries from a variety of cultures, educational systems, and degrees of wealth than did these earlier studies. In support of the gender-stratified hypothesis, we show here that greater male variability and gender gap in mathematics performance, when present, are both largely artifacts of a complex variety of sociocultural factors rather than intrinsic differences, co-educational schooling, or specific religious following per se. Importantly, we document that mathematics performance for both boys and girls exhibits a strong positive correlation with some measures of gender equity, especially participation rates and salaries of women in the paid labor force relative to men.

Methods

Measures of Mathematics Performance

Most measures of mathematics performance presented here are based on the TIMSS, a quadrennial study that includes a mathematics assessment administered to samplings of countries' students. Approximately 138,000 fourth graders from twenty-six countries and 256,000 eighth graders from forty-eight countries participated in the TIMSS in 2003, with twenty-four of the latter countries also participating in the 2003 PISA. Approximately 183,000 fourth graders from thirty-eight countries and 242,000 eighth graders from fifty-two countries participated in the TIMSS in 2007. Summaries of the data are presented in the TIMSS 2003 and 2007 International Mathematics Reports ([32], [33]); other details are available in [12], [28], [29], and [32]–[34]. The benchmark participants from Basque Country, Dubai, and Ontario were used as representative measures for Spain, United Arab Emirates, and Canada, respectively.

The TIMSS sets the overall mean score among the benchmark participants at 500 with a standard deviation of 100 so scores can be compared across studies; scores of all other participants are presented relative to these benchmarks. We examined both the overall mean on the mathematics test for each country and the means and variances for each gender within each country. Gender gap was calculated as the difference in means, with positive values indicating that boys outscored girls. Normalized gender gap, called the effect size (d), was calculated as this difference divided by the standard deviation of the combined boys' and girls' scores within the country. The variance ratio (VR) for each country was calculated as the variance in their boys' scores divided by the variance in their girls' scores. To obtain the distribution of scores within a country and to see how individual scores relate to gender and other demographic

attributes, we examined the raw data available through the TIMSS 2003 and 2007 websites, using the first of the five plausible values for individual students' scores. Other available data included each student's school, sex, age, and answers to survey questions, such as his or her attitude toward learning mathematics.

The Program for International Student Assessment (PISA) is a triennial study of fifteen-year-old schoolchildren's scholastic performance that measures reading, mathematics, and science literacy. In 2003, approximately 275,000 students from forty-one countries, thirty of which were members of the Organisation for Economic Co-operation and Development (OECD), participated in a PISA that primarily focused on math literacy, testing problem solving and real-life situations that use math ([35]). In 2009, over 475,000 students from sixty-five countries (thirty-four from the OECD) participated in a PISA that focused on reading but included a mathematics section as well ([37]). We examined PISA data to compare it with prior findings of other researchers and our own findings with the TIMSS data.

Several differences exist between the PISA and TIMSS data sets:

(a) Countries. Prior to the 2009 PISA, countries participating in the TIMSS for eighth graders were more diverse with respect to wealth, religion, and gender-related schooling practices. Thus our findings presented here primarily come from analyses performed with the 2007 TIMSS eighth-grade data set. Afterward, we used the recently released 2009 PISA data to determine whether these findings were reproducible with a different examination in which only thirty-one out of eighty-six countries participated in both studies.

(b) Students' ages. The PISA samples students between the ages of fifteen years, three months and sixteen years, two months regardless of their grade in school, with most being in the equivalent of U.S. tenth grade. The TIMSS samples eighth graders, regardless of their age. Although most are 13.3 to 15.3 years of age, a few are younger, and the number of students over the age of 15.3 exceeded 10 percent in one-third of the countries. We also examined the 2003 and 2007 TIMSS fourth-grade data sets because in these, presumably, fewer students would have already dropped out of school, reducing potential sample bias.

(c) Religion. In eighteen of the countries that participated in the 2007 TIMSS eighth-grade examination, a majority of citizens come from Muslim backgrounds. To test the Muslim culture hypothesis, we sometimes separately analyzed data from countries with greater than 75 percent Muslims, indicating them by open circles or white bars in the figures.

(d) Schooling. To test the single-gender classroom hypothesis, we examined data from countries in which 17 percent or more of students attended single-gender schools, separately comparing students attending gender-segregated and coeducational ones.

During the past decade, over eighty countries per year from throughout the world have sent six-member teams of precollegiate students to participate in the IMO ([22]). To examine mathematics performance at an extremely high level, we analyzed IMO gender data from countries with mean team member performance among the top sixty that had at least thirty students participate during 2001 through 2010.

Measures of Gender Equity

This study used two measures of the degree to which women within a country have yet to reach full equality with men living in the same country. The first, the World Economic Forum's GGI, is a composite, weighted measure of the gap between men and women with respect to: (i) economic participation and opportunity (EPO); (ii) educational attainment (ED); (iii) political empowerment (POL); and (iv) health and survival (H&S). It is measured on a 0–1 scale, with 1.00 being complete gender equity. The GGI data used here for year 2007 ([17]) ranged from a low of 0.4510 for Yemen to a high of 0.8146 for Sweden, with the United States scoring 0.7002 for a rank of 31st highest out of the 128 countries for which data were available. For correlations with the 2009 PISA data, we used 2009 GGI rankings ([18]).

Because the H&S subcomponent of the GGI is to a considerable degree a reflection of the wealth of a country and its citizens, we also analyzed data available through the Social Watch Group. Their Gender Equity Index (GEI) is a composite, weighted measure with respect to only: (i) economic participation rate and income earned (EPI); (ii) educational literacy rate and school enrollment (ED); and (iii) empowerment as reflected by percentage of women in technical, management, and government positions (TMG). It typically yielded slightly higher correlations with mathematics performance. It is measured on a 0–100 scale, with 100 being complete gender equity. The GEI data used here for year 2007 ([44]) ranged from a low of 31 for Yemen to a high of 89 for Sweden, with the United States scoring 74 for a rank of 24th highest out of the 154 countries for which data were available. For correlations with the 2009 PISA data, we used 2009 GEI rankings ([45]).

Other Measures

(i) Economic wealth. The gross domestic product (GDP) per capita used here was the 2007 GDP per capita in real terms deflated with Laspeyres Price Index. It was taken from the Penn World Table ([19]).

(ii) Religious affiliation. Each country's predominant religion was obtained from the CIA's *The World Factbook* ([7]); the percentage of citizens

affiliated as Muslim was taken from the Pew Research Center's 2009 report ([31]).

Statistical Analyses

Comparison of measures of mathematics performance and gender equity were performed using Pearson correlations (r) and regressions. Comparisons of attitudes toward mathematics education among groupings of countries were done by constructing contingency tables and performing chi-square tests. Statistics were considered significant if associated with a p-value of at most 0.10; all such correlations are displayed with † for a p-value < 0.10, * for < 0.05, ** for < 0.01, and *** for < 0.001.

Results and Discussion

Gender Gap in Math Performance versus Equity Indexes

Except for the 2007 eighth graders, among whom girls outperformed boys by five points ($p < 0.05$), no statistically significant gender gap existed overall in the mean scores of fourth and eighth graders on the 2003 and 2007 TIMSS ([32], [33]). To test the gap due to inequity hypothesis, we compared various measures of countries' gender equity (i.e., their equity indexes and subcomponents) with their gender gaps in mean mathematics performance on these examinations by calculating effect sizes, d (see Table 1). As already noted by others ([11], [14]), an insignificant Pearson correlation of –0.027 was observed between countries' GGIs and effect sizes calculated using the 2003 TIMSS eighth-grade data set. This correlation was 0.295 ($p < 0.05$) using the larger 2007 TIMSS eighth-grade data set; that is, the gap tended to increase in countries with greater gender equity as measured by their GGIs, a finding opposite of the one previously reported using the 2003 PISA data set ([16]). The positive correlation was even greater and highly significant ($r = 0.577$; $p < 0.001$) using the 2007 TIMSS fourth-grade data set. Replacement of the 2007 GGI ratings with the 2007 GEI ones led to fairly similar correlations (Table 1). Again, they were more positive in fourth grade than in eighth grade and in 2007 than in 2003. No correlation was found between countries' effect sizes in mean mathematics performance on the 2009 PISA and their 2009 GGIs ($r = 0.083$) or GEIs ($r = 0.136$). This irreproducibility in the relationship between gender gap and equity indexes negates the gap due to inequity hypothesis.

Gender Gap versus Variance Ratio in Math Performance

Next, we tested the greater male variance hypothesis. If true, the variance ratios (VRs) for all countries should be greater than unity and similar in value. This is not what we observed. The VR measured for any given nation was quite reproducible, that is, it rarely differed by more than 20 percent from one test administration year to the next, among students in different grades, or between the PISA and TIMSS; typically, it differed by at most 10 percent (see Table 2). For example, the VRs for Australia, England, Hungary, and the United States ranged from 1.10 to 1.21, 1.05 to 1.12, 1.03 to 1.10, and 1.08 to 1.19, respectively, among the five tests analyzed here. These findings agree well with the VR of 1.08 reported from a large meta-analysis involving data from 242 studies involving over 1 million Americans ([25]). However, for Indonesia, Morocco, and Tunisia, the VRs ranged from 0.95 to 1.02, 0.96 to 1.04, and 0.93 to 1.09, respectively; that is, they were essentially unity. For Singapore and Taiwan, they ranged from 1.21 to 1.25 and 1.25 to 1.31, respectively. In fact, the VRs calculated using the 2007 TIMSS eighth-grade data set studied in detail here varied widely among countries, ranging all the way from

Table 1. Correlations between measures of gender equity and mean mathematics scores.

	2003 TIMSS						2007 TIMSS						2009 PISA		
	4th Graders			8th Graders			4th Graders			8th Graders			15-year-olds		
	Gap[1]	Girls	Boys	Gap	Girls	Boys	Gap	Girls	Boys	Gap	Girls	Boys	Gap	Girls	Boys
GGI[3]	.144	.302	.304	-.027	.281†[2]	.283†	.577***	.624***	.660***	.295*	.408**	.462***	.083	.400***	.405***
EPO	.174	.547**	.546**	-.044	.327*	.330*	.511***	.757***	.780***	.258†	.442**	.488***	-.025	.398***	.387**
POL	.233	.019	.039	.073	.007	.020	.557***	.315†	.362*	.262†	.262†	.314*	.123	.340**	.352**
ED	.126	.420*	.417*	-.292†	.246	.207	.317†	.550***	.562***	-.168	.248†	.200	.043	.003	.010
H & S	.385†	.053	.089	.247	.098	.136	.433**	.136	.181	.279†	.177	.231	.146	-.129	-.102
No.Countries[4]:	24			43			36			46			61		
GEI[5]	.210	.525**	.529**	-.075	.425**	.424**	.637***	.698***	.738***	.176	.479***	.510***	.136	.333**	.345**
EPI	.259	.572**	.581**	-.029	.420**	.427**	.564***	.691***	.723***	.261†	.453**	.506***	.015	.412***	.405***
TMG	.121	.423*	.420*	-.039	.341*	.342*	.681***	.603***	.651***	.160	.422**	.450**	.196	.320*	.342**
ED	.187	.381†	.386†	-.235	.268†	.237	.386*	.543***	.566***	-.160	.263†	.219	.058	-.366**	-.350**
No.Countries:	24			44			35			46			61		

[1]Gender gap in mean score, calculated as effect size, d; positive value means boys scored higher than girls.
[2]p-values: †, <0.1; *, <0.05; **, <0.01; ***, <0.001.
[3]GGI, World Economic Forum's Gender Gap Index; EPO, economic participation and opportunity subcomponent; POL, political empowerment subcomponent; ED, educational attainment subcomponent; and H & S, health and survival subcomponent.
[4]Number of participating countries for which equity data exist.
[5]GEI, Social Watch's Gender Equity Index; EPI, economic participation rate and income earned subcomponent; TMG, empowerment as reflected by percentage of women in technical, management, and government positions; and ED, educational literacy rate and school enrollment.

Table 2. Variance ratios in mathematics performance among countries in different examinations, grades, and years[1].

	2003			2007	
Country	PISA[2] 15-year -olds	TIMSS 4th Graders	TIMSS 8th Graders	TIMSS 4th Graders	TIMSS 8th Graders
Armenia	-	1.12	1.13	0.98	1.00
Australia	1.18	1.10	1.16	1.21	1.20
Belgium	1.19	1.11	1.06	-	-
Canada	1.24	1.09	1.06	1.12	1.19
Cyprus	-	1.15	1.16	-	1.25
Czech Rep	1.07	-	-	1.18	1.03
England	1.06	1.12	1.05	1.12	1.07
Hong Kong	1.36	1.21	1.12	1.20	1.29
Hungary	1.10	1.03	1.08	1.07	1.07
Indonesia	0.95	-	1.02	-	0.98
Iran	-	1.10	1.15	1.21	1.15
Italy	1.27	1.08	1.14	1.05	1.08
Japan	1.29	1.28	1.19	1.17	1.02
Korea	1.10	-	1.10	-	1.14
Latvia	1.19	1.18	1.18	1.15	-
Lithuania	-	1.08	1.13	1.17	1.08
Morocco	-	0.96	1.00	1.04	1.00
Netherlands	1.00	0.96	1.03	1.00	-
New Zealand	1.16	1.10	1.20	1.20	-
Norway	1.20	1.11	1.09	1.00	1.17
Russian Fed	1.20	1.00	1.14	1.10	1.16
Scotland	-	1.17	1.14	1.22	1.08
Serbia	1.30	-	1.14	-	1.12
Singapore	-	1.21	1.25	1.21	1.22
Slovak Rep	1.10	-	1.16	1.00	-
Slovenia	-	1.17	1.18	1.18	1.15
Spain	1.20	-	1.28	-	1.23
Sweden	1.10	-	1.06	1.13	1.12
Taiwan	-	1.25	1.25	1.26	1.31
Tunisia	1.03	1.06	0.93	1.09	0.91
United States	1.19	1.11	1.11	1.08	1.08

[1]Calculated as boys' variance divided by girls' variance within country. Data shown only for countries that participated in 3 or more of these 5 examinations.
[2]Taken from Machin and Pekkarinen (26).

0.91 to 1.52 (Figure 1A). This distribution of VRs is similar to the one previously reported using the 2003 PISA data set ([26]) except for being even broader with the inclusion of more predominantly Muslim countries (white bars in Figure 1A), many of which exhibit usually low or high VRs.

Variances for girls and boys also varied widely throughout a threefold range (Figure 1B). Countries with small variances typically had VRs within 0.2 of unity. Most of the countries with large VRs were ones that also had unusually large boys' variances. Thus, for the 2007 TIMSS eighth-grade data set, the correlation between variance and VR was 0.297 ($p < 0.05$); the correlation between boys' variance and VR was 0.414 ($p < 0.01$). Therefore, we conclude that both variance and VR in mathematics performance vary greatly among countries. Confirming our earlier finding ([21]), we also conclude that VR is reproducibly essentially unity for some countries. These findings are inconsistent with the greater male variability hypothesis.

Interestingly, a strong negative correlation ($r = -0.640$, $p < 0.001$) was observed between VR and

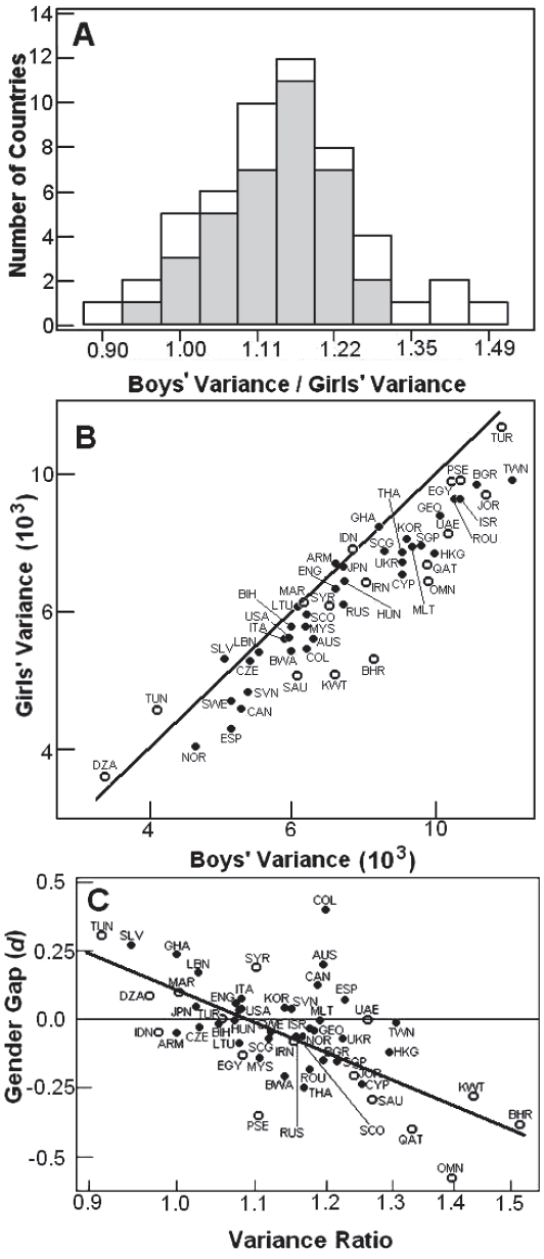

Figure 1. Variance ratio, variances, and gender gap on 2007 TIMSS for eighth graders vary widely among countries and strongly correlate. (A) Histogram showing distribution of measured variance ratios among predominantly Muslim (i.e., >75%; white bars) and other participating countries (gray bars). X axis is standard VR units but presented in evenly spaced intervals in $\log_{10}$. (B) Scatter plot showing girls' versus boys' variance in score distributions plotted using log scales. The diagonal line indicates equity. (C) Scatter plot showing relationship between normalized gender gap, i.e., effect size *d*, and variance ratio plotted on a log scale. Pearson correlation, $r = -0.640$ ($p < 0.001$); $r = -0.790$ ($p < 0.001$) for countries >75% Muslim countries, indicated by open circles. Regression line is indicated. The 3-letter ISO codes adjacent to each circle indicate the countries they represent.

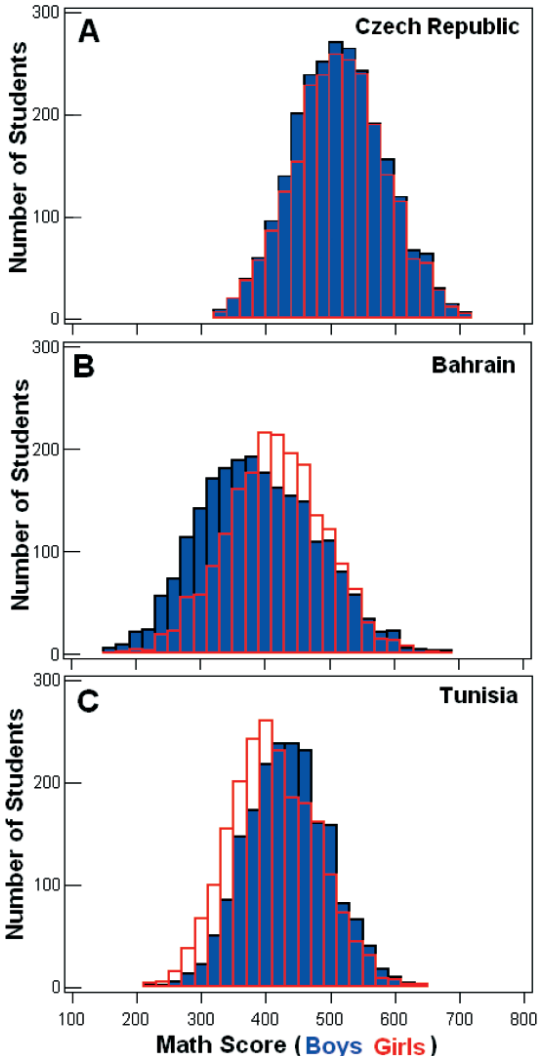

Figure 2. Distributions of eighth-grade girls' and boys' mathematics scores on 2007 TIMSS in (A) the Czech Republic, (B) Bahrain, and (C) Tunisia. The Czech Republic had 2,335 girls and 2,510 boys participate, with VR = 1.02 and d = -0.027. Bahrain had 1,974 girls and 2,256 boys participate, with VR = 1.52 and d = -0.38. Tunisia had 2,121 girls and 1,915 boys participate, with VR = 0.91and d = 0.31.

effect size (Figure 1C). This negative correlation was even stronger ($r = -0.790$; $p < 0.001$) among the predominantly (that is, > 75 percent) Muslim countries (open circles in Figure 1C), with effect size ranging from quite negative, i.e., favoring girls, to somewhat positive. Furthermore, the percentage of Muslims in a country's population did not correlate with effect size [$r = -0.029$ for 2003 TIMSS eighth graders; $r = -0.285$ ($p < 0.05$) for 2007 TIMSS eighth graders, but $r = -0.107$ when the four countries with outlier VRs > 1.30 are omitted]. These findings negate the Muslim culture hypothesis. Rather, we conclude that gender gap in mathematics performance exhibits a strong negative correlation with variance ratio.

Why might effect size correlate with VR? Comparison of actual boys' and girls' score distributions for individual countries was informative. For example, they were essentially coincident in some countries, such as the Czech Republic, where VR and gender gap were near unity and zero, respectively (Figure 2A). On the other hand, in Bahrain, the country with the largest VR, the right sides of the distributions were similar, whereas the left sides contained many more boys than girls (Figure 2B). This country also had 282 fewer eighth-grade girls than boys participate in this test. One hypothesis consistent with these data is that Bahraini girls who potentially might have scored poorly were more likely to have left school prior to eighth grade than were potentially poorly scoring boys due to sociocultural factors; thus they would not have been among this country's eighth-grade test-takers. If true, it would explain why Bahraini girls' variance was much smaller than the boys' variance (Figure 1B). It would also account for the fact that Bahraini girls significantly outscored boys on average when, in reality, they might not have done so if the population sampled had included school dropouts. Another potential contributing factor is that some Bahraini boys receive their education at religious schools [24], which may devote less time to mathematics education than do secular schools. Among Bahraini eighth graders attending mixed-gender schools, the VR and gender gap were near unity and zero, respectively (Table 3).

Gender differences in schooling practices may also explain variance ratios that are less than unity and gender gaps that favor boys. For example, boys were preferentially missing from the left half of the score distributions for eighth graders in Tunisia (Figure 2C), the country with the smallest VR (Figure 1C) and somewhat fewer male than female participants. Thus we conclude that math variance ratios and gender gaps significantly different from unity and zero, respectively, are both largely consequences of the same sociocultural factors that differ among countries, some of which lead to different educational experiences and patterns of school attendance. This latter finding is reminiscent of the Hyde et al. [20] conclusion that the gender gap on the U.S. college entrance ACT examination disappears when sample bias is eliminated by testing all eleventh-grade students rather than just college-bound ones.

Single- versus Mixed-Gender Schooling

We next tested the single-gender classroom hypothesis by examining data at the level of individual eighth-grade students from the seventeen countries in which 17 percent or more of students attended single-gender schools (Table 3). In agreement with numerous previous studies including findings from 2003 TIMSS data [52], 2006 PISA

Table 3. Math performance on 2007 TIMSS among eighth graders attending single- versus mixed-gender schools.

	%	Predom.	Single-gender schools				Mixed-gender schools				Difference school type	
Country	SG[1]	Religion	Girls Mean	Boys Mean	Gap[2]	VR[3]	Girls Mean	Boys Mean	Gap	VR	Girls[4]	Boys[5]
Australia	18	Christian	520 (5.2)[6]	544 (3.6)	0.30	0.90	483 (1.8)	488 (1.8)	0.07	1.14	-0.47	-0.71
Bahrain	91	Muslim	412 (1.7)	380 (1.9)	-0.39	1.40	473 (6.0)	480 (5.1)	0.08	1.04	0.73	1.19
Dubai, UAE	54	Muslim	425 (2.8)	401 (3.6)	-0.24	1.44	487 (3.3)	484 (3.6)	-0.03	1.27	0.61	0.82
Egypt	66	Muslim	423 (2.0)	393 (2.2)	-0.29	1.17	406 (3.1)	423 (3.1)	0.17	1.11	-0.17	0.29
Hong Kong	17	None	619 (3.3)	612 (6.0)	-0.08	2.44	572 (2.3)	563 (2.5)	-0.10	1.23	-0.52	-0.54
Iran	97	Muslim	415 (2.0)	417 (2.0)	0.02	1.26	-	-	-	-	-	-
Israel	23	Jewish	492 (4.2)	486 (5.1)	-0.06	1.25	456 (2.7)	454 (3.0)	-0.02	1.14	-0.36	-0.33
Jordan	85	Muslim	435 (1.8)	408 (2.4)	-0.27	1.25	430 (6.8)	410 (4.3)	-0.21	1.10	-0.05	0.02
Korea	43	None	589 (3.0)	596 (3.0)	0.08	1.10	598 (2.6)	600 (2.7)	0.01	1.16	0.10	0.04
Kuwait	82	Muslim	367 (1.6)	338 (2.3)	-0.37	1.39	361 (5.0)	343 (3.8)	-0.23	1.27	-0.07	0.07
Malta	58	Catholic	485 (2.1)	451 (3.5)	-0.38	1.53	503 (3.2)	516 (1.9)	0.14	0.77	0.20	0.72
Oman	83	Muslim	399 (1.8)	346 (2.3)	-0.56	1.48	397 (8.0)	346 (3.8)	-0.54	0.82	-0.02	0.00
Palestine	81	Muslim	391 (2.1)	345 (2.7)	-0.45	1.25	372 (5.2)	359 (4.7)	-0.12	0.95	-0.19	0.13
Qatar	17	Muslim	335 (2.4)	269 (8.2)	-0.71	1.29	322 (1.7)	292 (1.7)	-0.33	1.29	-0.14	0.24
Saudi Arabia	98	Muslim	346 (1.5)	322 (1.8)	-0.31	1.32	-	-	-	-	-	-
Singapore	17	Buddhist	650 (3.7)	639 (5.0)	-0.12	1.40	585 (2.0)	569 (2.0)	-0.18	1.16	-0.71	-0.77
Syria	64	Muslim	383 (1.9)	405 (2.1)	0.27	1.18	397 (3.0)	401 (3.0)	0.05	1.00	0.18	-0.04

[1]Percentage of participating students who were attending a single-gender school.
[2]Gender gap in mean score among students attending same school type, calculated as effect size, *d*, with normalization to total within-country standard deviation; positive means boys scored higher than girls.
[3]Calculated as boys' variance divided by girls' variance within country among students attending same school type.
[4]Mean score of girls attending mixed-gender schools minus mean score of girls attending single-gender schools, with normalization to total within-country standard deviation.
[5]Mean score of boys attending mixed-gender schools minus mean score of boys attending single-gender schools, with normalization to total within-country standard deviation.
[6]Standard errors of means indicated within parentheses.

data [8], and a 2005 U.S. Department of Education report that systematically reviewed dozens of articles with data on single-sex versus coeducational schools [27], we observed no consistent trends among either the predominantly Muslim or non-Muslim countries. Importantly, in South Korea, where middle school students are randomly assigned to single- or mixed-gender public schools [23] and the demographics of the students attending them are quite similar (data not shown), both girls and boys performed approximately one standard deviation above the benchmark mean of 500 regardless of school type. In predominantly Muslim Dubai, boys and girls performed similarly in the coeducational schools, much better than either of them did in the single-gender ones. Girls did significantly outperform boys in gender-segregated schools in some of the Muslim countries. However, it was not because their girls performed well; rather, their boys performed quite poorly. In fact, a strong positive correlation ($r = 0.687$; $p < 0.01$) was found between boys' mean score and gender gap among countries > 75 percent Muslim, that is, the gap favoring girls became smaller as boys' mean score improved; above 400, the gap was either not significantly different from zero or favored boys for all predominantly Muslim countries except Jordan.

Why did boys perform so poorly in some countries? Attendance at single-gender schools per se is not the answer, given that boys attending such schools in Hong Kong, South Korea, and Singapore averaged a standard deviation or more above the benchmark mean, doing as well if not significantly better than their peers in coeducational schools. Conversely, boys attending mixed-gender schools in Ghana, Kuwait, and Oman had mean scores below 350; in Qatar, the mean was only 292.

Thus we also reject the single-gender classroom hypothesis, concluding, instead, that other factors are the main determinants of mean mathematics performance for both girls and boys; gender gap, when present in either direction, is a consequence of these other factors that differentially affect performance.

Math Performance versus Equity Indexes

What are these factors? One of them is poverty, a fact observable in the relationship between log real gross domestic product (GDP) per capita and eighth-grade 2007 TIMSS mean mathematics performance (Figure 3E). A strong positive correlation ($r = 0.622$; $p < 0.01$) exists among the twenty-one participating countries with real GDPs per capita below US$11,500. However, this correlation was not significant ($r = -0.183$; $r = 0.076$ with outlier Qatar omitted) for the twenty-nine wealthier participating countries. Analysis of the data from the 2009 PISA confirmed these findings: (i) Among the sixteen poorer countries with known GDPs, a strong positive correlation ($r = 0.605$; $p < 0.05$) was

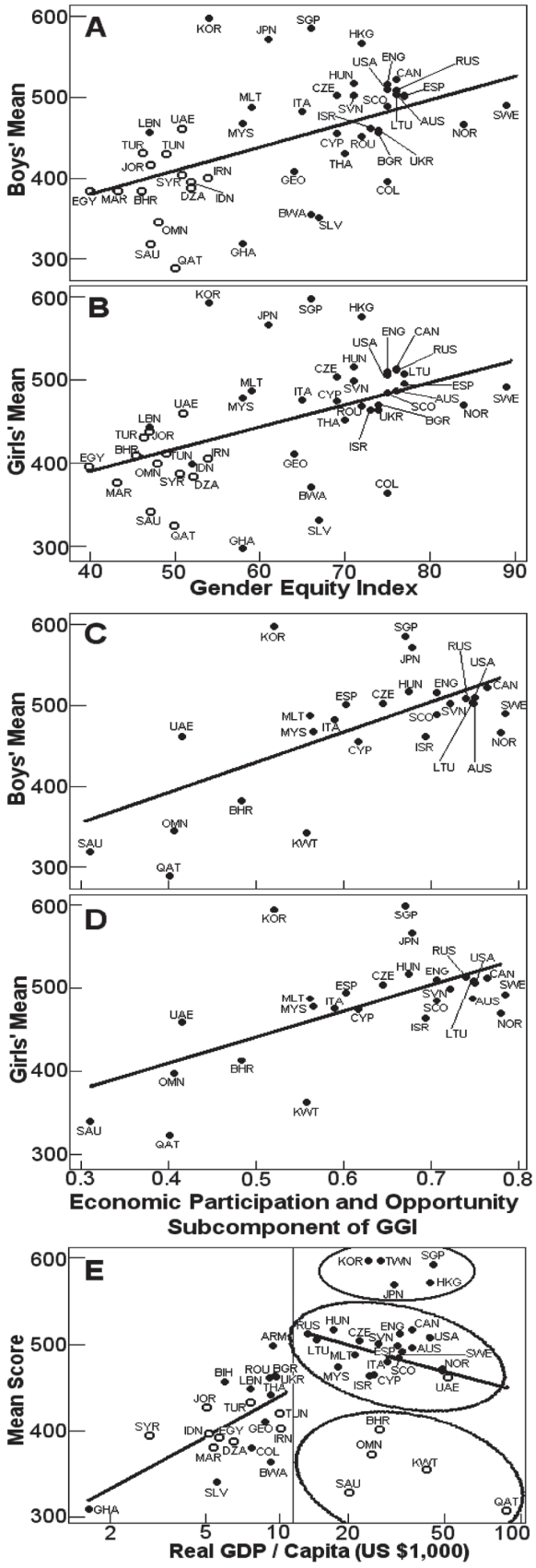

Figure 3 (left). Scatter plots showing relationships among countries in mathematics performance of eighth graders on 2007 TIMSS. (A, B) GEI versus boys' ($r = 0.510$, $p < 0.001$) and girls' ($r = 0.479$, $p < 0.001$) mean, respectively. (C, D) EPO subcomponent of GGI among countries with real GDP per capita above US$11,500 versus boys' ($r = 0.658$, $p < 0.001$) and girls' ($r = 0.618$, $p < 0.001$) mean, respectively. (E) Nations' mean versus their real GDP per capita plotted on a log scale. For the 29 countries with GDP per capita above US$11,500, $r = 0.183$; $r = 0.076$ with outlier Qatar omitted. For the 21 countries with GDP per capita below US$11,500, $r = 0.622$ ($p < 0.01$); $r = 0.420$ ($p < 0.10$) with outlier Ghana omitted. Ovals indicate the three subgroups of wealthier countries described in the text and Table 6 as Middle Eastern, East Asian, and other plus Dubai.

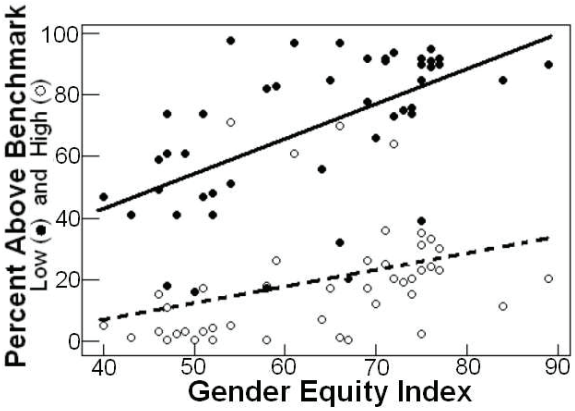

Figure 4. Scatter plots showing relationships between GEI and percentage of eighth graders scoring at or above the low (400, filled circles; $r = 0.570$, $p < 0.001$) and high (550, open circles; $r = 0.366$, $p < 0.05$; $r = 0.635$, $p < 0.001$ with the four East Asian outlier countries omitted) benchmarks on the 2007 TIMSS. Regression lines indicated.

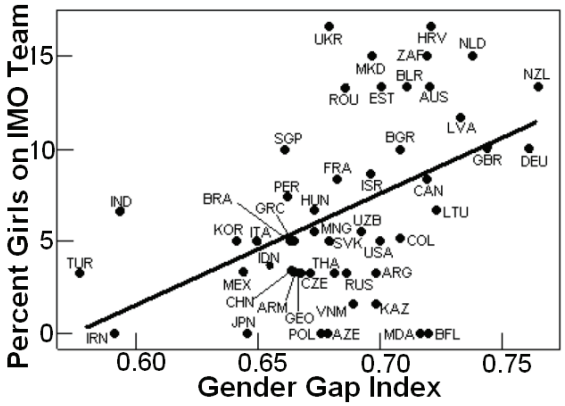

Figure 5. Scatter plot showing relationship between GGI and percentage of girls on IMO teams whose mean participant scores ranked among the top 50 countries during 2001–2010 ($r = 0.474$, $p < 0.001$). Regression line indicated.

Table 4. Correlations between measures of gender equity and mean mathematics scores for poorer and richer countries.[1]

	8th graders 2007 TIMSS						15-year-olds 2009 PISA		
	19 poorer countries			27 richer countries			47 richer countries		
	Gap	Girls	Boys	Gap	Girls	Boys	Gap	Girls	Boys
GGI	.017	.092	.116	.591***	.418*	.478*	.095	.206	.217
EPO	-.139	.087	.062	.643***	.618***	.658***	-.043	.344**	.329*
POL	.314	-.337	-.294	.423*	.229	.283	.137	.150	.168
GEI	-.105	.162	.152	.598***	.454*	.516**	.048	.190	.193
EPI	-.062	.023	.010	.652***	.574**	.630***	-.017	.406***	.393**
TMG	-.056	.104	.101	.501**	.392*	.442*	.074	.118	.126

[1]Demarcation between poorer and richer countries was drawn at a Real GDP per capita of US$11,500.

found between a country's log real GDP per capita and its mean mathematics score; (ii) Among the forty-seven richer countries, this correlation was, again, not significant ($r = 0.186$), having changed from negative to positive largely due to the absence of several Middle Eastern countries that had participated in the 2007 TIMSS. The wealthy countries included ones such as Qatar whose students performed among the very lowest in the world on both tests. Since the GEI is less influenced by wealth than the GGI, we used it here as our primary measure of gender equity.

Strikingly, a strong positive correlation ($r = 0.510$, $p < 0.001$) was found between GEI and eighth-grade boys' mean performance on the 2007 TIMSS (Figure 3A; Table 1). This correlation is slightly stronger than the one observed for eighth-grade girls ($r = 0.479$, $p < 0.001$). Similar correlations were obtained using data only from the wealthier countries (Table 3). Even stronger correlations were observed between GEI and fourth-grade boys' ($r = 0.738$, $p < 0.001$) and girls' ($r = 0.698$, $p < 0.001$) mean scores. Good correlations between these factors also exist using the 2003 TIMSS data sets (Table 1). Positive correlations with GEI were also observed with respect to percentage of boys and girls scoring at or above low and high benchmark scores (Table 5; Figure 4). Analysis of the 2009 PISA data confirmed these findings (Tables 1, 2, and 4). Noteworthy is the fact that 26 and 27 percent of the girls and boys, respectively, from Shanghai, China, scored above 669 on the 2009 PISA; the corresponding numbers for the U.S. girls and boys were 1.2 and 2.5 percent, respectively, below the 2.8 percent overall for OECD countries. Thus mathematics performance at the low, median, and high levels for both boys and girls strongly correlates with equity indexes; gender inequity may be one of the reasons boys do poorly in some wealthy countries.

Table 5. Correlations between economic participation and income subcomponent of GEI and percentage of students scoring at or above benchmarks.

Exam:	8th graders 2007 TIMSS[1]			15-year-olds 2009 PISA[2]		
Score:	400	475	550	420	482	607
Girls	.519***	.536***	.386**	.446***	.419***	.266*
Boys	.571***	.544***	.408**	.439***	.410***	.274*

[1]The international mean score was 475; standard deviation was set at 100.
[2]The average score was 496; it was determined by averaging the mean scores of the OECD countries, with each country weighted equally.The scores of 420, 482,and 607 correspond to levels 2, 3, and 5, respectively, out of six levels of proficiency.

This finding explains why equity indexes and gender gap in mean mathematics performance do not reproducibly correlate; that is, while girls' scores increase as equity indexes increase, boys' scores do likewise. The eighth-grade 2007 TIMSS data set included some wealthy countries with low equity indexes, such as Bahrain, Kuwait, Oman, Qatar, and Saudi Arabia, where boys significantly underperformed relative to girls (Figure 1C). Thus boys' mean mathematics scores on this examination increased with equity indexes even more than girls' scores, leading to the unintuitive finding of a positive correlation between gender gap favoring boys and GGI (Table 1). This correlation is highly positive ($r = 0.591$, $p < 0.001$) when the data from the poorer countries are omitted (Table 4). However, the correlation between equity indexes and gender gap in mathematics performance is insignificantly different from zero on the 2009 PISA, in which only one of these five Middle Eastern countries participated (Tables 1 and 4).

Noteworthy is the specific subcomponent of the gender equity indexes that largely accounts for the strong positive correlation with boys' and girls' mathematics performance at the low, intermediate, and high levels. While educational quality and equity may still be an important factor in poor countries (e.g., [15], [40]), it no longer is among most wealthy countries, where females have now largely reached if not exceeded parity with males in this area ([17], [18]). Instead, the primary contributor is the economic subcomponent of the GGI and GEI (EPO and EPI, respectively) that includes women's income and rates of participation in the work force relative to men's (Tables 1 and 4). The strong positive correlation between this economic subcomponent and mean mathematics performance is slightly stronger for boys than girls on the 2007 TIMSS and similar between the genders on the 2003 TIMSS and 2009 PISA. Thus, even though family income is, presumably, not limiting the ability of most children in the wealthier countries to obtain an education through at least eighth grade, quality employment opportunities for women nevertheless strongly parallel the mathematics performance of their students. This finding is consistent with the gender similarities hypothesis [20], with maternal education and employment opportunities likely having indirect effects on learning by their offspring regardless of gender (e.g., [13], [30], [38]).

Also noteworthy is the fact that culturally related wealthier countries cluster into largely nonoverlapping groups with respect to mean

mathematics scores: Middle Eastern predominantly Muslim (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia), East Asian (Hong Kong, Japan, South Korea, Singapore, Taiwan), and remaining countries (ovals in Figure 3E). A multiple regression indicates that the mean scores among these twenty-nine wealthier countries can be determined to a very high degree (R^2 = 94 percent) by simply knowing the country's EPO, its real GDP per capita, and into which of these three clusters the country falls (Table 6). In particular, the mean scores show a significant ($p < 0.05$) strong positive dependence on EPO and negative dependence on GDP, with East Asian countries scoring higher and Middle Eastern ones, except for Dubai, scoring lower than the other countries. Among the many cultural factors on which these groups of countries differ are parents' and students' attitudes regarding the importance of mastering school mathematics and whether the ability to do so requires innate ability or effort (e.g., [36], [47], [50], [53]). Interestingly, a country's mean mathematics score tends to be higher when its students attribute a lower importance to mastering mathematics (i.e., chi-square with six degrees of freedom on students' answers to each of four questions varies from 6,100 to 9,700; $p < 0.0001$). Thus mathematics performance of students largely reflects the academic standards and expectations of the community in which they are raised. These findings are consistent with and extend prior findings ([2], [11], [16], [39], [41]) of correlations between educational and economic gender equity and mathematics performance.

GGI and IMO

Our previously reported correlation between GGI and percentage of IMO team members who were girls [21] was based upon analysis of data from teams with median ranks among the top thirty during 1989–2008. Although female IMO participants were quite rare in the past, they have composed approximately 10 percent of participants in recent years [22]. Also, many more countries now participate: 90 to 104 per year since 2005, up from 50 in 1989. Ellison and Swanson analyzed IMO data from 100 percent of the countries that participated at any time during 2007–2009 [10]. They did not observe a significant correlation. However, their analysis included some countries with low gender equity indexes whose teams were not of IMO caliber, rarely participated, and contained multiple female students, for example, the 2009 all-girl U.A.E. team that scored only three points. We redid this calculation using the 2001–2010 IMO data, omitting countries with either (i) < 50 percent participation rate during this time period or (ii) mean student scores below 8.6 out of 42 possible points. Again, we obtained a strong positive correlation between GGI and percentage of girls on teams, with $r = 0.407$ ($p < 0.01$), $r = 0.474$ ($p < 0.001$), and $r = 0.415$ ($p < 0.001$) for teams with mean student scores of at least 12.1, 10.5, and 8.6 corresponding to a rank among the top forty, fifty, and sixty participating countries, respectively (Figure 5). This finding confirms our conclusion that GGI correlates with identification of females who excel in mathematics performance at an extremely high level.

Table 6. Multiple linear regression analysis of mean mathematics performance on 2007 TIMSS of eighth graders from the 27 wealthier countries.[1]

Predictor	β[2]	s[3]	T[4]	p
Constant	651.27	95.49	6.82	0.000
Log real GDP/capita	-22.47	9.18	-2.45	0.023
GGI-EPO	104.44	40.61	2.57	0.017
Indicator Middle Eastern*[1]	-109.51	13.97	-7.84	0.000
Indicator East Asian*[1]	103.39	11.98	8.63	0.000
R^2 = 94.0%				

[1]Countries correspond to the ones indicated in the ovals in Fig. 3E.
[2]β, least squares estimate for the coefficient of the predictor term in the regression model.
[3]s, standard deviation of the estimate β.
[4]T, associated Student-t statistic β/s.

Conclusions

In summary, we conclude that gender equity and other sociocultural factors, not national income, school type, or religion per se, are the primary determinants of mathematics performance at all levels for both boys and girls. Our findings are consistent with the gender stratified hypothesis, but not with the greater male variability, gap due to inequity, single-gender classroom, or Muslim culture hypotheses. At the individual level, this conclusion suggests that well-educated women who earn a good income are much better positioned than are poorly educated women who earn little or no money to ensure that the educational needs of their children of either gender with regard to learning mathematics are well met. It is fully consistent with socioeconomic status of the home environment being a primary determinant for success of children in school. At the national level, the United States ranked only thirty-first in mean mathematics performance out of the sixty-five countries that participated in the 2009 PISA. Eliminating gender discrimination in pay and employment opportunities could be part of a win-win formula for producing an adequate supply of future workers with high-level competence in mathematics. Wealthy countries that fail to provide gender equity in employment are at risk of producing too few citizens of either gender with the skills necessary to compete successfully in a knowledge-based economy driven by science and technology.

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References

[1] T. Andreescu, J. Gallian, J. M. Kane, and J. E. Mertz, Cross-cultural analysis of students with exceptional talent in mathematical problem solving, *Notices of the AMS* **55** (2008), 1248–1260.

[2] D. P. Baker and D. P. Jones, Creating gender equality: Cross-national gender stratification and mathematical performance, *Sociol. Ed.* **66** (1993), 91–103.

[3] L. Brody and C. Mills, Talent search research: What have we learned? *High Ability Studies* **16** (2005), 101.

[4] J. Burrelli, *Thirty-Three Years of Women in S&E Faculty Positions*, InfoBrief, Science Resources Statistics, NSF 08-308, National Science Foundation Directorate for Social, Behavioral, and Economic Sciences, 2008. Retrieved from http://www.nsf.gov/statistics/infbrief/nsf08308/nsf08308.pdf.

[5] S. J. Ceci and W. M. Williams, *The Mathematics of Sex: How Biology and Society Conspire to Limit Talented Women and Girls*, Oxford University Press, 2010.

[6] _____, Understanding current causes of women's underrepresentation in science, *Proc. Nat. Acad. Sci. USA* **108** (2011), 3157–3162.

[7] Central Intelligence Agency, *The World Factbook*. Retrieved from https://www.cia.gov/library/publications/the-world-factbook/fields/2122.html.

[8] J. Cresswell, M. Ikeda, M. Jakubowski, A. Schleicher, S. Vayssettes, and P. Zoido, *Equally Prepared for Life? How 15-Year-Old Boys and Girls Perform in School*, OECD, Brussels, 2009. Retrieved from http://www.oecd.org/dataoecd/59/50/42843625.pdf.

[9] R. J. Daverman (AMS Secretary), Statistics on women mathematicians compiled by the AMS, *Notices of the AMS* **58** (2011), 1310.

[10] G. Ellison and A. Swanson, The gender gap in secondary school mathematics at high achievement levels: Evidence from the American Mathematics Competitions, *J. Econ. Per.* **24** (2010), 109–128.

[11] N. M. Else-Quest, J. S. Hyde, and M. C. Linn, Cross-national patterns of gender differences in mathematics: A meta-analysis, *Psychol. Bull.* **136** (2010), 103–127.

[12] P. Foy and J. F. Olson (eds.), *TIMSS* 2007 *International Database and User Guide*, TIMSS and PIRLS International Study Center, Boston College, Chestnut Hill, MA, 2009. Retrieved from http://timss.bc.edu/timss2007/idb_ug.html.

[13] P. M. Frome and J. S. Eccles, Parents' influence on children's achievement-related perceptions, *J. Personality Social Psychol.* **74** (1998), 435–452.

[14] R. G. Fryer and S. D. Levitt, An empirical analysis of the gender gap in mathematics, *Am. Econ. J.: Applied Econ.* **2** (2010), 210–240.

[15] T. Fuchs and L. Wössmann, What accounts for international differences in student performance? A re-examination using PISA data, *Empirical Econ.* **32** (2007), 433–464.

[16] L. Guiso, F. Monte, P. Sapienza, and L. Zingales, Culture, gender, and math, *Science* **320** (2008), 1164–1165.

[17] R. Hausmann, L. D. Tyson, and S. Zahidi, *The Global Gender Gap Report* 2007, World Economic Forum, Geneva, Switzerland, 2008. Retrieved from http://www3.weforum.org/docs/WEF_GenderGap_Report2007.pdf.

[18] _____, *The Global Gender Gap Report* 2009, World Economic Forum, Geneva, Switzerland, 2010. Retrieved from https://members.weforum.org/pdf/gendergap/report2009.pdf.

[19] A. Heston, R. Summers, and B. Aten, Penn World Table Version 6.3, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania, August 2009. Retrieved from http://pwt.econ.upenn.edu/php_site/pwt63/pwt63_form.php.

[20] J. S. Hyde, S. M. Lindberg, M. C. Linn, A. Ellis, and C. Williams, Gender similarities characterize math performance, *Science* **321** (2008), 494–495.

[21] J. S. Hyde and J. E. Mertz, Gender, culture, and mathematics performance, *Proc. Nat. Acad. Sci. USA* **106** (2009), 8801–8807.

[22] International Mathematical Olympiad home page, http://official.imo2011.nl/.

[23] T. Kim, J.-H. Lee, and Y. Lee, Mixing versus sorting in schooling: Evidence from the equalization policy in South Korea, *Econ. Ed. Rev.* **27** (2008), 697–711.

[24] Kingdom of Bahrain Ministry of Education, *Education in Bahrain*. Retrieved from http://www.moe.gov.bh/en/education/religious.aspx.

[25] S. M. Lindberg, J. S. Hyde, J. L. Petersen, and M. C. Linn, New trends in gender and mathematics performance: A meta-analysis, *Psychol. Bull.* **136** (2010), 1123–1135.

[26] S. Machin and T. Pekkarinen, Global sex differences in test score variability, *Science* **322** (2008), 1331–1332.

[27] F. Mael, A. Alonso, D. Gibson, K. Rogers, and M. Smith, *Single-sex versus Coeducational Schooling: A Systematic Review*, U.S. Department of Education Office of Planning, Evaluation and Policy Development, Washington, D.C., 2005. Retrieved from http://www2.ed.gov/rschstat/eval/other/single-sex/single-sex.pdf.

[28] M. O. Martin (ed.), *TIMSS* 2003 *User Guide for the International Database*, TIMSS and PIRLS International Study Center, Boston College, Chestnut Hill, MA, 2005. Retrieved from http://timss.bc.edu/timss2003i/userguide.html.

[29] M. O. Martin, I. V. S. Mullis, and S. J. Chrostowski (eds.), *TIMSS* 2003 *Technical Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*, IEA TIMSS and PIRLS International Study Center, Boston College, Chestnut Hill, MA, 2004. Retrieved from http://timss.bc.edu/PDF/t03_download/T03TECHRPT.pdf.

[30] E. C. Melhuish, K. Sylva, P. Sammons, I. Siraj-Blatchford, B. Taggart, et al., Preschool influences on mathematics achievement, *Science* **321** (2008), 1161–1162.

[31] T. Miller (Ed.), *Mapping the Global Muslim Population: A Report on the Size and Distribution of the World's Muslim Population*, Pew Research Center, October 2009. Retrieved from http://pewforum.org/newassets/images/reports/Muslimpopulation/Muslimpopulation.pdf.

[32] I. V. S. Mullis, M. O. Martin, and P. Foy (with J. F. Olson, C. E. Preuschoff, E. Erberber, A. Arora, and J. Galia), *TIMSS* 2007 *International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*, IEA TIMSS and PIRLS International Study Center, Boston College, Chestnut Hill, MA, 2008. Retrieved from http://timss.bc.edu/TIMSS2007/mathreport.html.

[33] I. V. S. Mullis, M. O. Martin, E. J. Gonzalez, and S. J. Chrostowski (eds.), *TIMSS* 2003 *International Mathematics Report: Findings from IEA's Trends in International Mathematics and Science Study at the Fourth and Eighth Grades*, IEA TIMSS and PIRLS International Study Center, Boston College, Chestnut Hill, MA, 2004. Retrieved from http://timss.bc.edu/PDF/t03_download/T03INTLMATRPT.pdf.

[34] J. F. Olson, M. O. Martin, and I. V. S. Mullis (eds.), *TIMSS* 2007 *Technical Report*, IEA TIMSS and PIRLS International Study Center, Boston College, Chestnut Hill, MA, 2008. Retrieved from http://timss.bc.edu/timss2007/techreport.html.

[35] Organisation for Economic Co-operation and Development, *Learning for Tomorrow's World: First Results from PISA* 2003, OECD, Paris, France, 2004. Retrieved from http://www.oecd.org/pages/0,3417,en_32252351_32236173_1_1_1_1_1,00.html.

[36] Y.-S. Park and U. Kim, Family, parent-child relationship, and academic achievement in Korea: Indigenous, cultural, and psychological analysis, *Indigenous and Cultural Psychology: Understanding People in Context* (U. Kim, K.-S. Yang, and K.-K. Hwang, eds.), Springer, 2006, 421–444.

[37] *PISA* 2009 *Results.* Retrieved from www.oecd.org/edu/pisa/2009.

[38] D. G. Pope and J. R. Sydnor, Geographic variation in the gender differences in test scores, *J. Econ. Perspectives* **24** (2010), 95–108.

[39] C. Riegle-Crumb, The cross-national context of the gender gap in math and science, in *The Social Organization of Schooling* (L. Hedges and B. Schneider, eds.), Russell Sage Fdn., New York, NY, 2005, 227–243.

[40] H. Rindermann and S. J. Ceci, Educational policy and country outcomes in international cognitive competence studies, *Perspectives Psychol. Sci.* **4** (2009), 551–577.

[41] C. Shen and H. P. Tam, The paradoxical relationship between student achievement and self-perception: A cross-national analysis based on three waves of TIMSS data, *Ed. Res. Eval.* **14** (2008), 87–100.

[42] S. A. Shields, The variability hypothesis: The history of a biological model of sex differences in intelligence, *Signs: J. Women Cult. Soc.* **7** (1982), 769–797.

[43] J. P. Shonkoff and D. A. Phillips (eds.), *From Neurons to Neighborhoods: The Science of Early Childhood Development,* Committee on Integrating the Science of Early Childhood Development, National Research Council and Institute of Medicine, 2000. Retrieved from http://www.nap.edu/openbook.php?record_id=9824.

[44] *Social Watch Gender Equity Index* 2007. Retrieved from http://www.socialwatch.org/node/9355.

[45] *Social Watch Gender Equity Index* 2009. Retrieved from http://www.socialwatch.org/node/11561.

[46] C. H. Sommers (ed.), *The Science on Women and Science*, American Enterprise Institute Press, 2009.

[47] H. W. Stevenson, S.-Y. Lee, C. Chen, J. W. Stigler, C.-C. Hsu, S. Kitamura, and G. Hatano, *Contexts of Achievement: A Study of American, Chinese, and Japanese Children*, Mono. Soc. Res. Child Devel., 55, No. 1/2, Blackwell, 1990, i+iii-vi+1-119.

[48] L. Summers, *Remarks at NBER Conference on Diversifying the Science and Engineering Workforce*, 2005, January 14. Retrieved from http://www.harvard.edu/president/speeches/summers_2005/nber.php.

[49] J. Tierney, Daring to discuss women in science, *New York Times* (2010, June 8), D1; Legislation won't close gender gap in science, *New York Times*, (2010, June 15), D4.

[50] D. H. Uttal, Beliefs about genetic influences on mathematics achievement: A cross-cultural comparison, *Genetica* **99** (1997), 165–172.

[51] J. Wai, M. Cacchio, M. Putallaz, and M. C. Makel, Sex differences in the right tail of cognitive abilities: A 30-year examination, *Intelligence* **38** (2010), 412–423.

[52] A. W. Wiseman, A culture of (in)equality?: A cross-national study of gender parity and gender segregation in national school systems, *Res. Comp. Int. Ed.* **3** (2008), 179–201.

[53] Z. Y. Zadeh, E. Geva, and M. A. Rogers, The impact of acculturation on the perception of academic achievement by immigrant mothers and their children, *School Psych. Int.* **29** (2008) 39–70.

Is There a Crystal Lattice Possessing Five-Fold Symmetry?

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Kepler's Mosaics

The German scholar Johannes Kepler (1571–1630), who worked as a court mathematician for the Holy Roman Emperor Rudolf II in Prague, is well known especially for his astronomical discoveries. We still today admire his ability to obtain his three laws of planetary motion from data analysis of Tycho Brahe's observations of Mars. Another outstanding discovery is Kepler's equation describing the connection between the time and the position of a planet on its orbit around the Sun. At present this equation is usually derived from Kepler's first and second laws by means of infinitesimal calculus, but Kepler found a way to obtain it using geometric properties of an ellipse and a circle.

Kepler, however, examined purely mathematical problems as well. Recall, for instance, his famous conjecture on the densest sphere packing. There is still discussion on the validity of its "computer-based proof" given in [12], since it is not in integer arithmetic (only in real computer arithmetic). Kepler is regarded as one of the founders of crystallography. He was astonished by the beauty of snowflakes when he walked over the Charles Bridge in Prague. In his treatise *Strena seu de nive sexangula* (1611) he asked why all snowflakes possess six-fold symmetry even though each one has a different shape. Kepler constructed three interesting star-like polyhedra, for example stella octangula. The other two have six five-fold rotational axes of symmetry; see [23] and Figures 1 and 2.

In his treatise *Harmonices mundi* (1619) Kepler was dealing with the question of which tilings (i.e., mosaics) of the plane can be made from convex regular n-gons such that any two adjacent n-gons have an entire edge in common. Moreover, he demanded that each vertex be of the same type $(n_1, n_2, \dots, n_k)$, that is, it is surrounded by the regular n_1-gon, n_2-gon, and so forth. We shall treat the k-tuple $(n_1, n_2, \dots, n_k)$ as equivalent to $(n_k, \dots, n_2, n_1)$, that is, it is independent of ordering the regular polygons clockwise or counterclockwise. We shall also treat k-tuples $(n_1, n_2, \dots, n_k)$ and $(n_2, \dots, n_k, n_1)$ as equivalent, that is, it does not matter where we start numbering regular polygons. Such a tiling is called *semiregular*. In particular, if $n_1 = n_2 = \cdots = n_k$, then it is called *regular*. Two tilings will be considered equivalent if each can be obtained from the other by translation, rotation, reflection (mirror imaging), dilatation, or composition of such mappings.

Theorem (Kepler)**.** *There exist exactly eleven different semiregular tilings of the plane. Three of them are regular.*

Let us outline the main idea of the proof (see [15]). The interior angle of the regular n_i-gon is equal to

$$\frac{n_i - 2}{n_i} 180^\circ.$$

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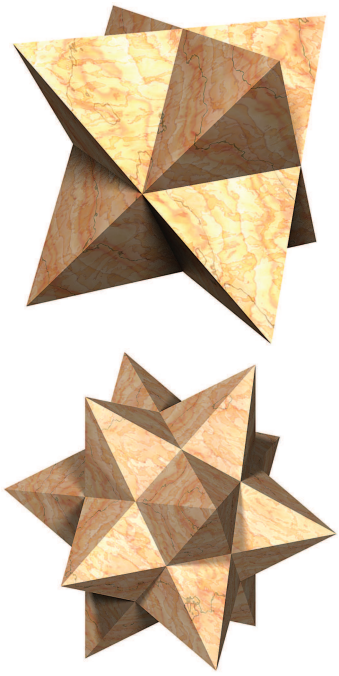

Figure 1. Kepler's star-polyhedra. Stella octangula, top, is the union of two regular tetrahedra. It may be inscribed in a cube. The small stellated dodecahedron is on the bottom. We observe that twelve pentagonal pyramids are, in fact, joined with the twelve pentagonal faces of the regular dodecahedron. Edges of this star-like polyhedron are suitable connections of all vertices of the regular icosahedron.

Therefore, for the vertex of type $(n_1, n_2, \ldots, n_k)$, the following necessary (but not sufficient) condition for the existence of semiregular tiling holds:

$$\frac{n_1-2}{n_1}180 + \frac{n_2-2}{n_2}180 + \cdots + \frac{n_k-2}{n_k}180 = 360.$$

From this we come to the Diophantine integer equation

$$\frac{1}{n_1} + \frac{1}{n_2} + \cdots + \frac{1}{n_k} = \frac{k-2}{2}. \tag{1}$$

The right-hand side of (1) has to be positive, and thus $k \geq 3$. Since a point can be surrounded by six equilateral triangles and all other n-gons have larger inner angles, we obtain the further necessary condition $k \leq 6$ for the solvability of (1). For clarity let us order all entries of the resulting k-tuples according to their sizes. Then we get the following seventeen solutions of equation (1).

Triples:

$(3,7,42)$, $(3,8,24)$, $(3,9,18)$, $(3,10,15)$, $(3,12,12)$, $(4,5,20)$, $(4,6,12)$, $(4,8,8)$, $(5,5,10)$, $(6,6,6)$;

quadruples:

$(3,3,4,12)$, $(3,3,6,6)$, $(3,4,4,6)$, $(4,4,4,4)$;

Figure 2. Kepler's great stellated icosahedron in the Charles Square in Prague near the place where Kepler lived. The group of its direct symmetries (i.e., rotation without reflection) is the simple alternating group A_5, which is used to prove that there does not exist a general formula to evaluate all roots of a polynomial of fifth degree.

quintuples:

$$(3,3,3,3,6), \quad (3,3,3,4,4);$$

sextuple:

$$(3,3,3,3,3,3).$$

However, not all of the above solutions correspond to semiregular tilings of the whole plane. For instance, in the case of the solution (5, 5, 10), we may surround a point by two regular pentagons and one regular decagon, but this is not enough for tiling the whole plane in this way, as one can easily check.

In what follows, we will not require that all entries of the above seventeen k-tuples be ordered according to their sizes. Then by inspection of all particular cases we obtain only the following eleven solutions that correspond to tilings of the plane (see Figure 3):

$(3,3,3,3,3,3)$,	$(4,4,4,4)$,	$(6,6,6)$,
$(3,12,12)$,	$(4,8,8)$,	$(4,6,12)$,
$(3,6,3,6)$,	$(3,4,6,4)$,	$(3,3,4,3,4)$,
$(3,3,3,4,4)$,	$(3,3,3,3,6)$.	

Notice that the last two tilings of Figure 3 are mirror images of one another. These two tilings are equivalent, being the left- and right-handed forms of the same tiling. The remaining ten tilings have an axis of symmetry.

Notice that Kepler's semiregular tilings do not have five-fold rotational symmetry, but they have

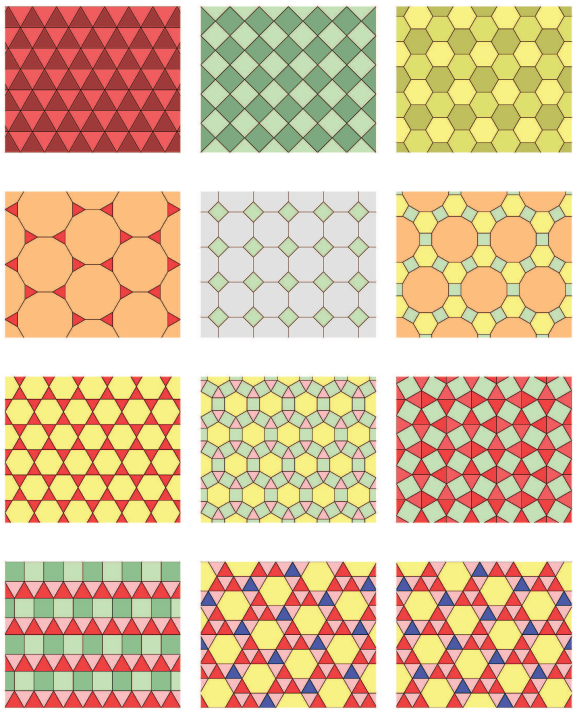

Figure 3. Kepler's mosaics. The last two tilings are mirror images of one another, i.e., they are equivalent. The remaining tilings have an axis of symmetry. Their types are:

(3, 3, 3, 3, 3, 3),	**(4, 4, 4, 4),**	**(6, 6, 6),**
(3, 12, 12),	**(4, 8, 8),**	**(4, 6, 12),**
(3, 6, 3, 6),	**(3, 4, 6, 4),**	**(3, 3, 4, 3, 4),**
(3, 3, 3, 4, 4),	**(3, 3, 3, 3, 6),**	**(3, 3, 3, 3, 6).**

two-, three-, four-, or six-fold symmetry (i.e., rotating each of Kepler's mosaics around an appropriate point about $360°/k$ for some $k \in \{2, 3, 4, 6\}$, we get the same mosaic, regardless of its coloring). Anyway, Kepler was dreaming about five-fold symmetry. In his *Harmonices mundi* we can find several mosaics that have five-point symmetry at least locally (see Figure 4).

In 1850 French mathematician and crystallographer Auguste Bravais proved that there is no five-fold symmetry for three-dimensional crystal lattices.

Note that the whole essay is confined only to Euclidean space and that tiling hyperbolic (or elliptic) space is a completely different problem (see, e.g., some of the famous artworks of M. C. Escher).

Penrose Mosaics

Let

$$\alpha = \frac{1+\sqrt{5}}{2} \quad \text{and} \quad \beta = \frac{1-\sqrt{5}}{2}. \tag{2}$$

They are the roots of the quadratic equation $x^2 - x - 1 = 0$. The number α is called the *golden section* (in Latin *sectio aurea*). It is one of the most

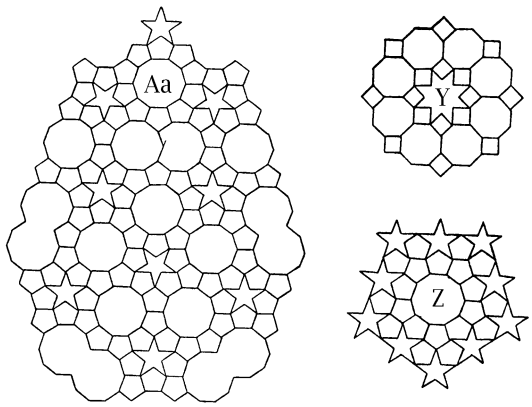

Figure 4. Kepler's experiments with five-fold symmetry in *Harmonices mundi*. Kepler aligned n-gons together to form a cycle. He tried to fill the inner region by other regular n-gons, as we may see in figure Y (octagons and squares). In the same manner he also joined ten pentagons; the inner region forms a regular decagon (Figure Z). Kepler's major result is shown in Figure Aa. Note that the overlapping areas of decagons have the exact shape as the smaller Penrose tile.

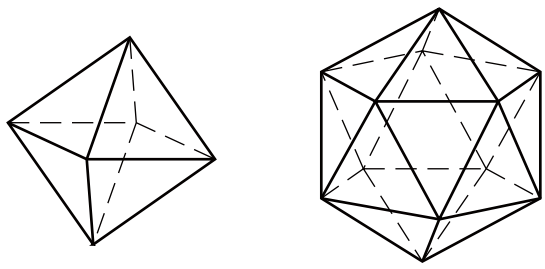

Figure 5. The regular octahedron is on the left. The regular icosahedron on the right has six five-fold rotational axes of symmetry.

mysterious irrational numbers, as we shall see. It appears in some unexpected situations (see, e.g., [13]).

The golden section represents the fundamental aesthetic ratio from antiquity (see [17]). A rectangle whose ratio of edges equals α is generally considered to be the most beautiful. Such a rectangle arises, for instance, as the convex hull of two opposite edges of the regular icosahedron (see Figure 5). The ratio of lengths of the diagonal and an edge of the regular pentagon is α. Also the length of an edge of the regular pentagon is the larger part of its diagonal when it is divided into two line segments whose lengths have ratio α. The ratio of the radius of the circumscribed circle to the regular decagon and the length of its edge is also α. The volume of the regular dodecahedron and icosahedron is $2 + 7\alpha/2$ and $5(1 + \alpha)/6$,

respectively, provided the length of their edges is equal to 1.

Johannes Kepler discovered a polyhedron with thirty congruent faces (the so-called *Kepler's rhombic triacontahedron*) which is the intersection of five differently oriented cubes with the same center (cf. Figures 6 and 7). All thirty faces have rhombic shape, and the ratio of their diagonals is $\alpha = -1/\beta$, too. The same faces are found in the rhombic hexecontahedron which was discovered by H. Unkelbach around 1940 (see [9], [27]). Amazingly, this sixty-faced solid (which was chosen as the logo of WolframAlpha) is believed to exist in nature as the central core of a quasicrystal aggregate of Al_6Li_3Cu produced by slow solidification (see [11]).

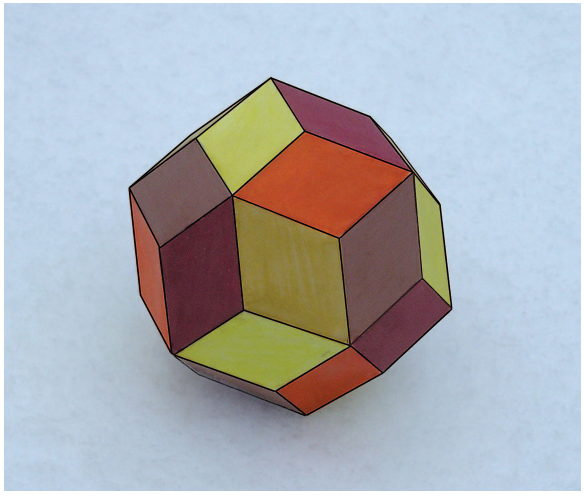

Figure 6. Kepler's rhombic triacontahedron is the intersection of five differently oriented and differently colored cubes with the same center. This polyhedron has six five-fold rotational axes of symmetry.

The coordinates of vertices of the regular four-dimensional simplex with center at the origin can also be expressed by means of the golden section, namely

(3)

$$v_1 = (3\alpha - 1, \beta, \beta, \beta)^\top, \quad v_2 = (\beta, 3\alpha - 1, \beta, \beta)^\top,$$
$$v_3 = (\beta, \beta, 3\alpha - 1, \beta)^\top, \quad v_4 = (\beta, \beta, \beta, 3\alpha - 1)^\top,$$
$$v_5 = (-2, -2, -2, -2)^\top.$$

In four-dimensional space there exists another regular polytope—the 600 cell, which is really an extraordinary mathematical object. Its three-dimensional boundary consists of 600 regular tetrahedra (see, e.g., [6], [25]). This hypersurface contains 720 edges that form, altogether, 72 edge-disjoint regular decagons with a common center. (Similarly, the surface of the regular octahedron contains twelve edges that form three

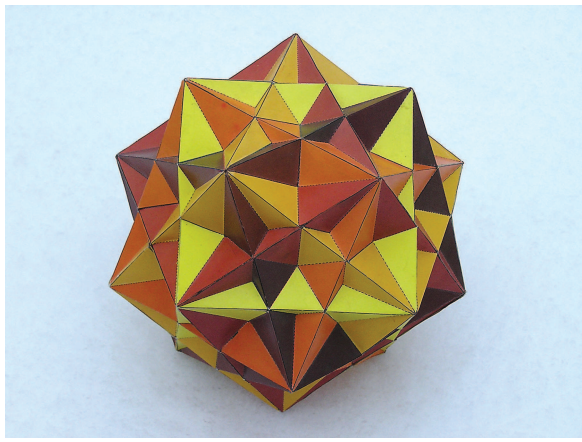

Figure 7. The union of the five cubes whose intersection is Kepler's polyhedron. It also has six five-fold rotational axes of symmetry, and its convex hull is the regular dodecahedron (and, conversely, the convex hull of eight suitably chosen vertices of the dodecahedron is a cube).

edge-disjoint squares.) The ratio of the radius of the circumscribed ball to the 600 cell and the length of its edge is again α. There are other analogous examples.

In the beginning of the 1970s the British mathematician and physicist Roger Penrose discovered tilings of the plane by two types of rhombic tiles that possess a local five-fold symmetry (see Figure 8) and have a close connection to the golden section. The edges of both tiles have the same length. The first tile has an acute angle equal to 72° and

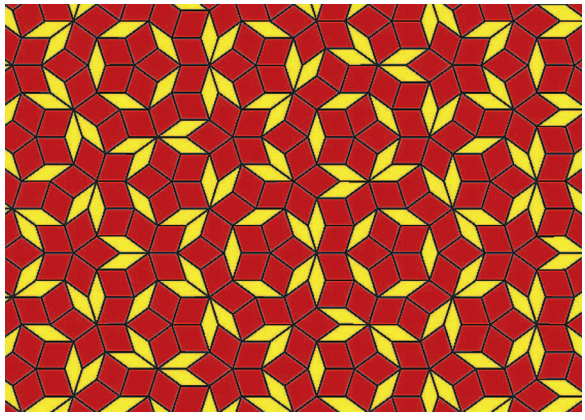

Figure 8. Penrose nonperiodic tiling.

the second equal to 36°. They are called *Penrose tiles.*

We can easily verify that

$$\cos 72^\circ = \frac{1}{2\alpha}.$$

Assume that the length of the edges of both tiles is equal to 1. Then the area of the first Penrose tile is $\sin 72^\circ = 2 \sin 36^\circ \cos 36^\circ$ and $\sin 36^\circ$ of the second tile. Thus the ratio of their areas is again the golden section

$$\sin 72^\circ : \sin 36^\circ = 2 \cos 36^\circ = \alpha.$$

Penrose himself admits that he was inspired by Kepler's work *Harmonices mundi,* in which tiling by pentagonal tiles is examined as well. To construct the Penrose tiling it is necessary that all tiles satisfy the so-called *Penrose rule:*

It is necessary to join tiles so that the bold curves of the same color meet (see Figure 9).

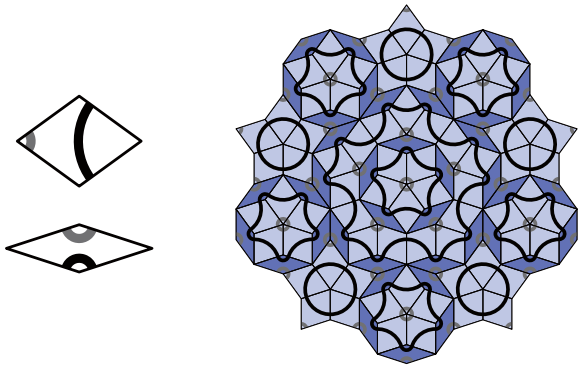

Figure 9. To generate a nonperiodic Penrose tiling it is necessary to join Penrose tiles so that the bold curves of the same color meet. Then we may even get a mosaic that possesses the five-fold symmetry globally with respect to one point.

The most surprising property of Penrose tilings is that they do not admit a nontrivial translative symmetry (see Figure 8). Shifting the Penrose tiling about any vector will never be consistent with the original tiling, even though the possible number of combinations of tiles surrounding a given vertex is finite. The following definition is from [22]: A tiling is said to be *nonperiodic* if it does not admit any nontrivial transitive symmetry.

There is a large amount of literature on Penrose tilings. We mention here only the original article [20], in which the rhombic tiles from Figure 9 appear for the first time.

Theorem (Penrose)**.** *Every tiling of the plane by Penrose tiles that satisfies the Penrose rule is nonperiodic.*

For the proof we refer to the monograph [10, Chapter 10].

When the Penrose rule is violated, we can form periodic tilings from the Penrose tiles. For instance, we may arrange these tiles into infinite strips, which may then be used to construct periodic tilings. For construction of a nonperiodic tiling it is not enough to assume that any two adjacent tiles do not form a parallelogram. We may generate periodic tiling from Penrose tiles, for example, so that each vertex is surrounded by four tiles with angles 36°, 72°, 144°, and 108° (always in this order). In this case the Penrose rule is also not satisfied. Penrose tilings can be generalized into higher-dimensional spaces.

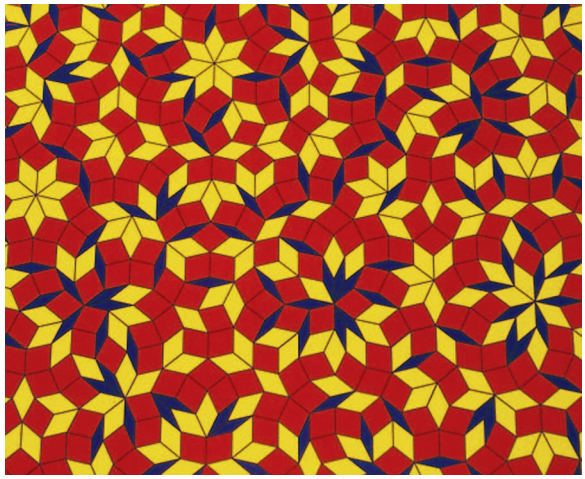

Figure 10. Katz nonperiodic tiling.

In 1986 André Katz found nonperiodic tilings of the plane that possess a local seven-fold rotational symmetry (see Figure 10). His three types of tiles again have rhombic shapes, whose acute angles are successively $180^\circ/7$, $360^\circ/7$, and $540^\circ/7$. For more details see [21], [26].

Note that the plane can be tiled nonperiodically using tiles of a single shape, for instance, by right isosceles triangles. It is enough to consider the famous Ulam spiral (see Figure 11), which was proposed in 1963 by the Polish mathematician Stanislaw Marcin Ulam (1909–1984). Prime numbers are written in black squares and the others in white squares. All black squares will be divided by the diagonals with slope 1 into two right isosceles triangles. The other squares will be divided by the diagonals with slope (-1). This gives the required nonperiodic tiling with one tile only.

Semiregular Polyhedra

In his dialogue treatise *Timaios* the Greek philosopher Plato (427–347 B.C.) mentioned five regular polytopes in the three-dimensional space. Recall that a *regular polyhedron* (also *Platonic solid*) is a convex polyhedron whose faces are congruent regular polygons and in which each vertex is surrounded by the same number of faces. Note that the assumption of convexity is essential. There exists a nonconvex polyhedron whose surface consists of twenty congruent equilateral triangles in which each vertex is surrounded by five faces.

91	90	89	88	87	86	85	84	83	82
92	57	56	55	54	53	52	51	50	81
93	58	31	30	29	28	27	26	49	80
94	59	32	13	12	11	10	25	48	79
95	60	33	14	3	2	9	24	47	78
96	61	34	15	4	1	8	23	46	77
97	62	35	16	5	6	7	22	45	76
98	63	36	17	18	19	20	21	44	75
99	64	37	38	39	40	41	42	43	74
100	65	66	67	68	69	70	71	72	73

Figure 11. Ulam's square spiral of positive integers. The background color of prime numbers is black.

A *semiregular polyhedron* is a convex polyhedron whose faces are regular polygons and whose spatial angles at vertices are directly or indirectly congruent. Note that a spatial angle is indirectly congruent with its mirror image.

Platonic solids are special cases of semiregular polyhedra. Their boundary is formed by polygons of a single shape. Semiregular polyhedra whose surfaces are formed by two or more types of polygons are classified into Archimedean solids, regular prisms, and regular antiprisms. Their existence can be investigated similarly as semiregular tilings of the plane by means of Diophantine inequalities as in the proof of Kepler's theorem. The regular prisms (resp., regular antiprisms) have two opposite faces formed by a regular n-gon, and the other faces are squares (resp., equilateral triangles). A special case of the regular prism (resp., regular antiprism) is the cube (resp., regular octahedron). A survey of the thirteen Archimedean solids is given in the second chapter of *Harmonices mundi* by Johannes Kepler.

Around 1905 a fourteenth Archimedean solid was discovered that can be obtained by rotating the "upper layer" of the tenth body from Figure 12 about 45° (see [24, Figure 27]). It has no point of symmetry. The last two polyhedra in Figure 12 exist in left- and right-handed forms, like Kepler's last two tilings in Figure 3. Terminology (what is meant by an Archimedean solid) is unfortunately not unique. Notice that there are several semiregular polyhedra that have five-fold rotational symmetry with respect to six axes.

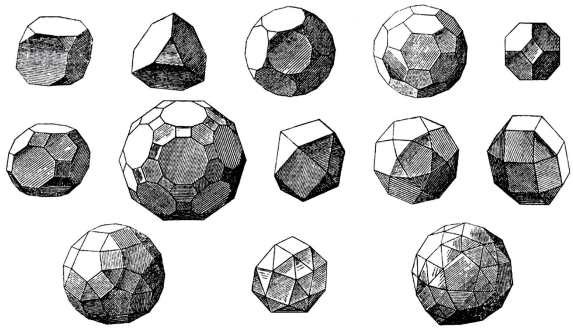

Figure 12. Archimedean solids from Kepler's treatise *Harmonices mundi.*

The classic football (soccer ball) resembles an Archimedean solid with twelve pentagonal and twenty hexagonal faces (see the fourth body in Figure 12). This polyhedron has sixty vertices and appears as a model in chemistry, since there exists a stable carbon molecule, the so-called fullerene C_{60}, that has sixty atoms placed at vertices of such a semiregular polyhedron. In addition, pollen dust and viruses sometimes have the shape of semiregular polyhedra.

Construction of a partition of a ball surface is often derived from partitions of triangular faces of the regular icosahedron. The regular icosahedron (see Figure 5) has been used to partition three-dimensional space into acute tetrahedra (see [8] and [2]). The cube is the only Platonic solid that can be used to tile three-dimensional space. Three-dimensional space can also be tiled by regular tetrahedra and regular octahedra arranged in such a way that each triangular face is common just to one tetrahedron and one octahedron. A diamond has such a crystal lattice, and therefore it is the hardest of all minerals.

Let us point out that Archimedean solids can be generalized to higher-dimensional spaces $\mathbb{R}^d$. For $d > 3$ there exist exactly seven semiregular polytopes (except for regular polytopes, prisms, and antiprisms); three of them lie in dimension $d = 4$ and one each in dimensions $d = 5, 6, 7, 8$ (see [1]). For instance, in four-dimensional space there exists a semiregular polytope that has ten vertices and whose surface is formed by five regular tetrahedra and five regular octahedra. It possesses five-fold symmetry.

The space $\mathbb{R}^8$ can be tiled by a semiregular polytope whose group of symmetry is E_8 (see [28]). It is worth mentioning that inscribed balls to these bodies form the densest sphere packing in $\mathbb{R}^8$ (see [16] and [19]). Each ball touches 240 other balls. This property is applied in the construction of one of the most effective Hamming error-correcting

codes. The set of centers of these balls is

$$\{(x_1, x_2, \ldots, x_8) \in \mathbb{Z}^8 \cup (\mathbb{Z} + \tfrac{1}{3})^8 \mid \sum_{i=1}^{8} x_i \equiv 0 \mod 2\}.$$

Voronoi cells corresponding to these centers form just particular copies of this interesting semiregular body.

Five-Fold Symmetry in Four-Dimensional Space

A crystal lattice is formed by the edges of mutually congruent parallelepiped cells defined by three linearly independent vectors $a_1, a_2, a_3 \in \mathbb{R}^3$ (see Figure 13). We shall assume that the lattice is unbounded and that it has a translation symmetry with respect to integer multiples of the vectors a_i. The French crystallographer Auguste Bravais (1811–1863) investigated point groups of symmetries of crystal lattices in $\mathbb{R}^3$, that is, isometric mappings of the whole lattice onto itself, which have at least one fixed point (see [4]). Here symmetries with respect to direct congruent transformations are meant (i.e., reflections and rotatory reflections are not considered). Symmetries of such lattices can be rotations about an axis through the angle $k \cdot 360^\circ/n$, where k is an integer and $n \in \{1, 2, 3, 4, 6\}$. Crystal lattices thus may have two-, three-, four-, and six-fold symmetry but not five-fold symmetry. As an immediate consequence we get the following theorem.

Theorem (Bravais)**.** *There is no crystal lattice in* $\mathbb{R}^3$ *with five-fold symmetry.*

The five-fold symmetry may appear only locally, for instance in quasicrystals whose atoms are arranged into regular icosahedra that are separated by gaps (see [18]). By means of Coxeter groups Chen, Moody, and Patera [5] give a detailed analysis of noncrystallographic root system based on five-fold symmetry and the quasicrystals that are associated with them.

Consider now an unbounded crystal lattice in higher dimensions defined by linearly independent vectors $a_1, a_2, \ldots, a_d \in \mathbb{R}^d$. Denote by

$$V = \left\{ \sum_{i=1}^{d} c_i a_i \mid c_i \in \mathbb{Z} \right\}$$

its set of vertices. Recall that a mapping $\mathcal{A} : V \to V$ is said to be an isometry if it preserves distances, that is, $||\mathcal{A}(x)|| = ||x||$ for all $x \in V$, where $||\cdot||$ is the Euclidean norm.

We say that the lattice has a *five-fold symmetry* if there exists a nonidentical isometry mapping $\mathcal{A} : V \to V$ such that

$$\mathcal{A}^5(x) = x \qquad \text{for all } x \in V.$$

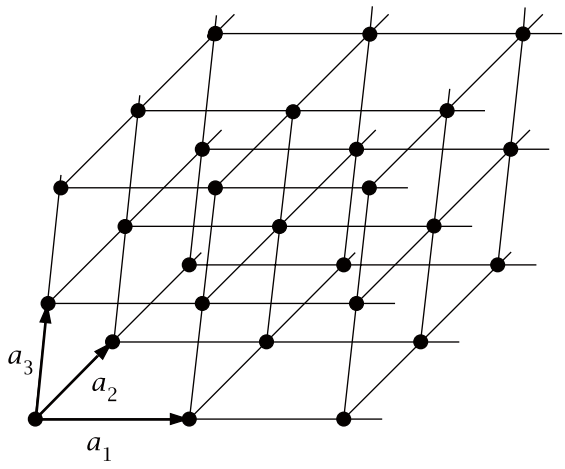

Figure 13. Crystal lattice.

Let $e_i = (0, 0, \ldots, 0, 1, 0, \ldots, 0)$ be the standard basis vector with d entries having 1 at the ith position. Let

$$P = \begin{bmatrix} 0 & 0 & \ldots & 0 & 1 \\ 1 & 0 & \ldots & 0 & 0 \\ 0 & 1 & \ldots & 0 & 0 \\ & & \ddots & & \\ 0 & 0 & \ldots & 1 & 0 \end{bmatrix}$$

be a $d \times d$ permutation matrix. Then we get

$$e_{i+1} = Pe_i, \quad i = 1, \ldots, d-1, \quad \text{and} \quad e_1 = Pe_d.$$

Hence we arrive at:

Corollary. *For any integer* $d \geq 2$ *the power* P^d *is the unit* $d \times d$ *matrix.*

As an immediate consequence we find that the hypercube lattice in $\mathbb{R}^5$ has a five-fold symmetry. Thus a natural question arises: *Does there exist a lattice with five-fold symmetry in spaces of dimension less than five?*

The answer is positive for $d = 4$ (see, e.g., [7], [18]). However, it is not easy to visualize a complicated geometry in four dimensions. For α and β from relations (2) we define linearly independent unit vectors

$$\begin{aligned} &a_1 = (1, 0, 0, 0)^\top, && a_2 = (-\tfrac{1}{2}, \tfrac{\alpha}{2}, \tfrac{\beta}{2}, 0)^\top, \\ &a_3 = (0, -\tfrac{\beta}{2}, -\tfrac{\alpha}{2}, \tfrac{1}{2})^\top, && a_4 = (0, 0, 0, -1)^\top \end{aligned} \tag{4}$$

and mirror image mappings r_i by (see [18]):

$$\begin{aligned} r_i(a_i) &= -a_i, \\ r_i(a_j) &= a_i + a_j \quad \text{for } |i-j| = 1, \\ r_i(a_j) &= a_j \quad \text{for } |i-j| > 1, \end{aligned} \tag{5}$$

where $i, j \in \{1, 2, 3, 4\}$. Later (see (6) below) we show that the r_i are uniquely determined. From (4) we can easily verify that the sum of two (or more) vectors a_i with adjacent indices is again a unit vector.

The mirror plane of r_i is orthogonal to the vector a_i and passes through the origin. The mirror planes corresponding to r_i and r_j with adjacent indices form an angle of 60°, since $a_i^\top a_j = \pm\frac{1}{2}$. If the difference of the indices i and j in absolute value is larger than one, then the mirror planes of r_i and r_j are orthogonal.

The set of vertices of the corresponding crystal lattice in $\mathbb{R}^4$,

$$V = \Big\{\sum_{i=1}^{4} c_i a_i \mid c_i \in \mathbb{Z}\Big\},$$

clearly has a translation symmetry in integer multiples of each direction a_i. The lattice itself consists of edges of congruent four-dimensional parallelepiped cells. Now we prove that it has a five-fold symmetry for $d = 4$.

Theorem. *There exists a nonidentical isometry $\mathcal{A}$ from the set V into itself such that*

$$\mathcal{A}^5(x) = x \quad \forall x \in V.$$

Proof. Define the isometry mapping

$$\mathcal{A} = r_1 r_3 r_2 r_4.$$

Then by (5) we get

$$\begin{aligned}
\mathcal{A}(a_1) &= r_1 r_3 r_2(a_1) = r_1 r_3(a_1 + a_2)\\
&= r_1(a_1 + a_2 + a_3) = a_2 + a_3,\\
\mathcal{A}(a_2) &= r_1 r_3 r_2(a_2) = -r_1 r_3(a_2)\\
&= -r_1(a_2 + a_3) = -a_1 - a_2 - a_3,\\
\mathcal{A}(a_3) &= r_1 r_3 r_2(a_3 + a_4) = r_1 r_3(a_2 + a_3 + a_4)\\
&= r_1(a_2 + a_3 + a_4) = a_1 + a_2 + a_3 + a_4,\\
\mathcal{A}(a_4) &= -r_1 r_3 r_2(a_4) = -r_1 r_3(a_4)\\
&= -r_1(a_3 + a_4) = -a_3 - a_4.
\end{aligned}$$

From this we find that $\mathcal{A}$ is a linear operator from the discrete set V into V which maps the following elements as:

$$\begin{aligned}
&a_1 \mapsto a_2 + a_3 \mapsto a_4 \mapsto -(a_3+a_4) \mapsto -(a_1+a_2) \mapsto a_1,\\
&a_2 \mapsto -(a_1 + a_2 + a_3) \mapsto -(a_2 + a_3 + a_4)\\
&\quad \mapsto a_3 \mapsto a_1 + a_2 + a_3 + a_4 \mapsto a_2.
\end{aligned}$$

We observe that $\mathcal{A}^5(a_i) = a_i$ for all $i = 1, 2, 3, 4$, and thus $\mathcal{A}^5$ is the identity. □

Let us take a closer look at the operator $\mathcal{A}$ from the previous theorem. We will express it by means of matrix theory. The mappings r_i are uniquely defined by the orthogonal matrices of mirror imaging

$$A_i = I - 2a_i a_i^\top, \quad i = 1, 2, 3, 4, \tag{6}$$

i.e., $r_i(x) = A_i x$ for $x \in \mathbb{R}^4$, where

$$A_1 = \begin{bmatrix} -1 & 0 & 0 & 0\\ 0 & 1 & 0 & 0\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & 1 \end{bmatrix}, \quad A_2 = \frac{1}{2}\begin{bmatrix} 1 & \alpha & \beta & 0\\ \alpha & \beta & 1 & 0\\ \beta & 1 & \alpha & 0\\ 0 & 0 & 0 & 2 \end{bmatrix},$$

$$A_3 = \frac{1}{2}\begin{bmatrix} 2 & 0 & 0 & 0\\ 0 & \alpha & 1 & \beta\\ 0 & 1 & \beta & \alpha\\ 0 & \beta & \alpha & 1 \end{bmatrix}, \quad A_4 = \begin{bmatrix} 1 & 0 & 0 & 0\\ 0 & 1 & 0 & 0\\ 0 & 0 & 1 & 0\\ 0 & 0 & 0 & -1 \end{bmatrix}.$$

Then $\mathcal{A}$ is given by the orthogonal matrix

$$A = A_1 A_3 A_2 A_4 = \frac{1}{2}\begin{bmatrix} -1 & -\alpha & -\beta & 0\\ 1 & 0 & \alpha & -\beta\\ 1 & \beta & 0 & -\alpha\\ -1 & 1 & 1 & -1 \end{bmatrix}.$$

For $\varphi = 72^\circ$ and $\psi = 144^\circ$ the eigenvalues of A are

$$\lambda_{1,2} = \cos\varphi \pm \mathrm{i}\sin\varphi, \quad \lambda_{3,4} = -\cos\psi \pm \mathrm{i}\sin\psi. \tag{7}$$

Since they are not real, the only fixed point of the mapping $\mathcal{A}(x) = Ax$ is zero. According to the previous theorem, A^5 is the identity matrix. Let us still note that the eigenvalues of the matrix

$$A^4 = A^{-1} = A^\top = \frac{1}{2}\begin{bmatrix} -1 & 1 & 1 & -1\\ -\alpha & 0 & \beta & 1\\ -\beta & \alpha & 0 & 1\\ 0 & -\beta & -\alpha & -1 \end{bmatrix}$$

are the same as those of the matrix A.

Remark. The operator $\mathcal{A}$ from the previous theorem and the corresponding matrix A are, of course, not unique. Setting, for instance,

$$B = \begin{bmatrix} a & b & c & c\\ a & c & b & c\\ a & c & c & b\\ d & a & a & a \end{bmatrix},$$

where $a = -\alpha/4$, $b = (\alpha + 2)/4$, $c = -(\beta + 1)/4$, and $d = (3\beta - 1)/4$, we find that B^5 is also the identity matrix. This follows from the fact that

$$v_{i+1} = Bv_i, \quad i = 1, 2, 3, 4, \text{ and } v_1 = Bv_5, \tag{8}$$

where v_i are vertices of the regular four-dimensional simplex (see (3)). Hence B is the orthogonal matrix, since $B^4 = B^{-1} = B^\top$. The eigenvalues of B are the same as those in (7). Another block diagonal matrix (cf. again (7))

$$D = \begin{bmatrix} \cos\varphi & -\sin\varphi & 0 & 0\\ \sin\varphi & \cos\varphi & 0 & 0\\ 0 & 0 & \cos\varphi & -\sin\varphi\\ 0 & 0 & \sin\varphi & \cos\varphi \end{bmatrix}$$

with similar properties is given in [7, p. 80].

Analogously we can prove that there exists a lattice with seven-fold symmetry in $\mathbb{R}^6$. It is enough to consider the regular six-dimensional simplex and relations similar to (8).

Conclusions

At the beginning of the seventeenth century, Johannes Kepler was thinking about periodic mosaics with five-fold symmetry. Also many other scholars wanted to discover planar mosaics or spatial crystal lattices with such a symmetry. However, in 1850 Auguste Bravais proved that crystal

lattices in two- and three-dimensional space may have only two-fold, three-fold, four-fold, or six-fold symmetry.

In this paper we showed that five-fold symmetry appears in special crystal lattices in four-dimensional space, and we gave an explicit algorithm to construct it. Five-fold symmetry in lower-dimensional Euclidean spaces can appear only locally, which can be seen, for example, in paintings of some of Kepler's mosaics or in the famous Penrose tilings in the early 1970s. Projections from physically abstract more-dimensional constructs produce real space maps with local symmetries that show correlations with the quasicrystal atomic arrangements in some alloys, which may have many applications in the future.

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References

[1] G. Blind and R. Blind, The semiregular polytopes, *Comment. Math. Helvetici* **66** (1991), 150–154.

[2] J. Brandts, S. Korotov, M. Křížek, and J. Šolc, On nonobtuse simplicial partitions, *SIAM Rev.* **51** (2009), 317–335.

[3] S. Baranidharan, V. S. K. Balagurusamy, A. Srinivasan, E. S. R. Gopal, and V. Sasisekharan, Nonperiodic tilings in 2-dimensions: 4- and 7-fold symmetries, *Phase Transition* **16** (1989), 621–626.

[4] A. Bravais, Mémoire sur les systèmes formés par les points distribués régulièrement sur un plan ou dans l'espace, *J. Ecole Polytech.* **19** (1850), 1–128.

[5] L. Chen, R. V. Moody, and J. Patera, Noncrystallographic root systems, in *Quasicrystals and Discrete Geometry* (J. Patera, ed.), Fields Inst. Monographs, vol. 10, 1998, 135–178.

[6] H. S. M. Coxeter, *Regular Polytopes*, Methuen, London, New York, 1948, 1963.

[7] P. Engel, *Geometric Crystallography: An Axiomatic Introduction to Crystallography*, D. Reidel, Boston, Lancaster, Tokyo, 1986.

[8] D. Eppstein, J. M. Sullivan, and A. Üngör, Tiling space and slabs with acute tetrahedra, *Comput. Geom.: Theory and Appl.* **27** (2004), 237–255.

[9] B. Grünbaum, Dodecahedron and assorted parallelohedra, zonohedra, monohedra, isozonohedra and otherhedra, *Math. Intelligencer* **32** (2010), no. 4, 5–15.

[10] B. Grünbaum and G. C. Shephard, *Tilings and Patterns*, W. H. Freeman, New York, 1987.

[11] P. Guyot, News on five-fold symmetry, *Nature* **326** (1987), 640–641.

[12] T. C. Hales, Cannonballs and honeycombs, *Notices Amer. Math. Soc.* **47** (2000), 440–449.

[13] T. Koshy, *Fibonacci and Lucas Numbers with Applications*, Wiley, New York, 2001.

[14] F. Krafft (ed.), *Johannes Kepler: Was die Welt im Innersten zusammenhält—Antworten aus Keplers Schriften mit einer Enleitung, Erläuterungen und Glossar herausgegeben von Fritz Krafft*, Marix Verlag, GmbH, Wiesbaden, 2005.

[15] M. Křížek and J. Šolc, From Kepler's mosaics to five-fold symmetry (in Czech), *Pokroky Mat. Fyz. Astronom.* **54** (2009), 41–56.

[16] V. I. Levenshtein, On bounds for packing in n-dimensional Euclidean space, *Soviet Math. Dokl.* **20** (1979), 417–421.

[17] M. Livio, *The Golden Ratio*, Headline, London, 2002.

[18] Z. Masáková, J. Patera, and E. Pelantová, Inflation centers of the cut and project quasicrystal, *J. Phys. A: Math. Gen.* **31** (1998), 1443–1453.

[19] A. M. Odlyzko and N. J. A. Sloane, New bounds on the number of unit spheres that can touch a unit sphere in n dimensions, *J. Combin. Theory Ser. A* **26** (1979), 210–214.

[20] R. Penrose, Role of aesthetics in pure and applied mathematical research, *Bull. Inst. Maths. Appl.* **10** (1974), 266–271.

[21] V. Sasisekharan, A new method for generation of quasi-periodic structures with n fold axes: Application to five and seven folds, *Pramana* **26** (1986), 283–293.

[22] E. Schulte, Tilings, in *Encyclopedia of Physical Science and Technology*, third ed., vol. 16, Academic Press, San Diego, 2001, 273–282.

[23] A. Šolcová, *Johannes Kepler, The Founder of Celestial Mechanics* (in Czech), Prometheus, Prague, 2004.

[24] D. M. Y. Sommerville, Semi-regular networks of the plane in absolute geometry, *Trans. Roy. Soc. Edinburgh* **41** (1905), 725–747.

[25] J. Stillwell, The story of the 120-cell, *Notices Amer. Math. Soc.* **48** (2001), 17–24.

[26] A. Subramaniam and K. Ramakrishnan, Rational approximants to 5-, 8-, and 7-fold two-dimensional tilings, *Zeitschrift für Kristallographie* **218** (2003), 590.

[27] H. Unkelbach, Die kantensymmetrischen, gleichkantigen Polyeder, *Deutsche Math.* **5** (1940), 306–316.

[28] M. van Leeuwen, Computing Kazhdan-Lustig-Vogan polynomials for split E_8, *Nieuw Archief voor Wiskunde* **9** (2008), 113–116.

A Revolution in Mathematics? What Really Happened a Century Ago and Why It Matters Today

Frank Quinn

The physical sciences all went through "revolutions": wrenching transitions in which methods changed radically and became much more powerful. It is not widely realized, but there was a similar transition in mathematics between about 1890 and 1930. The first section briefly describes the changes that took place and why they qualify as a "revolution", and the second describes turmoil and resistance to the changes at the time.

The mathematical event was different from those in science, however. In science, most of the older material was wrong and discarded, while old mathematics needed precision upgrades but was mostly correct. The sciences were completely transformed while mathematics split, with the core changing profoundly but many applied areas, and mathematical science outside the core, relatively unchanged. The strangest difference is that the scientific revolutions were highly visible, while the significance of the mathematical event is essentially unrecognized. The section "Obscurity" explores factors contributing to this situation and suggests historical turning points that might have changed it.

The main point of this article is not that a revolution occurred, but that there are penalties for not being aware of it. First, precollege mathematics education is still based on nineteenth-century methodology, and it seems to me that we will not get satisfactory outcomes until this changes [9]. Second, the mathematical community is adapted to the social and intellectual environment of the mid- and late twentieth century, and this environment is changing in ways likely to marginalize core mathematics. But core mathematics provides the skeleton that supports the muscles and sinews of science and technology; marginalization will lead to a scientific analogue of osteoporosis. Deliberate management [2] might avoid this, but only if the disease is recognized.

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The Revolution

This section describes the changes that took place in 1890–1930, drawbacks, objections, and why the change remains almost invisible. In spite of the resistance, it was incredibly successful. Young mathematicians voted with their feet, and, over the strong objections of some of the old guard, most of the community switched within a few generations.

Contemporary Core Methodology

To a first approximation the method of science is "find an explanation and test it thoroughly", while modern core mathematics is "find an explanation without rule violations". The criteria for validity are radically different: science depends on comparison with external reality, while mathematics is internal.

The conventional wisdom is that mathematics has always depended on error-free logical argument, but this is not completely true. It is quite easy to make mistakes with infinitesimals, infinite series, continuity, differentiability, and so forth, and even possible to get erroneous conclusions about triangles in Euclidean geometry. When intuitive formulations are used, there are no reliable rule-based ways to see these are wrong, so in practice ambiguity and mistakes used to be resolved with external criteria, including testing against accepted conclusions, feedback from authorities, and comparison with physical reality. In other words, before the transition mathematics was to some degree scientific.

The breakthrough was development of a system of rules and procedures that really worked, in the sense that, if they are followed very carefully, then arguments without rule violations give completely reliable conclusions. It became possible, for instance, to see that some intuitively outrageous things are nonetheless true. Weierstrass's nowhere-differentiable function (1872) and Peano's horrifying space-filling curve (1890) were early

examples, and we have seen much stranger things since. There is no abstract reason (i.e., apparently no proof) that a useful such system of rules exist, and no assurance that we would find it. However, it does exist and, after thousands of years of tinkering and under intense pressure from the sciences for substantial progress, we did find it. Major components of the new methods are:

> **Precise definitions:** Old definitions usually described what things are supposed to be and what they mean, and extraction of properties relied to some degree on intuition and physical experience. Modern definitions are completely self-contained, and the only properties that can be ascribed to an object are those that can be rigorously deduced from the definition.
>
> **Logically complete proofs:** Old proofs could include appeals to physical intuition (e.g., about continuity and real numbers), authority (e.g., "Euler did this so it must be OK"), and casual establishment of alternatives ("these must be all the possibilities because I can't imagine any others"). Modern proofs require each step to be carefully justified.

Definitions that are modern in this sense were developed in the late 1800s. It took awhile to learn to use them: to see how to pack wisdom and experience into a list of axioms, how to fine-tune them to optimize their properties, and how to see opportunities where a new definition might organize a body of material. Well-optimized modern definitions have unexpected advantages. They give access to material that is not (as far as we know) reflected in the physical world. A really "good" definition often has logical consequences that are unanticipated or counterintuitive. A great deal of modern mathematics is built on these unexpected bonuses, but they would have been rejected in the old, more scientific approach. Finally, modern definitions are more accessible to new users. Intuitions can be developed by working directly with definitions, and this is faster and more reliable than trying to contrive a link to physical experience.

Logically complete proofs were developed by Frege and others beginning in the 1880s, and by Hilbert after 1890 and (it seems to me) rounded out by Gödel around 1930. Again it took awhile to learn to use these: the "official" description as a sequence of statements obtained by logical operations, and so forth, is cumbersome and opaque, but ways were developed to compress and streamline proofs without losing reliability. It is hard to describe precisely what is acceptable as a modern proof because the key criterion, "without losing reliability", depends heavily on background and experience. It is clearer and perhaps more important what is *not* acceptable: no appeals to authority or physical intuition, no "proof by example", and no leaps of faith, no matter how reasonable they might seem. As with definitions, this approach has unexpected advantages. Trying to fix gaps in first approximations to proofs can lead to conclusions we could not have imagined and would not have dared conjecture. They also make research more accessible: rank-and-file mathematicians can use the new methods confidently and effectively, while success with older methods was mostly limited to the elite.

Drawbacks

As mathematical practice became better adapted to the subject, it lost features that were important to many people.

The new methodology is less accessible to nonusers. Old-style definitions, for instance, usually related things to physical experience so many people could connect with them in some way. *Users* found these connections dysfunctional, and they can derive *effective* intuition much faster from precise definitions. But modern definitions have to be used to be understood, so they are opaque to nonusers. The drawback here is that nonusers only saw a loss: the old dysfunctionality was invisible, whereas the new opacity is obvious.

The new methodology is less connected to physical reality. For example, nothing in the physical world can be described with complete precision, so completely rule-based reasoning is not appropriate. In fact the history of science is replete with embarrassing blunders due to excessively deductive reasoning; see the section "Hilbert's Missed Opportunities" for context and illustrations. Professional practice now accommodates this through the use of mathematical models: mathematics applies to the model but no longer even pretends to say anything about the fit between model and reality. The earlier connection to reality may have been an illusion, but people saw it as a drawback that had to be abandoned. In the other direction, core mathematics no longer accepts externally verified (experimental) results as "known" because this would bring with it the same limitations on deductive reasoning that are necessary in science. Even the most seemingly minor flaw will sooner or later cause proof by contradiction and similar methods to collapse. In practice this led to a division into "core" mathematics and "mathematical science". For instance, if numerical approximations of fluid flow seem to reproduce experimental observations, then this could be taken as evidence that the approximation scheme converges. This conclusion does not have the certainty of modern proof and cannot be accepted as "known" in the core sense. However, it is a reasonable *scientific* conclusion and appropriate for mathematical *science*. Similarly the Riemann hypothesis is incredibly well tested. For scientific purposes it is a solid

fact, but it is unproved and remains dangerous for core use. Another view of this development is that, as mathematical methods diverged from those of science, mathematics divided into a core branch that separated from physical science in order to exploit these methods and a mathematical science branch that accepted the limitations in order to remain connected. The drawback here is that the new power in the core and the support it gives to applied areas are invisible to outsiders, whereas the separation from science is obvious. People wonder: is core mathematics a pointless academic exercise and mathematical science the real thing?

Opposition

Henri Poincaré was the most visible and articulate opponent of the new methods; cf. [6]. He felt that Dedekind's derivation of the real numbers from the integers was a particularly grievous conceptual error because it damaged connections to reality and intuitive understanding of continuity. Some of the arguments were quite heated; the graphic novel *Logicomix* [1] dramatically illustrates the turmoil (though it muddles the issues a bit). Scholarly works [3] are more dignified but give the same picture.

As the transition progressed, the arguments became more heated but more confined. At the beginning traditionalists were deeply offended but not threatened. But because modern methods lack external checks, they depend heavily on fully reliable inputs. Older material was filtered to support this, and as the transition gained momentum some old theorems were reclassified as "unproved", some methods became unacceptable for publication, and quite a few ways of looking at things were rejected as dangerously imprecise. Understandably, many eminent late nineteenth-century mathematicians were outraged by these reassessments. These battles were fought by proxy, however. For instance, Poincaré's monumental development of the theory of manifolds was quite intuitive, and we now know that some of his basic intuitions were wrong. But, in the early twentieth century, only a fool would have openly criticized Poincaré, and he could not respond to implicit reproaches. As a result the arguments usually concerned abstractions such as "creativity" and "understanding", often in the context of education.

On a more general level, scientific concerns about the new methods were reasonable. The crucial importance of external reality checks in physics had been a hard-won lesson, and analogous revolutions in biology and chemistry were still in progress (Darwin's *Origin of Species* appeared in 1859, and Mendeleev's periodic table in 1869). How could mathematical use of the discredited "pure reason" approach possibly be a good thing?

Most of the various schools of philosophy were, and remain, unconvinced by the new methods. Philosophers controlled words such as "reality", "knowledge", "infinite", "meaning", "truth", and even "number", and these were interpreted in ways unfriendly to the new mathematics. For example, if a mathematical idea is not clearly manifested in the physical world, how can it be "real"? And if it is not real, how can it have "meaning", and how can it make sense to claim to "know" something about it? In practice mathematicians do find that their world has meaning and at least a psychological reality. If philosophy were a science, then this would qualify as a challenge for a better interpretation of "real". But philosophy is not a science. The arguments are plagued by ambiguity and cultural and linguistic biases. "Validation" is mostly a matter of conviction and belief, not functionality, so there are few mechanisms to correct or even expose the flaws. Thus, rather than refine the meaning of "reality" to accommodate what people actually do, philosophers split into Platonists and non-Platonists, depending on whether they believed mathematics fit their own interpretation. The Platonic view is hard to defend because mathematics honestly does not fit the usual meanings of "real" (see the confusion in Linnebo's overview [5]). The non-Platonic view is essentially that mathematicians are deluded. Neither view is useful for mathematics. To make real progress mathematics had to break with philosophy and, as usual in a divorce, there are bad feelings on both sides.[1]

The precollege-education community was, and remains, antagonistic to the new methodology. One reason is that traditional mathematicians, most notably Felix Klein, were extremely influential in early twentieth-century educational reform. Klein founded ICMI [4], the education arm of the International Mathematical Union. His 1908 book *Elementary Mathematics from an Advanced Viewpoint* was a virtuoso example of nineteenth-century methods and did a lot to cement their place in education. The "Klein project" [4] is a contemporary international effort to update the *topics* in Klein's book but has no plan to update the *methodology*.[2] In brief, traditionalists lost the battle in the professional community but won in education. The failure of "new math" in the 1960s and 70s is taken as further confirmation that modern mathematics is unsuitable for children. This was hardly a fair test of the methodology because it was very poorly conceived, and many traditionalists were determined that it would succeed only over their dead bodies. However, the experience

[1] *There are exceptions, but I wonder whether many of these might not be instances of another thing seen in divorces: one partner remains in love with a fantasy assembled from the good times they had together. See the "Other Views" section in* [7] *for instances.*

[2] *For detailed explanation see the essay* "Updating 'Klein's Elementary Mathematics from an Advanced Viewpoint': Content only, or the viewpoint as well?" *in* [10].

reinforced preexisting antagonism, and opposition is now a deeply embedded article of faith.

Many scientists and engineers depend on mathematics, but its reliability makes it transparent rather than appreciated, and they often dismiss core mathematics as meaningless formalism and obsessive-compulsive about details. This is a cultural attitude that reflects feelings of power in their domains and world views that include little else, but it is encouraged by the opposition in elementary education and philosophy.

In fact, hostility to mathematics is endemic in our culture. Imagine a conversation:

A: What do you do?

B: I am a _____.

A: Oh, I hate that.

Ideally this response would be limited to such occupations as "serial killer", "child pornographer", and maybe "politician", but "mathematician" seems to work. It is common enough that many of us are reluctant to identify ourselves as mathematicians. Paul Halmos is said to have told outsiders that he was in "roofing and siding"!

Obscurity

Like most people with some exposure to history of mathematics, I knew about the "foundational crisis" that occurred roughly a century ago. However, my first inkling that something genuinely revolutionary happened came at an international conference on proofs in mathematics education.[3] Sophisticated educators described proofs in ways that I did not recognize, while my description [8], based on an analysis of modern practice [7], was alien to them. The picture that emerged after a great deal of reading and study is that these educators were basing their ideas on insightful analysis of professional practice up through the nineteenth century. They were not misunderstanding modern mathematics but correctly understanding pre-modern mathematics. The disconnect stems from a change in mathematics itself, a change of which they were unaware.

No one is unaware of the scientific revolutions. The first subsection suggests that high-profile publicity had a lot to do with this, and obscurity of the mathematical transition is in a sense a public relations failure. To make this more concrete, the second section describes some public relations opportunities that Hilbert had but did not use.

Proxies and Belief

Scientific revolutions were methodological, but it was conclusions that attracted attention. The Copernican revolution, for instance, is known for the then-controversial conclusion that the earth orbits the sun, and the Darwinian revolution in biology is known for controversial conclusions about human origins. In both cases the real advances were methodologies effective enough to make alternative conclusions untenable, but methodology is complex and technical. High-profile conclusions served as public proxies for the methodology.

This proxy picture suggests several difficulties for mathematics. First, mathematical conclusions are not exciting enough to provide highly visible proxies. Second, conclusions used to promote mathematics are almost always applications to science, medicine, and engineering. They are proxies for *mathematical science* and have raised visibility of these areas, not the core. For the core, these efforts to use proxies may have actually backfired. Finally, when core results such as the Fermat conjecture or the Poincaré conjecture are described, it is—of necessity—in heuristic terms that are compatible with nineteenth-century viewpoints. The descriptions hide the crucial role of modern methodology, so they are not proxies for it. We will see that there are metamathematical conclusions that at one time might have served as proxies for modern methods, but they were not used.

The science examples also suggest a problem with belief. Users adopt more effective methods, but nonusers often reject things they do not like (e.g., evolution) regardless of benefits to the technical community. Core methods such as completely precise definitions (via axioms) and careful logical arguments are well known, but many educators, philosophers, physicists, engineers, and many applied mathematicians reject them as not really necessary. There are cases in which physical science has been unable to overcome rejection based on dislike, so even a very clear case for modern mathematics may not succeed.

Hilbert's Missed Opportunities

David Hilbert was the strongest and most highly visible proponent of the new methods during the transition, and as such he was frequently involved in controversies. I describe several situations in which Hilbert might have reframed debates and provided metamathematical proxies that could have led to a much clearer view today. The historical context is used to make the discussion more concrete, not to reproach Hilbert. After all, these opportunities are still just barely visible even with a century of hindsight. The first controversy occurred early in Hilbert's career and concerned his vigorous use of the "law of the excluded middle" (proof by contradiction). His response to the objections was that denying mathematicians use of this principle was "like denying boxers the use of their fists"; true but not a clear claim or challenge. If he had said the following, it would have caused an uproar:

> Excluded-middle arguments are unreliable in many areas of knowledge, but absolutely essential in mathematics. Indeed we might *define* mathematics as the domain in which excluded-

[3] *ICMI Study 19, Taipei, May 2009.*

> middle arguments are valid. Instead of debating whether or not it is true, we should investigate the constraints it imposes on our subject.

At the time mathematics was generally seen as an abstraction of physical reality, and it would have been outrageous to suggest that a logical technique should have higher priority in shaping the field. But in fact nothing physical can be described precisely enough to make excluded-middle arguments reliable, and this as much as anything drove the division of mathematics. In applied areas these arguments continued to be tempered by wisdom and experience. In the core the link to reality became indirect, with modeling as an intermediate, primarily to provide a safe environment for excluded-middle arguments.

Such a statement would have redirected the debate by making successful use of excluded-middle arguments a proxy for core methods. It would also have enabled the issue to be settled in a coherent way. As it was, this issue was a constant pain for Hilbert; Brouwer's Intuitionist school kept it alive into the 1930s; and it died out more from lack of interest than any clear resolution.

Next, Hilbert's axiomatic formulation of geometry in 1899 precisely specified how points, lines, and so forth *interacted*, rather than specifying what they "were" and extracting the interactions from physical intuition. Hilbert himself pointed out that this disconnected mathematics from reality because one could interpret "point" as "chair" and the axioms would remain valid. Again this provoked objections. He might have pointed out that it is a powerful advantage to be able to use a single mathematical construct to model many physical situations. This would have made the disconnect a proxy for mathematics as an independent domain. Widespread acceptance of explicit modeling would then have carried with it acceptance of mathematical independence. As it happened, modeling became widespread in the professional community without being seen as having any such significance.

Hilbert's famous 1900 problems were powerful technical challenges that did a lot to drive development of infinite-precision methods. However, the few that were actually seen as proxies for new ways of thinking (e.g., the second, on consistency of arithmetic) did not fare well, and the changes that the problems helped drive remained mostly invisible.

Another debate concerned the use of axiomatic definitions and detailed logical arguments. These provoked strong objections about lack of reality and meaning, artificial rigidity, and content-free formal manipulation. Hilbert might have replied:

> Axiomatic definitions can be artificial and useless, but they can also encapsulate years, if not centuries, of difficult experience, and newcomers can extract reliable and effective intuitions from them. Similarly, fully detailed arguments can be formal and content-free, but fully confronting all details usually deepens understanding and often leads to new ideas. Fully detailed arguments also give fully reliable conclusions, and full reliability is essential for successful use of the powerful but fragile excluded-middle method.

This would have acknowledged the dangers of formality but established reliability as a proxy for high-precision methodology and implicitly staked a claim to a nonphysical sort of meaning. Instead, Hilbert accepted the slanders by saying "mathematics is a game played according to certain rules with meaningless marks on paper." Hilbert also suggested that these mathematical methods might be prototypes for similar developments in other sciences. Such things were in vogue at the time. Arthur Conan Doyle, for instance, set his enormously popular Sherlock Holmes stories in a world where excluded-middle logic actually worked:

> …when you have eliminated the impossible, whatever remains, however improbable, must be the truth…
> —*The Sign of the Four*, ch. 6 (1890)

It was probably not widely known that this sort of logic led Doyle himself to a strong and expensive belief in fairies. Blondlot's "N-ray" debacle in France around 1904 was not yet seen as a cautionary tale. Since then there have been quite a few embarrassing failures due to excessively deductive reasoning in science. In the "cold fusion" episode in 1989, for instance, electrochemists Fleischmann and Pons observed excess energy in some of their experiments. After eliminating electrochemical explanations, they deduced that the only alternative they could imagine—hydrogen fusion in the electrodes—must be the truth. This is a standard move in mathematics and in Doyle's fiction, but bad science because there is no way to ensure that all alternatives have been imagined. Good *scientific* practice would have required them to test the fusion deduction, for instance by looking for the radiation that would have been a byproduct of fusion. Not seeing radiation would have turned them back to interesting electrochemistry. Presumably they had stumbled on a previously unimagined way to make a battery, and it was releasing energy accumulated during earlier experiments. But their reliance on the power of deduction led instead to crashing ends to their careers and reputations.

The modern view is that Hilbert's proposal— that mathematical deduction might be a general prototype for science—is a failure. His linkage ended up casting doubt on mathematical developments

instead of justifying them. Meanwhile, very high reliability has been achieved in mathematics without drawing attention or having significance attached to it. The axiomatic-definition approach also made mathematics more accessible. A century ago original research was possible only for the elite. Today it is accessible enough that publication is required for promotion at even modest institutions, and an original contribution can be required for a Ph.D. Again this is a profound change that had no significance attached to it.

The final missed opportunity concerns disagreements about knowledge, meaning, and "true". By 1920 the search for secure foundations had bogged down in obscure philosophical arguments. Hilbert had proposed a precise technical meaning for "true", namely, "provable from axioms that themselves could be shown to be consistent". But ten years later Gödel showed that in the usual formulation of arithmetic there are statements that are impossible to contradict but not provable in Hilbert's sense. In particular, consistency of the system could not be proved within the system. This was seen as a refutation of Hilbert's proposal. Ironically, it had the same practical consequences because it established "impossible to contradict" as the precise mathematical meaning of "true". Hilbert might have been explicit about deeper goals, for instance:

> Mathematics needs a precise definition of "true" that is internal and accessible to mathematical verification, and in particular unconstrained by philosophy or imagined connections to physical reality. We can worry about what such a definition "means" after it has been developed and shown to be successful in actual practice.

In this light Gödel's work would have been seen as a successful modification rather than a refutation.[4] Since that time a precise internal meaning for "true" has been enormously liberating for professional work, but its benefits have gone unnoticed.

Summary

The mathematical transition had such a low profile that no one understood its significance. Felix Klein was still denouncing the new methods in the 1920s, and because his views were not only unrefuted but almost unchallenged, outsiders accepted them as fact. Historians, educators, and philosophers went forward largely unaffected, propelled by the momentum of three thousand years and rebuffed by the technical complexity of modern practice.

Strangely, mathematicians are also unaware that their field changed so profoundly. Newcomers found philosophical arguments incomprehensible and irrelevant, and philosophy went from a respectable pursuit to an object of ridicule and evidence of senility in just a few decades. But this replaced bad understanding with no understanding at all. Mathematicians have joined fish and birds in doing something very well without any idea how!

The Core at Risk?

For most of the twentieth century, mathematics was mainly supported in the higher educational system. Core mathematicians dominated this system, so mathematics had a secure niche that did not depend on understanding what it was about. However, this niche is eroding, and the security is gone.

A large-scale problem is that resource constraints are eroding the ability of the higher education system to support basic research. There is pressure to increase instructional productivity by replacing researchers with teaching faculty at half the cost. Mathematics departments with large service loads are particularly vulnerable. There is also pressure to increase research productivity, with consequences discussed below.

There is a problem with external research funding. In the United States, external support for core mathematics comes almost exclusively from the National Science Foundation. A desire to have something to show for the money has led the NSF to want "wider impacts", and the use of applications as proxies to promote mathematics has led to "applications" being the default interpretation of "wider impacts". The result is a steady shift of funding toward applied areas (and education; see below). Because external funding is a major indicator of productivity, a decline in NSF support for core activity has contributed to the decline in core activity in academic departments.

Yet another problem comes from changes in applied mathematics. Up through the late twentieth century, applied mathematicians were trained in mainstream graduate programs and had foundations in modern methods and values. Today many are several generations removed from these core mathematical foundations. Many are scientists rather than mathematicians in the modern sense, and some are actually hostile to core methodology. At the same time, demand from science and engineering and pressure for more highly visible research have caused many academic departments to shift toward applied areas. The result is culturally divided departments in which core mathematics is increasingly at a disadvantage.

[4] *It is doubtful that either Hilbert or Gödel would have accepted this formulation. Both felt that the core axioms of mathematics should be "concrete intuitions", an extramathematical criterion. Their interpretations of "finitistic" were also less well defined and less internal than those used today; see Tait* [11]. *In these ways Hilbert and Gödel were still not fully modern.*

The final problem concerns the disconnect between school mathematics and higher education. School mathematics is still firmly located in the nineteenth century, so student success rates in modern courses have been very low. There is a great deal of pressure to improve this situation, but recent changes, such as use of calculators and emphasis on vague understanding over skills, have actually worsened the disconnect. Something has to change. Ideally, school mathematics could be brought into the twentieth century. Unfortunately the K–12 education community is better organized, more coherent, and far more powerful politically. External funding agencies are committed to the K–12 position. At the NSF this means funds have shifted from research to educational programs that are actually hostile to the research methodology. It seems possible that the K–12/college articulation will be "improved" by forcing higher education to revert to nineteenth-century models.

The point in all these examples is that the nature of modern core mathematics must be much better understood to even see the problems. And if the problems are not recognized and addressed quickly, then—in the United States anyway—core mathematics may well be marginalized, and the mathematical Golden Age that began in the twentieth century will end in the twenty-first.

The big question is: Why would marginalization of the core be a problem, if one is not particularly interested in the subject itself? In fact, core mathematics provides a rigid skeleton that supports the muscles of science, engineering, and applied mathematics. It is relatively invisible because it cannot interact directly with the outside world; it grows slowly; and it would not cause immediate problems if it stopped growing. Premodern mathematics and contemporary mathematical science, on the other hand, are more like exoskeletons: in direct contact with reality but putting strong constraints on size and power. The long-term consequence of mathematical osteoporosis is that science would have to go back to being a bug!

Solutions for Education?

The point briefly addressed here[5] is that modern methods were adopted because they are much more effective at advanced levels. If the reasons for their success are clearly understood, then some of these methods might be adaptable to elementary levels. This is the meaning of "brought into the twentieth century" in the discussion above, and at the very least it would improve K–12/college articulation. But it might do far more.

To be specific, consider fractions. Currently these are introduced in the old-fashioned way, through connections with physical experience. This is philosophically attractive and "easy" but follows the historical pattern (see the discussion in "Drawbacks") of being dysfunctional for most students. If we want students to be able to actually *use* fractions, then core experience points a way: use a precise definition that looks obscure at first but that can be internalized by working with it and that is far more effective once it is learned. Such an approach is suggested in [9] and elaborated in some of the essays in [10]. Similarly, in [8] I explain how a careful understanding of the nature of modern proofs might improve success even with arithmetic. (These are detailed and specific illustrations but are given as starting points rather than "classroom ready").

The big question is: Can any version of these approaches be used by real children? Children are attracted to rule-based reasoning (think *games*), and rich applications and success downstream should more than compensate for initial obscurity. I suspect that it is a bigger challenge for educators to think this way than it is for children. The starting point would be to acknowledge the significance of the mathematical revolution a century ago and to see the new methods—properly understood—as profoundly rich resources rather than alien threats.

[5] *And at great length in* [9] *and* [10].

References

[1] A. Doxiadis, C. Papadimitriou, A. Papadatos, and A. DiDonna, *Logicomix: An Epic Search for Truth,* Bloomsbury, 2009.

[2] Tom Everhart, Mark Green, and Scott Weidman, Math Sciences 2025, *Notices of the AMS* **58** (July 2011), 765.

[3] Jeremy Gray, *Plato's Ghost: The Modernist Transformation of Mathematics,* Princeton University Press, 2008.

[4] International Commission on Mathematical Instruction, `http://mathunion.org/icmi/home`—ICMI Klein Project `http://www.kleinproject.org/`.

[5] Oystein Linnebo, Platonism in the Philosophy of Mathematics, in *Stanford Encyclopedia of Philosophy,* (E. Zalta, ed.) 2011, `http://plato.stanford.edu/archives/fall2011/entries/platonism-mathematics`.

[6] Henri Poincaré, *Science et Méthode*, E. Flammarion Pub., Paris, 1908.

[7] Frank Quinn, *Contributions to a science of contemporary mathematics*, preprint; current draft at `http://www.math.vt.edu/people/quinn/`.

[8] _____, *Contemporary proofs for mathematics education*, to appear in ICMI study 19 (fall 2011).

[9] _____, A science-of-learning approach to mathematics education, *Notices of the AMS* **58** (2011), 1264–1275.

[10] _____, *Contributions to a science of mathematical learning*, preprint; current draft at `http://www.math.vt.edu/people/quinn/`.

[11] W. W. Tait, Gödel on Intuition and on Hilbert's finitism, in *Kurt Gödel: Essays for His Centennial* (K. Gödel, S. Feferman, C. Parsons, S. G. Simpson, eds.), Cambridge Univ. Press, 2010, pp. 88–108.

A Perspective on Wigner's "Unreasonable Effectiveness of Mathematics"

Jason Scott Nicholson

Introduction

Many people have weighed in on the topic of Wigner's "Unreasonable Effectiveness of Mathematics in the Natural Sciences" [7], notably Hilary Putnam [5] and Richard Hamming [2]. However, none of their arguments have left the domain of academic philosophy and so were never accepted (or even heard about) by most mathematicians and physicists. What I propose instead is the invocation of a philosophical system outside of academic philosophy that I believe will shed some light on this, and other, quandaries. The system of metaphysics I will invoke is the "Metaphysics of Quality". It was introduced by Robert M. Pirsig, in nascent form, in his book *Zen and the Art of Motorcycle Maintenance* [3] and then more fully conceived, expanded upon, and applied in *Lila* [4].

Zen and the Art of Motorcycle Maintenance captured the imagination of the public when it was first published in 1974 and has become generally acknowledged as one of the most widely read philosophy books ever written. In it Pirsig tells the story of how he arrived at the concept he calls Quality, embedded in an autobiographical journey "in search of himself" on a motorcycle with his son, Chris, and interwoven with various meditations on related topics. Through his experience of teaching rhetoric at a college in Bozeman, Montana, he relates how the concept of Quality first came to him. Exploration of its consequences led to his pursuing (unsuccessfully) a Ph.D. at the University of Chicago and his eventual "nervous breakdown" and committal to a psychiatric hospital, where he was treated with electrical shock therapy.

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A Short Summary of Pirsig's Work and Ideas

Pirsig discusses his breakdown experience more fully in his second book, *Lila*, in which he explains that his exploration of Quality actually led to his arrival at a state of enlightenment, which was misinterpreted as a mental breakdown. In his first book, he equates his idea of Quality with the ancient *Tao* of eastern philosophy, the *arête* of Greek philosophy, and finally he equates Quality with the *dharma* of Hindu philosophy in his second book. Along with this, and a critique of anthropology, he fleshes out his understanding of Quality by creating a Metaphysics of Quality and using it, after expanding on insights in his first book, to solve many well-known but outstanding metaphysical quandaries.

The Metaphysics of Quality is, in some limited sense, as follows. He had in his first book realized (and made the case) that Quality is an undefinable entity that is the precursor of subjects and objects; everyone knows what it is but no one can define it. He proceeds to understand that subjects and objects are only one dual pair of defined things into which the undefined Quality event gets split as it is "realized"—that is, made real through a necessarily incomplete attempt to define it. He pursues the split into another pair, this time of complementary ways of understanding (or aspects of) the universe, which he terms "classic" and "romantic". These terms may be understood with the example of two different ways of valuing a car: a classical value might keep the car's engine perfectly tuned but not care about how it looks, whereas a romantic value might keep the car looking perfect but not worry about whether it runs well. He uses this split to explore, in some depth, the "evils" of technology.

In his second book, however, he is led to a different split into what he calls "static" and "dynamic" aspects of reality as the best split possible, the most useful. He actually terms them *static quality* (or value) and *Dynamic Quality*, and with them he builds his Metaphysics of Quality, a metaphysical framework that provides a different, and, he demonstrates, better way of understanding the world we live in. Dynamic Quality is the undefined Quality that was described in his first book, but now he introduces static patterns of quality alongside it to reflect the "realization" of that undefined Quality which makes up our world. They act like a ratchet: the Dynamic Quality is the constant stimulus to move to something "better", to ratchet *up*, but the static quality is the latch of the ratchet itself, the making tangible of the motion up into something concrete which will prevent falling *down* into something "worse". Dynamic Quality is the creative urge, whereas static quality, or patterns of static quality, is what is created in response.

In building his Metaphysics of Quality, Pirsig classifies patterns of static quality into four discrete yet interrelated levels: Inorganic, Biological, Social, and Intellectual. He describes the relationship between these levels as being analogous to the relationship of computer hardware to computer software—the software is run on the hardware, but has nothing, really, to do with it. The program that you run on your computer and write your article with has nothing to do with the computer hardware itself. Furthermore, the content of your article has nothing to do with the program you write it in. In this way the levels of static quality are related to each other: Biological is built on Inorganic, Social is built on Biological, and Intellectual is built on Social, but each level is independent of the other.

Using this idea, Pirsig makes the case that Darwinian evolution is just Dynamic Quality at work by understanding "survival of the fittest" as meaning the movement of static quality (survival) towards Dynamic Quality (fittest). Then the four levels of static quality are levels of evolution. Further, Pirsig makes the case that Quality is morality, and as such the four levels are a hierarchy of morals. "It is more moral for an idea to kill a society than for a society to kill an idea" is an expression of this concept between Social (society) and Intellectual (idea) levels of evolution. But morality, as we commonly think of it, is a static pattern of morals. The Metaphysics of Quality tells us that there is also, above all the static patterns of morals, a Dynamic Morality (Quality) that cannot be defined. There is a tension between the two, as exemplified by the example of a religion as contrasted to a saint. A religion is a static pattern of values, of morality, whereas a saint follows a higher morality, Quality, that cannot be pinned down by dogma. To summarize this, Pirsig quotes the adage: "Nothing disturbs a bishop quite so much as the presence of a saint in the parish" [4, p. 377].

With this breakdown, Pirsig immediately solves three long-standing philosophical puzzles. First, the idea of "value", which is another word for Quality, seen as being the precursor of everything, is confusing and unclear—"value" to one atom choosing to bond to another to form a stable molecule is different from the "value" an animal sees in a mate, which is different from the "values" that form a nation, which is different from the "value" that one proof of a theorem has that makes it better than another. But with the levels of evolution, values are clarified. They all refer to *static patterns* of value: a static Inorganic pattern of value in the case of the molecule, a static Biological pattern of value in the case of the animal, a static Social pattern of value in the case of the nation, and a static Intellectual pattern of value in the case of the proof. Second, he solves the classical mind-matter dilemma: what is the relationship between the patterns of mind and patterns of matter if the world is composed only of these? The solution, from the perspective of the Metaphysics of Quality, is simple. The first two of the levels of static quality, the Inorganic and Biological, constitute "matter", and the other two, Social and Intellectual, constitute "mind". Since the former two are composed of "substance" and the latter two are not, they may be called "objects" and "subjects", which are eternally separate in a subject-object metaphysics. In fact, Matter is really only thought of as being static Inorganic patterns, and Mind is really only thought of as being static Intellectual patterns. What the Metaphysics of Quality adds is a way of relating them, namely as two ends of an evolutionary continuum, connected by static Biological and Social patterns of value. Thus they are completely separate, but yet related, and the paradox vanishes. Third, Pirsig resolves the "free will versus determinism" controversy by simply noting that, within the Metaphysics of Quality, behavior is determined to the extent that it is controlled by static patterns of quality, and free to the extent that Dynamic Quality is followed.

Pirsig then goes on to apply his Metaphysics of Quality to some unexplained curiosities in the world and comes up with some remarkable clarifications as to the meaning of events in the twentieth century. He also critiques western philosophy as a whole but connects his Metaphysics of Quality with the work on pragmatism and radical empiricism of William James by adding Quality as the primal *empirical* reality from which all subjects and objects spring. Pirsig illustrates this empirical reality using the metaphor of sitting on a hot stove. First there is an awareness that something is not good, and then the intellectual awareness follows that the stove is hot and that we are getting burned. Pirsig speaks of this as the "preintellectual awareness" that we all have of Quality, the primary empirical

reality, in this case the low quality of being on a hot stove. He makes the point that this phenomenon is around us all the time and explains that there is always a small gap of time between our first awareness of anything (awareness of Quality) and our intellectual conception of it (into subjects and objects). Thus, he says, Quality may be thought of as the source of all subjects and objects.

He ends his second book by connecting Quality with the deepest roots of eastern philosophy and religion, seeing that they are one and the same thing. Finally, he explores insanity and how it relates to static intellectual and social patterns of value, as well as to mysticism, by noting that both insanity and mysticism are instances in which a person has taken leave of the static intellectual patterns of quality that compose his or her culture. The insane person, Pirsig explains, has gone into a world composed of static intellectual patterns of quality that only he or she knows about, whereas the mystic has left all static intellectual patterns behind in favor of being only with pure Dynamic Quality.

Applying the Metaphysics of Quality to Some Questions Surrounding Mathematics and Physics

Our goal here is to apply these ideas to some quandaries surrounding mathematics, in particular to get an understanding of Wigner's observation that mathematics is "unreasonably" effective in describing phenomena in the natural sciences. First, mathematics, in the language of the Metaphysics of Quality, is a static pattern of intellectual values. Mathematics is built up from definitions or axioms and their logical consequences. Definitions can be reinterpreted as "static patterns of intellectual value", and the logical consequences of these definitions are just "static intellectual patterns that value the definitions/axioms". The reason, Pirsig explains, is that implication or causality can be rephrased in terms of value by saying that *A causes B* is the same as *B values* the precondition *A*. Pirsig talks about Poincaré, who also held that even the axioms of mathematics are only definitions, but definitions guided by what he called the "subliminal self", something similar to Pirsig's "preintellectual awareness". Poincaré noted that a mathematician does not just explore any combination of the definitions he works with or create new definitions in any mechanical way; there are too many such possibilities. Rather, the subliminal self is what guides mathematicians to solutions on the basis of "mathematical beauty". About this mathematical beauty, he famously said, "This is a true aesthetic feeling which all mathematicians know… but of which the profane are so ignorant as often to be tempted to smile" [3, p. 261]. Poincaré was criticized for this view, his ideas being called "conventionalism". His critics thought that it implied that mathematics was then based on nothing but the whims of mathematicians doing "whatever they like" with nothing solid to back it up. But "whatever you like" is only dubious in a subject-object metaphysical system. If the metaphysics is changed to include Quality, then "what you like" is merely following Quality, the progenitor of reality.

But this is the link between mathematics and science that Wigner intuited, and why mathematics is so unreasonably effective at describing it. When Poincaré spoke of "our choice among all possible conventions being guided by experimental facts" [3, p. 257], he meant that mathematics (in his case the axioms of geometry) are a *model* for science and nature. And since nature is simply *inorganic* and *biological* patterns of value that follow Dynamic Quality, it is not surprising that mathematics, a static *intellectual* pattern of quality that also follows Dynamic Quality, should arrive at the same conclusions. That is the reason that mathematics that is done in isolation ends up explaining nature so well—both are patterns of static quality created by following Dynamic Quality!

The key word in Wigner's thesis is "unreasonable"; he actually hit on the solution to the problem in the title of his article. Since Dynamic Quality cannot be defined, it is by definition (so to speak) unreasonable. But that is the reason that any explanation of Wigner's observation requires an expanded metaphysics. In our tacitly assumed subject-object metaphysics, as Pirsig makes clear, anything "unreasonable" is discarded, and so the effectiveness of mathematics in describing the natural world is an insoluble quandary. Once an "unreasonable" entity, Quality is seen as the root or precursor to all subjects and objects, the quandary fades.

That mathematics follows Quality has been claimed in many different ways by many different people, especially working mathematicians. One of the best such expressions was made by the famous Princeton mathematician Goro Shimura. Discussing his famous Taniyama-Shimura conjecture, part of whose proof led to the solution of Fermat's Last Theorem, Shimura said,

> I have this philosophy of goodness. Mathematics should contain goodness…. It's a rather crude philosophy but one can always take it as a starting point…. I might say that the conjecture stemmed from that philosophy of goodness. Most mathematicians do mathematics from an aesthetic point of view and that philosophy of goodness comes from my aesthetic viewpoint. [6, p. 210]

A "crude philosophy" perhaps because he knows what the "goodness" his mathematics follows is but cannot define it, making it imprecise and certainly

unreasonable. However, with the Metaphysics of Quality, what Shimura was trying to explain may now be made more precise—the "goodness" that was his starting point is not some abstract idea, but Quality, reality itself.

The Metaphysics of Quality also explains something else long debated in mathematics: whether it is an art or a science. Art is the realization of Dynamic Quality in a given medium—that is, Art is following Dynamic Quality, and the pattern of static quality which is a "work of art" is left in its wake, in whatever medium the artist chose. In this sense, mathematics, especially pure mathematics, is an art, as it is the realization of Dynamic Quality in the medium of mathematical definitions and their logical consequences. Wigner, in fact, began his article with one of the famous quotes describing this, by Bertrand Russell:

> Mathematics, rightly viewed, possesses not only truth, but supreme beauty—a beauty cold and austere, like that of sculpture, without appeal to any part of our weaker nature, without the gorgeous trappings of painting or music, yet sublimely pure, and capable of a stern perfection such as only the greatest art can show. The true spirit of delight, the exaltation, the sense of being more than Man, which is the touchstone of the highest excellence, is to be found in mathematics as surely as in poetry. [7]

But mathematics is also a science. It is commonly classified as such, being in the science faculty of most universities. More to the point, though, it is also generally seen as similar to empirical sciences in that it involves an objective, careful, and systematic study of an area of knowledge. It is, however, different because it verifies its knowledge using a priori rather than empirical methods. But, within the Metaphysics of Quality, its methods are totally empirical. In fact, it may be argued that from this perspective, it is even *more* empirical than the other sciences. Mathematics is following empirical reality (Quality) directly, whereas other sciences are one step removed from empirical reality (Quality): they follow nature, which, in turn, follows Quality. Thus mathematics is really both an art and a science and, in fact, can act as something of a bridge between the two.

The Metaphysics of Quality also easily solves another long-standing dilemma among mathematicians regarding the nature of their subject: the "is mathematics invented or discovered?" debate. The solution to this debate is reminiscent of the Metaphysics of Quality's resolution of the "free will versus determinism" debate referred to above. Mathematics is invented insofar as it is a process of following Dynamic Quality—that is, insofar as it is "free". It is discovered insofar as it is a process of fleshing out previously unknown consequences within the static patterns of quality that are mathematics as it stands. Most Ph.D. theses and much published mathematics are more of this latter type—original work, that is, new consequences of existing static patterns, but not in the sense of following only Dynamic Quality. In fact, one might say that any new development comes as a mixture of both types of originality; it lies on a continuum between purely static quality at one end and purely Dynamic Quality at the other. The most "creative" and "original" mathematics obviously sits toward the Dynamic Quality end of the spectrum.

Finally, turning to Wigner's own natural science of physics, we apply the Metaphysics of Quality to the recent "free will theorem" of John H. Conway and Simon Kochen. This theorem "…asserts, roughly, that if indeed we humans have free will, then elementary particles already have their own small share of this valuable commodity" [1]. As was mentioned above, Pirsig showed that free will in humans is simply the ability to follow Dynamic Quality, whereas determinism is simply the degree to which our actions are molded by static patterns of value. However, within the Metaphysics of Quality, this also applies to elementary particles: Their "will" is free to the extent they follow Dynamic Quality as well, and their actions are determined by how much they follow static patterns of value. The only difference is that humans have four levels of static patterns (Inorganic, Biological, Social, and Intellectual) to be free from, whereas elementary particles have only one (Inorganic). As the four levels are built one upon another, and in fact evolved from each other, the Inorganic level is far older and thus, we may infer, far more "stable" in terms of Dynamic Quality than any of the higher levels. That is, we may think of the movement toward Dynamic Quality as a limiting process that never reaches Quality but gets closer the longer the process continues. It is in this sense that Inorganic patterns of quality are more "stable" than those of higher levels. So the free will versus determinism, Dynamic Quality versus static quality, debate is more apparent in humans than elementary particles as the higher levels of evolution are less stable. What Conway and Kochen have confirmed is that elementary particles do, in fact, have this debate. The Metaphysics of Quality gives a framework within which to understand why.

The assertion that elementary particles have free will and follow Quality very closely leads to some startling consequences. For instance, the wave-particle duality paradox, in particular the baffling results of the famous double slit experiment, may now be reconsidered. In that experiment, first conducted by Thomas Young at the beginning of the nineteenth century, a point light source

illuminated a thin plate with two adjacent parallel slits in it. The light passing through the slits was projected on a screen behind the plate, and a pattern of bright and dark bands on the screen was observed. It was precisely the interference pattern caused by the diffraction patterns of waves passing through adjacent holes in an obstruction. However, when the same experiment was carried out much later, only this time with photons being shot at the screen one at a time—the same interference pattern resulted! But the Metaphysics of Quality can offer an explanation: the photons each follow Quality in their actions, and so either individually or en masse (i.e., from a light source) will do the same thing, that is, create the same interference pattern on the screen.

Conclusion

The Metaphysics of Quality presented by Robert M. Pirsig is a powerful extension of the subject-object metaphysics that is currently assumed by our culture. With it he offers an understanding of a number of pressing philosophical quandaries, including the mind-matter paradox and the free will versus determinism debate. We used it to offer an understanding of several quandaries surrounding mathematics and physics. In particular, Wigner's "unreasonable effectiveness of mathematics in the natural sciences" was looked at, as well as the "is mathematics invented or discovered?" debate, the question of whether mathematics is an art or a science, and finally the "free will theorem" of Conway and Kochen, along with a resolution of the long-standing wave-particle duality paradox. Many other long-standing quandaries and paradoxes may also benefit from having the Metaphysics of Quality applied to them.

The goal of this article, apart from offering a new perspective on several questions on the cusp between mathematics, physics, and philosophy, is to introduce the Metaphysics of Quality into academic discourse. The hope is that this will provide an expanded arena in which mathematics, physics, and really all science is done and allow many outstanding quandaries to be better understood in all areas—illustrated here with a resolution of the wave-particle duality paradox. It is also my hope that the introduction of the Metaphysics of Quality will allow research in science to flourish in many directions previously unavailable due to metaphysical barriers—directions intuited by scientists but unrealized for lack of a comprehensive framework, as Goro Shimura's intuition above illustrates. Further, I hope that the breakdown of barriers brought by the introduction of the Metaphysics of Quality will allow a dialogue to be opened with disciplines such as art, religion, philosophy, psychology (possible connections to these are alluded to by Pirsig and in this article), and many others in the arts and humanities and beyond and with which a common framework for understanding in the Metaphysics of Quality can now be applied.

References

[1] JOHN H. CONWAY and SIMON KOCHEN, The strong free will theorem, *Notices of the American Mathematical Society* **56** (2009), no. 2, 226–232.

[2] RICHARD W. HAMMING, The unreasonable effectiveness of mathematics, *American Mathematical Monthly* **87** (1980), no. 2, 81–90.

[3] ROBERT M. PIRSIG, *Zen and the Art of Motorcycle Maintenance*, William Morrow & Company, New York, 1974.

[4] _____ , *Lila*, Bantam Books, New York, 1991.

[5] HILARY PUTNAM, "What is mathematical truth?", *Mathematics, Matter, and Method*, Cambridge University Press, 2nd ed., 1975, pp. 60–78.

[6] SIMON L. SINGH, *Fermat's Last Theorem*, Fourth Estate, London, 1997.

[7] EUGENE WIGNER, The unreasonable effectiveness of mathematics in the natural sciences, *Communications on Pure and Applied Mathematics* **1** (1960), no. 1, 1–14.

The American Mathematical Society announces:

The AMS Graduate Student Blog

This blog serves as a tool for graduate students in mathematics, providing them with information from fellow graduate students.

AMS Vice President Frank Morgan (Williams College) is managing the blog. He is assisted by the Graduate Student Editorial Board, comprised of current graduate students, in content control of the blog.

The blog covers topics of importance to graduate students, offering advice on subject matter relevant to each stage of their development. Each writer brings a personal perspective based on experience, while keeping content broad enough to deliver valuable points to all those seeking assistance.

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AMS
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WHAT IS . . .

a Fenchel Conjugate?

Heinz H. Bauschke and Yves Lucet

The ideas of duality and transforms are ubiquitous in mathematics, the most classical example being the Fourier transform in harmonic analysis. Convex analysis, an area founded by W. Fenchel, J.-J. Moreau, and R. T. Rockafellar in the mid-twentieth century, concerns convex sets, convex functions, and their applications to optimization. The counterpart of the Fourier transform in convex analysis is the Fenchel conjugate. Suppose we have a real Hilbert space X and a function $f\colon X \to]-\infty,+\infty]$. We shall assume that f is *proper*, that is, $\operatorname{dom} f = \{x \in X \mid f(x) \in \mathbb{R}\} \neq \emptyset$. Then the *Fenchel conjugate* f^* at $u \in X$ is

$$f^*(u) = \sup_{x\in X} \big(\langle x, u\rangle - f(x)\big).$$

An immediate consequence of the definition is the *Fenchel-Young inequality*

$$f(x) + f^*(u) \geq \langle x, u\rangle .$$

We also note that f^* is convex and lower semicontinuous because it is the supremum of the family of affine continuous functions $(\langle x, \cdot\rangle - f(x))_{x\in X}$. One has the beautiful duality

$$f(x) = f^{**}(x) \Leftrightarrow \begin{cases} f \text{ is convex and} \\ \text{lower semicontinuous,} \end{cases}$$

which shows that such a function f can be represented as a supremum of affine functions $x \mapsto \langle u, x\rangle - f^*(u)$, where $f^*(u)$ determines the constant term of the affine function with slope u.

Given a subset C of X, its *indicator function* ι_C is defined by $\iota_C(x) = 0$, if $x \in C$; $+\infty$, otherwise. As a first example, we compute that if $f(x) = \langle x, a\rangle$, where $a \in X$, then $f^* = \iota_{\{a\}}$. Thus $+\infty$ is unavoidable and to be embraced in convex analysis. If f is convex and differentiable, then the supremum in the definition of $f^*(u)$ can be found by calculus, and we obtain

$$f^*(\nabla f(x)) = \langle x, \nabla f(x)\rangle - f(x).$$

This formula not only explains why the Fenchel conjugate is also known as the Fenchel-Legendre transform, but it also shows that the *energy* is self-dual; in fact,

$$f = f^* \Leftrightarrow f = \tfrac{1}{2}\|\cdot\|^2.$$

Given $\alpha > 0$, one also computes that $\alpha \exp$ and the following (scaled) negative entropy are conjugates of each other:

$$(\alpha \exp)^*(u) = \begin{cases} +\infty, & \text{if } u < 0; \\ 0, & \text{if } u = 0; \\ u\ln(u/\alpha) - u, & \text{if } u > 0. \end{cases}$$

By associating each $\alpha \in]0,1]$ with a color, we are able to display an entire family of conjugates (see Figures 1 and 2).

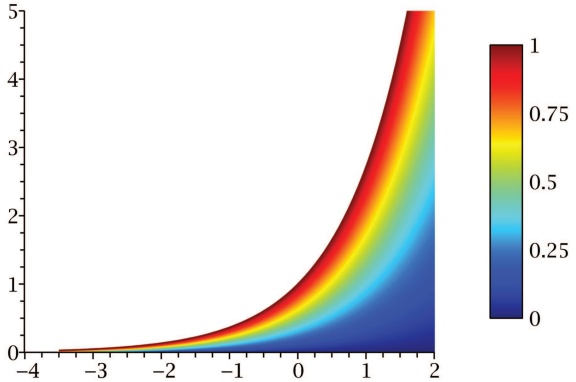

Figure 1. The family $(\alpha \exp)_{\alpha\in]0,1]}$.

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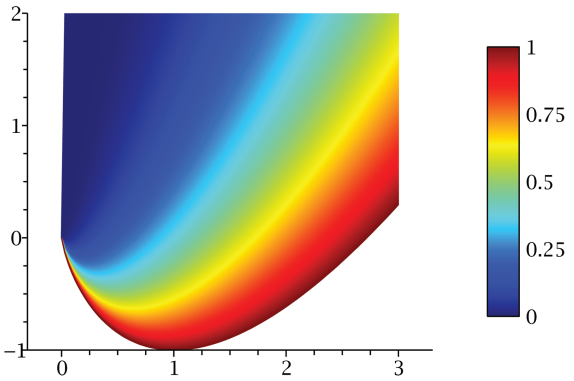


Figure 2. The associated family of conjugates.

Many more interesting pairs can be computed (in closed form, or at least numerically). For instance, if $1 < p < +\infty$, then

$$\left(\tfrac{1}{p}|\cdot|^p\right)^* = \tfrac{1}{p'}|\cdot|^{p'}, \text{ where } \tfrac{1}{p} + \tfrac{1}{p'} = 1,$$

which, along with the Fenchel-Young inequality, leads to an elegant proof of Hölder's inequality.

The natural domain for Fenchel conjugation is Γ_X, the cone of functions that are convex, lower semicontinuous, and proper on X. One now wishes to obtain calculus rules for Fenchel conjugation. In harmonic analysis, one is led to discover convolution as crucial in describing the Fourier transform of a product. The counterpart in convex analysis is the *infimal convolution* $f \square g$, defined by

$$(f \square g)(x) = \inf_{y \in X} \left(f(y) + g(x - y)\right).$$

Under appropriate hypotheses, one has

$$(f \square g)^* = f^* + g^* \text{ and } (f + g)^* = f^* \square g^*.$$

Moreover, $(\alpha f)^*(u) = \alpha f^*(u/\alpha)$ where $\alpha > 0$. Closely tied to the Fenchel conjugate of $f \in \Gamma_X$ is the *subdifferential operator* ∂f. This is a *set-valued* mapping on X, that is, it maps from X to the power set of X, and it is defined by

$$u \in \partial f(x) \;\Leftrightarrow\; (\forall h \in X)\, f(x) + \langle h, u\rangle \le f(x + h).$$

Now equality in the Fenchel-Young inequality characterizes *subgradients*, that is, elements in the subdifferential, in the sense that

$$\begin{aligned} f(x) + f^*(u) = \langle x, u\rangle &\Leftrightarrow u \in \partial f(x) \\ &\Leftrightarrow x \in \partial f^*(u). \end{aligned}$$

When f is continuous at x, then differentiability of f at x is the same as requiring $\partial f(x)$ to be a singleton, in which case $\partial f(x) = \{\nabla f(x)\}$. When $\operatorname{dom} f = X = \mathbb{R}$, then the left ($f'_-$) and right ($f'_+$) derivatives exist at every x and

$$\partial f(x) = \left[f'_-(x), f'_+(x)\right].$$

Thus the subdifferential operator is a powerful generalized derivative. It also has a property critical for optimization:

$$0 \in \partial f(x) \;\Leftrightarrow\; x \text{ is a global minimizer of } f.$$

Suppose that Y is another real Hilbert space, $A\colon X \to Y$ is continuous and linear, and $g \in \Gamma_Y$. The most important theorem concerns *Fenchel-Rockafellar* duality, which involves the *primal problem*

$$\text{(P)} \qquad \operatorname*{minimize}_{x \in X} \; f(x) + g(Ax),$$

and the associated *dual problem*

$$\text{(D)} \qquad \operatorname*{minimize}_{y \in Y} \; f^*(-A^*y) + g^*(y).$$

Set $\mu = \inf\{f(x) + g(Ax) \mid x \in X\}$ and $\mu^* = \inf\{f^*(-A^*y) + g^*(y) \mid y \in Y\}$. Then $\mu \ge -\mu^*$. The key result asserts that in the presence of a so-called (primal) *constraint qualification* such as $0 \in \operatorname{int}(\operatorname{dom} g - A \operatorname{dom} f)$, one has $\mu = -\mu^*$, and the dual problem possesses at least one solution. Let y be an *arbitrary* dual solution. Then the *entire set* of primal solutions is obtained as

$$\partial f^*(-A^*y) \cap A^{-1}\partial g^*(y).$$

As an example, one may formally derive the well-known *linear programming (LP) duality*, which concerns

$$\inf\{\langle c, x\rangle \mid x \ge 0,\, Ax = b\},$$

and

$$\sup\{\langle b, y\rangle \mid y \in \mathbb{R}^m, A^*y \le c\},$$

where $c \in X = \mathbb{R}^n$, $A \in \mathbb{R}^{m\times n}$, $b \in Y = \mathbb{R}^m$, and vector inequalities are interpreted entry-wise, by setting $f = \langle \cdot, c\rangle + \iota_{\mathbb{R}^n_+}$ and $g = \iota_{\{b\}}$.

Let $f \in \Gamma_X$. Then the operator $\partial f + \mathrm{Id}$ is surjective; here Id denotes the identity mapping. The inverse operator $(\partial f + \mathrm{Id})^{-1}$ is actually single-valued and called the *proximal mapping* Prox_f. In view of

$$x = \operatorname{Prox}_f x \;\Leftrightarrow\; x \text{ is a global minimizer of } f$$

and, for all x and y in X,

$$\begin{aligned} \|\operatorname{Prox}_f x - \operatorname{Prox}_f y\|^2 \le \|x - y\|^2 \\ - \|(\mathrm{Id} - \operatorname{Prox}_f)x - (\mathrm{Id} - \operatorname{Prox}_f)y\|^2, \end{aligned}$$

Prox_f is Lipschitz continuous with constant 1 and thus enables fixed-point algorithmic approaches to optimization problems.

Turning to further applications, let

$$q = \tfrac{1}{2}\|\cdot\|^2.$$

Strict-smooth duality: When $X = \mathbb{R}^n$ and $\operatorname{dom} f = \operatorname{dom} f^* = X$, then f is strictly convex if and only if f^* is differentiable.

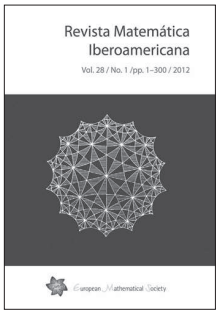
Moreau envelope and Moreau decomposition: The beautiful identity

$$(f \square q) + (f^* \square q) = q$$

becomes

$$\operatorname{Prox}_f + \operatorname{Prox}_{f^*} = \mathrm{Id}$$

New journal from the
European Mathematical Society



New in 2012

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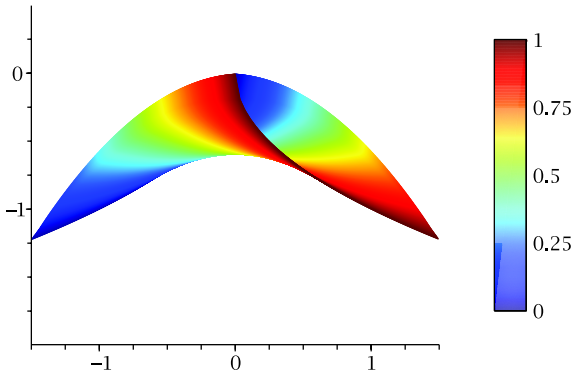


Figure 3.

after taking the derivative. Let P_Y denote the projector onto the closed subspace Y of X. Then this last decomposition turns into the well-known orthogonal subspace decomposition

$$P_Y + P_{Y^\perp} = \mathrm{Id}$$

since $\iota_Y^* = \iota_{Y^\perp}$ and $\mathrm{Prox}_{\iota_Y} = P_Y$.

The material thus far has been classical, although significant refinements continue to be made. We conclude with a recent development.

Proximal average: Let f_0 and f_1 be in Γ_X. Then the proximal average f_λ for $0 < \lambda < 1$ is defined by

$$\big((1-\lambda)(f_0+q)^* + \lambda(f_1+q)^*\big)^* - q.$$

We have $(f_\lambda)^* = (f^*)_\lambda$, that is, taking the Fenchel conjugate and the proximal average commute, and

$$\mathrm{Prox}_{f_\lambda} = (1-\lambda)\,\mathrm{Prox}_{f_0} + \lambda\,\mathrm{Prox}_{f_1}.$$

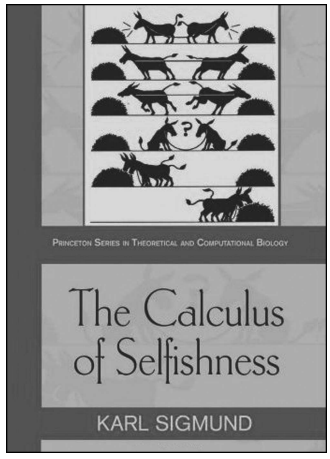
The proximal average provides a homotopy between f_0 and f_1, even when $\mathrm{dom}\, f_0 \cap \mathrm{dom}\, f_1 = \emptyset$, and it is useful for the construction of antiderivatives and maximally monotone operators. By associating each $\lambda \in [0,1]$ with a color, we are able to display the full family of proximal averages; see Figure 3 for the graph of the family of proximal averages $(f_\lambda)_{\lambda\in[0,1]}$ of $f_0(x) = -\sqrt{-x} + \iota_{[-3/2,0]}(x)$ and $f_1 = f_0 \circ (-\mathrm{Id})$. The following reading list is a starting point from which to explore the theory, history, applications, and (symbolic and numerical) computation of Fenchel conjugates.

Further Reading

1. H. H. Bauschke and P. L. Combettes, *Convex Analysis and Monotone Operator Theory in Hilbert Spaces*, Springer, 2011.
2. J. M. Borwein and J. D. Vanderwerff, *Convex Functions*, Cambridge University Press, 2010.
3. Y. Lucet, What shape is your conjugate?, *SIAM Rev.* **52** (2010), 505–542.
4. R. T. Rockafellar, *Convex Analysis*, Princeton University Press, 1970.

The Calculus of Selfishness

Reviewed by Olle Häggström



The Calculus of Selfishness
Karl Sigmund
Princeton University Press, January 2010
US$37.50, 192 pages
ISBN-13: 978-06911-427-53

Leading game theorist Karl Sigmund calls his latest book *The Calculus of Selfishness*, although arguably *The Calculus of Cooperation* would have been an equally suitable title. The central problem is this: How can cooperation, or even altruism, come about in a population of selfish individuals? We see plenty of cooperation around us, most prominently in human societies but also within other species and even between species. This is a bit of a mystery, because such cooperation appears to be prohibited by Darwinian survival of the fittest, which rewards those individuals who best look after their self-interest. It is they who get to pass their genes (and, presumably, their behavior) on to later generations, as opposed to those who waste time and resources helping others. What is going on here?

A prototype model, mimicking various real-world situations, is the *Prisoner's Dilemma*. Here two individuals, denoted Player I and Player II, simultaneously and independently decide on either of two moves: Cooperate (C) or Defect (D). Each player is rewarded by an amount that depends on both players' moves in such a way that, on the one hand, no matter what the other player does it is better for oneself to play D, whereas on the other hand it is better for both players if both of them play C than if both of them play D.

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DOI: http://dx.doi.org/10.1090/noti789.

A special case is the *Donation Game*, which is used by Sigmund as an example throughout much of the book. Here each player can choose to donate \$5 in order for the other player to receive \$15 (C) or to refrain from donating (D). Obviously it is better for both players if they both donate, leaving each with a net benefit of \$10, than if they both refrain, in which case they get nothing. On the other hand, each player has the incentive to save \$5 by refraining, no matter what the other player does. Hence, it seems that two self-interested players are doomed to both play D, thus missing out on the \$10 benefit that each of them might otherwise have acquired.

There are various ways to try to explain how the players might nevertheless come to play C. One approach, sometimes favored in evolutionary biology, is kin selection. Helping a sibling can be in my interest—or rather in the interest of my genes—because she shares 50% of them. From this perspective, the \$5 donation is a bargain, because the \$15 that my sibling receives is worth \$7.50 to me.

Another approach, receiving more attention in Sigmund's book, is repeated games. If you and I are set to play the Prisoner's Dilemma many times, then it might start to look like a good idea for me to play C early on, with the idea of building up a relation of trust in which you are more inclined to play C in later rounds than you otherwise might have been (and vice versa). The situation quickly becomes incomparably more complex than in the single-round game, due partly to a combinatorial explosion in the number of possible strategies.

Robert Axelrod's classic 1984 book *The Evolution of Cooperation*, which did much to popularize the subject and to stimulate further research, reports on a fascinating experiment. He invited colleagues and others to submit computer programs to play the iterated Prisoner's Dilemma

with each other. After a first round-robin tournament, he published an analysis of the results and opened invitations for another one.[1] A wide variety of strategies were submitted, but remarkably enough both tournaments were won by the same very simple strategy, called *tit for tat*, which plays C in the first round and from then on simply copies what the opponent just did. Tit for tat is by no means a universal winner independently of the environment of co-competitors—for instance, in his analysis of the first tournament Axelrod gave an example of a variation of tit for tat that would have won (ahead of tit for tat and all others) if only it had been submitted. Still, tit for tat performs well under sufficiently wide conditions to merit the large amounts of attention it has received in the game theory literature, including Sigmund's book.

All this is an example of game theory, which can be described as decision theory in the presence of other agents whose decisions affect how successful your own decisions are (and vice versa). This is interesting both as a mathematical topic in its own right and for modeling in biology and in economics. One of several aspects that contribute to game theory being a fascinating subject is the multiplicity of methodologies involved. In current research we find rigorous mathematical analysis, we find extensive computer simulations, and we find experiments aimed at uncovering how real human beings act in idealized game-theoretic situations. Sigmund concentrates on mathematical analysis, but there is of course interesting interplay with the other approaches, which he does not ignore.

Of particular interest is *evolutionary game theory*, in which one imagines a large population of agents playing with each other and in which the frequency of a given strategy in the population changes depending on how successful it is. With a symmetric game with n possible strategies, let A be the *payoff matrix* of dimension $n \times n$, where A_{ij} denotes Player I's payoff if he plays strategy i and Player II plays strategy j. Furthermore, let $x_i(t)$ denote the frequency at time t of strategy i in the population, and $\mathbf{x}(t) = (x_1(t), \dots, x_n(t))$. The so-called *replicator equation* prescribes that the rate of relative change of $x_i(t)$ equals the success of a player with strategy i in the population minus the average success in the population:

$$x_i'(t) = x_i(t)[(A\mathbf{x}(t)_i) - \mathbf{x}(t) \cdot A\mathbf{x}(t)]$$

for $i = 1, \dots, n$. In biological applications, we may think of this as describing the change of gene frequencies in the population resulting from Darwinian selection, whereas in economics it may be more natural to think of it as resulting from agents imitating the behavior of other, more successful, agents.

The replicator equation leads to fascinating and not-so-easy-to-guess dynamics even in seemingly simple situations. An important notion here is that of *rest points*, that is, population compositions such that $x_i'(t) = 0$ for $i = 1, \dots, n$. A central question is whether they are stable under perturbations. Rest points are closely related (but not quite equivalent) to so-called Nash equilibria. The bulk of Sigmund's book consists of analyses of the replicator dynamics in various situations.

One example is the iterated Prisoner's Dilemma, which, under reasonable conditions, can be represented as a single game and plugged into the replicator equation. There are infinitely many possible strategies for this game, and we need to focus on a finite collection of them. Already with three simple strategies—tit for tat (TFT), always cooperate (AC), and always defect (AD)—the dynamics become fairly intricate. If only TFT and AC are present in the population, everyone will cooperate forever, and the two kinds of agents will look the same to the outside observer. Introducing a noise term in the dynamics, allowing TFT and AC to mutate into each other, causes the frequencies of the two strategies to diffuse back and forth. What if we also introduce another mutation term, allowing occasional attempts by AD to invade the population? If, at the time of an invasion attempt, the population is dominated by AC, then AD will be able to exploit AC and quickly take over the entire population. On the other hand, if it is dominated by TFT, then AD will fail and be eliminated, at the same time as the proportion of TFT will increase at the cost of AC. This has the interesting consequence that, starting from a population dominated by TFT plus a smaller proportion of AC, AD will have a very hard time invading if the mutation rate in its favor is too high. This is so because, every time it attempts to invade, the proportion of TFT will go up, making the next attempt even less likely to succeed. Only if invasion attempts come more rarely, so that the TFT-versus-AC proportion has time to diffuse towards a significantly greater proportion of AC between invasion attempts, does AD have a chance to succeed in taking over the population reasonably quickly.

There are many natural ways to vary this situation. Introducing an error term in the players'

[1] *In this second tournament, he also adjusted for a flaw in the first one, namely that the number of iterations of the games was fixed beforehand at 200, opening up the nightmare of backward induction: Clever contestants realize that they have no reason to play anything other than D in the last round. It follows that they have no such reason in round 199, either, and so on, seemingly leading rational players to defect from round 1. In the second tournament the number of rounds between each pair of contestants was announced to be random—more specifically, geometrically distributed with a given expectation.*

choices (so that they sometimes make a different move than intended) can alter the dynamics drastically and tends to disfavor tit for tat. Another option, particularly popular in recent years, is the study of *indirect reciprocity* (as opposed to the direct reciprocity of tit for tat in the iterated Prisoner's Dilemma), in which two agents meet only once but can nevertheless adjust their moves depending on what has taken place before. This can be surprisingly effective, provided the agents apply *vicarious reciprocity* (Player I cooperates with Player II depending on how Player II has previously behaved towards third parties) rather than the psychologically tempting *misguided reciprocity* (Player I cooperates with Player II depending on how Player I himself has previously been treated by third parties).

Yet another variation treated by Sigmund is a multiplayer generalization of the Prisoner's Dilemma, sometimes known as the *Tragedy of the Commons*. The commons is a piece of grassland owned collectively by a group of local farmers. Everyone is free to use it for their sheep, but the tragedy consists in the fact that, if the total level of exploitation of the commons gets too large, it will collapse. The importance of understanding a game like the Tragedy of the Commons is its structural similarity with many important problems—environmental and others—in society; finding ways to stimulate agents to cooperate in Tragedy of the Commons-like situations is an enormously important task for political science and related subjects, and one may hope that game theory is able to contribute. A major example is the emission of greenhouse gases, where I find it disheartening to see that the biggest polluter[2] seems to be dead set on continuing to defect.

As a prerequisite for the book, a year of undergraduate mathematics should be more than sufficient. More important, however, is that the reader is willing to focus seriously on the material and to invest time and energy. Sigmund's enthusiasm for the topic shines through very clearly, and I enjoyed reading this up-to-date introduction to a very lively and exciting research area. Nevertheless, I would hesitate to use the book for a course. The reason for this is Sigmund's choice, despite the mathematical rigor he employs, to settle for a narrative structure entirely devoid of the definition-lemma-theorem-proof-exercise layout that, after all, has proved over the years to be an efficient means by which to structure and communicate mathematical ideas.

[2] *I am referring to the United States. Although it is true that, in absolute terms, China has recently surpassed the United States as the biggest emitter of greenhouse gases, it is nevertheless the case that the United States is still way ahead of China in terms of per capita emissions, as well as in terms of cumulative (historical) emissions.*

Mathematics Advanced Study Semesters (MASS)

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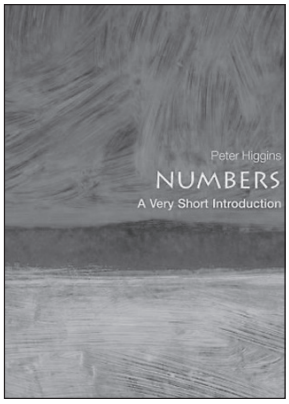
Book Review



Numbers: A Very Short Introduction

Reviewed by Rafe Jones

Numbers: A Very Short Introduction
Peter M. Higgins
Oxford University Press, 2011
US$11.95, 144 pages
ISBN 978-0-19-958405-5

Numbers: A Very Short Introduction, by Peter M. Higgins, is a little book with big aims. Its purpose, set forth in the first sentence, is "to explain, in language that will be familiar to everyone, what are the various kinds of numbers that arise and how they behave." While total fulfillment of this goal lies outside the reach of even much longer works, I found this to be an admirable effort that succeeds to a surprising degree in its 144 undersized pages.

Let me treat first the book's goal of explaining the kinds and behavior of numbers that arise in mathematics. The first five chapters describe the integers and their properties, mostly those involving prime numbers. In an opening chapter with the catchy title "How not to think about numbers", Higgins gives a leisurely account of basic properties of decimal representation and divisibility. He then proceeds to discuss primes and their properties in greater depth, describing unique factorization, the infinitude of the primes, Goldbach's conjecture, and much else besides. Then comes a tour of the flavors of positive integers: perfect numbers, friendly numbers, binomial coefficients, and Stirling numbers, to name a few. Amidst this tour is a full chapter devoted to detailing the RSA encryption algorithm. In Chapter 6, titled "Below the water line of the number iceberg", Higgins dives into a dissection of the real numbers, including irrationals and their colorful history, transcendentals, and a discussion of the "reality" of real numbers. In the penultimate chapter comes an excellent account of the cardinality of infinite sets, the Cantor middle-third set, and continued fractions. Finally, the complex numbers make up the backbone of Chapter 8. All in all, the book covers quite a bit of ground, saying something interesting about each of the principal kinds of numbers in wide use in mathematics. It achieves this about as gracefully as its length permits. That is to say, it sometimes skips about frenetically, such as in Chapter 5 while enumerating flavors of integers, but generally it follows the natural thread from counting numbers outward to the complex numbers. Even when the pace feels rushed, the interest of each nugget and the almost uniformly good quality of the writing minimize the distraction.

If the choice of subject and organization are merely good, the exposition is outstanding. Higgins's background as both a research mathematician and mathematics writer shows clearly in his prose. He writes with a casual flair that sacrifices nothing in clarity and makes the book engaging at every turn. His explanations nearly always find an elusive middle ground: they are precise enough to contain all the outlines of a rigorous proof, but colloquial enough to tell a friend over coffee. For instance, I appreciated the rigor in his description of how Cantor's diagonal argument that the real numbers are uncountable cannot be circumvented by simply adding the missing number to the original list: no matter how many times this is done, "…Cantor's point remains valid: although we can keep creating lists that contain additional numbers that were previously overlooked, there can never be one specific list that contains every real number" (p. 88). I enjoyed the conversational quality of this passage about transcendental numbers: "It is not at all clear that there are any such numbers. However, they do exist and they form a very secretive society, with those in it not readily divulging their membership of the club" (p. 79). Occasionally Higgins's writing even rises to the poetic, as when he describes the transcendental

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numbers as the dark matter on the real number line (p. 91), or when on p. 23 he remarks how the Riemann hypothesis would imply that "primality, in the realm of the very large, takes on the mantle of randomness, with no additional pattern or structure to emerge."

I believe that the book succeeds in its promise to explain the world of numbers in language that is familiar to all. However, that is not to say that no mathematical background is required to get at all the details given in the book. For example, to follow the proof of uniqueness of prime factorization in Chapter 2, the reader must be comfortable with abstract notation for numbers (e.g., n, p, q) and the idea of proof by contradiction. The primary mystery of the book for me is determining whom, exactly, it is written for. Surely it is for neither the true math neophyte nor anyone with a mathematics degree. I suspect its ideal reader is a relatively educated person, perhaps with a degree in a scientific discipline, or maybe an undergraduate partway through a math major and looking for outside reading.

While this ideal audience may not be the broadest, happily the book is engaging and varied enough to hold some interest for just about any reader. The neophyte will enjoy at least Chapter 1 and selected other passages, such as the description of the Hilbert Hotel in Chapter 7, which I found to be particularly well rendered. At the other extreme, the number theorist will smile at the wry humor (the exclamation mark in a factorial, we learn on p. 54, alerts us to its rather alarming rate of growth) and is likely to find many of the descriptions, if not the objects, to be fresh.

I should also note the altogether pleasant physical dimensions of the book. Its weight and length allow it to be picked up with one hand in a perfectly comfortable way, and the small page size makes it almost beg to be thumbed through. I found myself carrying it around even when secretly I knew I wouldn't have time to read any of it. One minor unpleasantness came in the form of several typos and usage problems, which were jarring given the otherwise good quality of the writing and seemingly could have been eliminated in so short a book. *Numbers* contributes to the dizzying expanse of coverage provided by the "Very Short Introduction" series, with pocket-size titles covering ground from *Advertising* to *Schopenhauer*. (There is also *Mathematics*, by Timothy Gowers, for those who are interested.)

In summary, this well-written little book contains a surprising amount of information and is well worth reading or recommending to others. Any reader, but particularly one with a bit of mathematical background, will likely come away enlightened, amused, and wanting to learn more.

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Tapia and Varadhan Receive National Medal of Science

On September 27, 2011, President Barack Obama announced the recipients of the National Medal of Science. Among the twelve recipients are two mathematicians: RICHARD A. TAPIA of Rice University and S. R. SRINIVASA VARADHAN of New York University.

Richard A. Tapia

Richard A. Tapia was honored "for his pioneering and fundamental contributions in optimization theory and numerical analysis and for his dedication and sustained efforts in fostering diversity and excellence in mathematics and science education." Tapia joined the faculty at Rice University in 1970. He is currently University Professor, Maxfield-Oshman Professor in Engineering, and professor of computational and applied mathematics. He is also director of Rice's Center for Excellence and Equity in Education and associate director of graduate studies.

The *Notices* asked Yin Zhang of Rice University to comment on the work of Tapia. Zhang responded: "Tapia's research centers around theory and algorithms for mathematical optimization—a field that he started to pursue in the days of his Ph.D. study at the University of California, Los Angeles, with a dissertation entitled *A generalization of Newton's method with an application to the Euler-Lagrange equation*. During his over forty-year tenure at Rice University, he helped build a first-class applied mathematics program including a world-leading optimization group. Deeply influenced by his advisor M. R. Hestenes at UCLA, a large part of Tapia's research concentrates on studying theoretical properties and computational performance of algorithms that are practically applicable, especially Newton's method and its variants such as quasi-Newton methods. Since the 1970s, Tapia has made a number of significant contributions to research extending Newton's method to various settings of constrained optimization, including eigenvalue problems. An important aspect of his work is to analyze asymptotic rates of convergence in Newton-type methods. As is well known, under standard conditions Newton's method applied to nonlinear systems has a quadratic rate of convergence, which is a source of effectiveness for the method. When one extends Newton's method, the ability to preserve a fast convergence rate, as much as practically viable, is a primary consideration in algorithm design and analysis. In the 1990s, when interior-point methods for linear and other convex programming became a focus of optimization research, Tapia and his co-workers treated a large class of interior-point methods in a Newton-like framework, establishing that these methods, when appropriately implemented, have not only nice global behavior in the form of polynomial-time complexity, but also a super-linear or even faster local convergence rate under weaker than usual assumptions. Taking into account both global and local behaviors, these results significantly bridge the gap between theory and practice of interior-point methods and provide guidelines for, as well as realistic explanations of, algorithm design and refinement."

Tapia grew up in Los Angeles as the son of Mexican immigrants. He was the first member of his family to attend college. He received his B.A. in 1961, his M.A. in 1966, and his Ph.D. in 1967, all from the University of California, Los Angeles. He was a lecturer at UCLA and a faculty member at the University of Wisconsin before joining the Rice faculty.

In 1992 Tapia became the first Hispanic elected to the National Academy of Engineering. He served on the National Science Board from 1996 until 2002, and from 2001 to 2004 he chaired the National Research Council's Board on Higher Education and the Workforce. He was the recipient of the AMS Distinguished Public Service Award in 2004. His other honors include the National Science Foundation's Presidential Award for Excellence in Science, Mathematics, and Engineering Mentoring (1996); the Lifetime Mentor Award from the American Association for the Advancement of Science (1997); the Distinguished Service to the Profession Award from the Society for Industrial and Applied Mathematics (2004); and the Distinguished Scientist Award from the Society for the

Advancement of Chicanos and Native Americans in Science (2000). He was named one of the most influential leaders in minority math education by the National Research Council and in 1994 was the first recipient of the Computing Research Association's A. Nico Habermann Award for outstanding contributions to aiding members of underrepresented groups within the computing research community. In 2005 Tapia was elected to the Board of Directors for TAMEST, which comprises the Texas members of the National Academy of Engineering, National Academy of Sciences, and the Institute of Medicine. Tapia has authored or coauthored two books and more than 100 mathematical research papers, and he is currently writing a graduate-level textbook on the foundations of optimization.

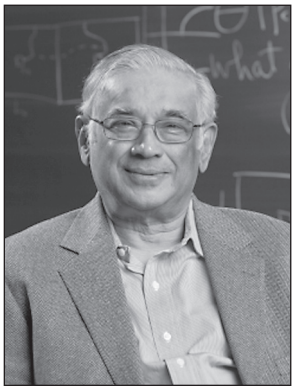
Tapia has been a leader in directing underrepresented minority and women doctoral students in mathematics. He directs programs supported by the Alfred P. Sloan Foundation, the National Science Foundation, and other organizations that are designed to increase the number of underrepresented minorities obtaining graduate degrees in science, technology, engineering, and mathematics and to enhance the preparation of underrepresented minorities for faculty positions in academia.

S. R. S. Varadhan

S. R. Srinivasa Varadhan is the Frank Jay Gould Professor of Science and professor of mathematics at the Courant Institute of Mathematical Sciences at New York University. He was honored with the National Medal of Science "for his work in probability theory, especially his work on large deviations from expected random behavior, which has revolutionized this field of study during the second half of the twentieth century and become a cornerstone of both pure and applied probability. The mathematical insights he developed have been applied in diverse fields, including quantum field theory, population dynamics, finance, econometrics, and traffic engineering." His research has centered on the theory of large deviations—the probability of rare events. His contributions have provided a method for understanding a range of phenomena, and his work has been employed in a variety of fields, including finance, traffic engineering, and biology.

The *Notices* asked Daniel Stroock of the Massachusetts Institute of Technology to comment on the work of Varadhan. Stroock responded: "The hallmark of Varadhan's work is his consistently elegant solutions to sometimes less than elegant problems. In his doctoral thesis at the Indian Statistical Institute in Calcutta, he characterized the family of infinitely divisible laws on a Hilbert space. In the process, he acquired a deep understanding of weak convergence of measures, an understanding whose depth would be demonstrated repeatedly throughout his career. After coming to the Courant Institute at New York University, he came under the influence of Monroe Donsker, who himself was an intellectual descendant of Norbert Wiener. In particular, like Wiener, Donsker thought of Wiener measure in more analytic terms than most of his contemporaries in probability theory. This viewpoint was reflected in the thesis of Donsker's student M. Schilder, who developed a systematic way of computing asymptotics for certain Wiener integrals. When he learned about Schilder's work, Varadhan realized that it could be seen as an infinite dimensional version of what statisticians call *the theory of large deviations* and that when one formulated Schilder's results in this context it would be possible to make significant extensions. In order to appreciate how remarkable this insight was, one has to know that, at the time, a theory of large deviations did not really exist. There was a hodgepodge of results, the most famous of which was due to H. Cramér, but there was nothing that deserved to be called a mathematically precise description, much less a *theory*, of large deviations. Hence, before he could carry out his program, Varadhan had to invent the theory in which he intended to embed Schilder's theorem, and thus was born what is now called *the large deviations principle*. For those who know the modern treatment of weak convergence, the large deviations principle has a familiar ring. However, to transform the ideas of weak convergence so that they become amenable to the study of large deviations required profound understanding of both topics. After his seminal work on large deviations, Varadhan took a vacation from large deviations, and for close to a decade he devoted his efforts to the study of diffusion processes. Here again he is responsible for major breakthroughs, both in the formulation of the theory as well as its applications. He was induced to end his vacation by Donsker. Many years before, M. Kac had given a formula for the principle eigenvalue of a Schrödinger operator in terms of the asymptotics of a Wiener integral, and Donsker was convinced that Kac's formula could be understood in a more general context. After Varadhan joined Donsker, he realized that Kac's formula could be obtained from a large deviations principle, albeit one of an entirely novel sort. Whereas Schilder's result involved large deviations of Wiener paths during short time intervals, the

Richard A. Tapia



S. R. S. Varadhan

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large deviations underlying Kac's formula involved the long-time behavior of Wiener paths and the deviations of their empirical measures from ergodic behavior. In a sequence of articles, the two of them developed the requisite theory and proved a sequence of remarkable results, including solutions to long-standing problems in mathematical physics. After Donsker's death, Varadhan applied his and Donsker's theory to elucidate and extend the theory of hydrodynamic limits, along the way introducing wholly new applications of entropy. Without question, the contributions of S. R. S. Varadhan place him in an elite group of modern mathematicians."

Born January 2, 1940, in Madras (Chennai), India, Varadhan received his B.Sc. in 1959 and his M.A. in 1960, both from Madras University. He received his Ph.D. in 1963 from the Indian Statistical Institute, Calcutta, under the direction of C. R. Rao. He began his long career at the Courant Institute with a postdoctoral fellowship in 1963 and has served two terms as its director (1980–1984 and 1992–1994). He received the AMS Leroy P. Steele Prize jointly with Daniel Stroock in 1996, and in 2007 he was awarded the Abel Prize in Mathematics by the Norwegian Academy of Science and Letters for "his fundamental contributions to probability theory". His other honors include the Birkhoff Prize (1994) and the Margaret and Herman Sokol Award of NYU's Faculty of Arts and Science (1995). He has held Alfred P. Sloan and Guggenheim Fellowships. He has been an invited speaker at the International Congresses of Mathematicians in 1978 and in 1994. He is a member of the American Academy of Arts and Sciences (1988), the Third World Academy of Sciences (1988), the Norwegian Academy of Science and Letters, and the U. S. National Academy of Sciences (1995). He is an elected fellow of the Institute of Mathematical Statistics (1991), the Royal Society (1998), and the Indian Academy of Sciences (2004).

About the Medal

The National Medal of Science is the country's highest distinction for contributions to scientific research. According to a news release from the Office of Science and Technology Policy, "the National Medal of Science honors individuals for pioneering scientific research in a range of fields, including physical, biological, mathematical, social, behavioral, and engineering sciences, that enhances our understanding of the world and leads to innovations and technologies that give the United States its global economic edge." The National Science Foundation administers the award, which was established by Congress in 1959.

— Elaine Kehoe

Teaching with High-Cognitive-Demand Mathematical Tasks Helps Students Learn to Think Mathematically

Jeremy F. Strayer and Elizabeth Brown

A recent *Doceamus* article in the *Notices* (Sweller, Clark, and Kirschner, 2010) argued that having students study worked examples of problem types rather than actually solving problems is the preferable way to teach mathematics. The article cited a study (Sweller and Cooper, 1985) that compared one group of students who solved multiple routine algebra problems with another group who studied worked examples of similar problem types. Their analysis showed that the worked-examples group outperformed the problem-solving group. To further make their case against problem solving, the authors critiqued Pólya and claimed that: (1) teaching only general problem-solving skills and (2) providing minimal instructional guidance to students does not lead to successful mathematics learning.

We agree with Sweller, Clark, and Kirschner that it is indeed misguided to use repeated routine problem solving as the primary means of mathematics instruction. We further agree that it is not preferable to base one's mathematics instruction on the above two criteria. *However,* we contend that the current vision and practice of the mathematics community that has been influenced by Pólya's ideas do not draw primarily on routine problem solving. Neither do they rely heavily on the two criteria outlined above. Thus the case that Sweller, Clark, and Kirschner (2010) make against problem solving in mathematics classrooms misses the point.

In this article, we provide a brief description of the progression of research into problem solving in mathematics classrooms over the last few decades and describe one way this research has led to productive mathematics teaching and learning in our classrooms.

Pólya's recommendation that teachers overtly teach problem-solving strategies was novel and indeed quite radical when first presented (Passmore, 2007). It should be noted that Pólya's aim was not to teach problem solving for problem solving's sake. Rather, it was to help students learn to think the way mathematicians think when they do mathematics (Pólya, 1945, 1954). Problem solving for mathematicians entails employing one's energies and talents to solve nonroutine, perplexing, and difficult mathematics problems (Schoenfeld, 1992). Influenced by Pólya's ideas, the mathematics education community embraced teaching mathematics *through* problem-solving tasks that develop conceptual understanding—without relying on traditional drill-and-practice routines. Does this way of teaching work? A recent meta-analysis of 109 independent experiments (both quasi- and randomized experimental designs) provides strong empirical support for the claim that teaching mathematics *conceptually* improves student achievement (Rakes, Valentine, McGatha, and Ronau, 2010).

As one can imagine, conducting research into mathematics instruction that is conceptually focused is multifaceted and quite complex. One line of research that we have found particularly interesting and useful in our classrooms focuses on the nature of the

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Members of the Editorial Board for Doceamus *are: David Bressoud, Roger Howe, Karen King, William McCallum, and Mark Saul.*

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mathematical problems (or tasks) that students complete and what occurs in the classroom when these tasks are implemented. Stein, Smith, Henningsen, and Silver's (2009) research-based Task Analysis Guide (TAG) provides a helpful four-tier classification of classroom tasks. The first two task types are low in cognitive demand. *Memorization* tasks require students to commit to memory and/or recall previously learned definitions, facts, rules, or other mathematical knowledge. *Procedures without connections to underlying mathematical concepts* tasks focus on the procedure required to get the correct answer to the given problem with no connection to the underlying concepts or mathematical meaning in the task. The next two task types are high in cognitive demand. *Procedures with connections to underlying mathematical concepts* tasks do imply the use of a specific procedure to complete the task, but the purpose for the use of the procedure is to foster deeper levels of understanding of the mathematical concepts underlying the task. To accomplish this conceptual connection, these tasks often rely on multiple representations of the problem (e.g., graphical, verbal, analytic) and require significant cognitive effort to complete. *Doing mathematics* tasks presents students with a nonroutine mathematics problem that does not hint at a predictable pathway toward a solution in the task itself, the instructions, or a worked-example solution. This kind of task requires students to explore mathematical concepts, analyze the task to understand the structure of possible solutions, make use of existing mathematical knowledge, and regulate their own cognitive processes as they work through the task.

The majority of tasks completed in mathematics classrooms across the United States (as well as the tasks referenced in the aforementioned *Doceamus* article) are low-cognitive-demand tasks of the first two types in the TAG. Although there is a place for all types of mathematical tasks depending on the learning goals of the lessons, research into the instructional differences that exist between countries in which students perform highly in mathematics versus countries in which students perform at lower levels, such as the United States, shows that the higher performing countries provide students opportunities for prolonged engagement with mathematical tasks at a high cognitive level (Stigler and Hiebert, 2004).

It is a challenge to provide college students with opportunities for prolonged engagement with mathematical tasks at a high cognitive level, something many of our students have never been asked to do. Nevertheless, we believe it is crucial to give students an opportunity to engage in tasks in this way, particularly if some of these students will be future mathematics teachers. Here, we describe our efforts to accomplish this in a portion of the Analytic Geometry course we teach for mathematics and mathematics education majors. We begin the course with a series of routine low-cognitive-demand *review* activities that ask students to plot points, find the distance between points, find equations for lines, and so forth. Then we challenge students to develop mathematical habits of mind through the sustained use of sequenced high-cognitive-demand tasks in the following way. First, we define the Euclidean and taxicab metrics as

$$d_E = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2} \text{ and}$$
$$d_T = |x_2 - x_1| + |y_2 - y_1|, \text{ respectively.}$$

Next, we present students with tasks that ask them to graph circles with various centers A and radii r using the locus of points definition of a circle $\{P|d(P,A)=r\}$ using *both* metrics. As students complete these tasks relying strictly on the definition of distance, they are confronted with the counterintuitive task of graphing taxi circles, which are shaped like squares. Once students are comfortable with creating circles, the next set of tasks requires students to *use circles as tools* to find particular loci, such as $\{P|d(P,A)=d(P,B)\}$ and $\{P|d(P,A)+d(P,B)=2a\}$. In the Euclidean case, these loci are the perpendicular bisector of a segment and an ellipse, respectively. The idea of using circles and intersections of circles as a tool to find a locus of points is new to students, and they require time to struggle with the concept. It is crucial that students are pushed to express their thinking and engage in meaningful student-student and student-teacher discourse for these tasks to be successful in supporting learning.

We use Texas Instruments *n*spire technology to help students investigate and complete the above tasks. At first, the circles get in the way, and it is our experience that students feel lost in the details. But, as both teacher and student press each other to make sense of the task and justify reasoning, students learn at deep levels. Figure 1 and Figure 2 show student work in creating the locus of points equidistant to (0,0) and (6,2) using both metrics. Figure 3 and Figure 4 show ellipses in both metrics

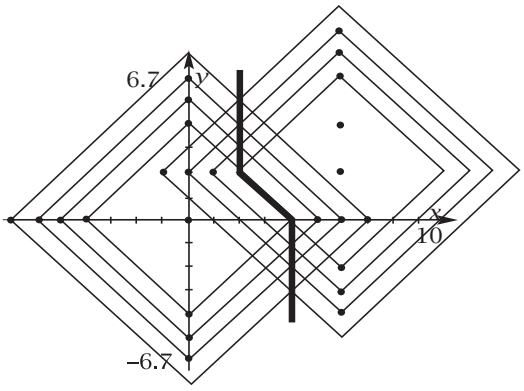

Figure 1.

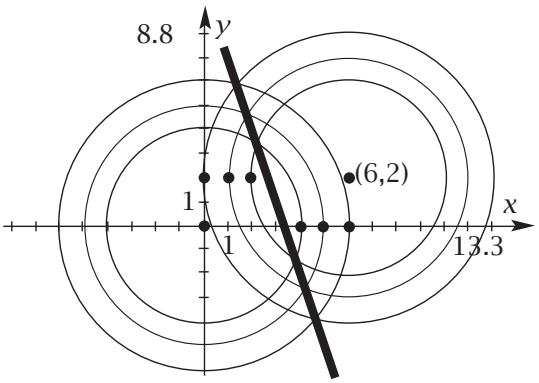

Figure 2

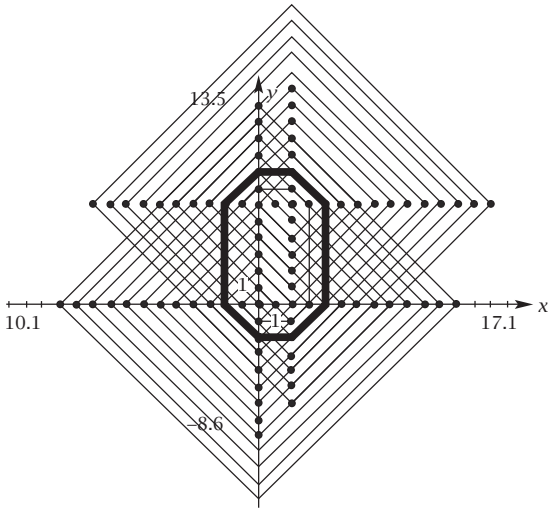

Figure 3

with focal distance 8 and $2a=12$. Students complete other examples and are confronted by the fact that these loci have varying properties when using d_T that depend on the relative locations of the points A and B (try a few examples to investigate!), while they behave more consistently under d_E.

Implementing the above tasks can be quite messy at times. However, if we, as the instructors, build on prior student knowledge, support student thinking as they complete the task, require students to justify and explain their work, and repeatedly make explicit conceptual ties to student work, then the tasks are likely to support high-level cognitive engagement with mathematical ideas (Stein et al., 2009). Conversely, if we give in to student pressure to show them the steps to go through to solve the problem, shift the focus to the correct answer rather than the mathematical meaning and concepts, or give credit for low-level work on the task, then the task will likely decline into low-level engagement with mathematical ideas. Further, we have found that if we press for high-level engagement with the above tasks, then students are better able to make sense of the connections between various definitions of conic sections later in the course.

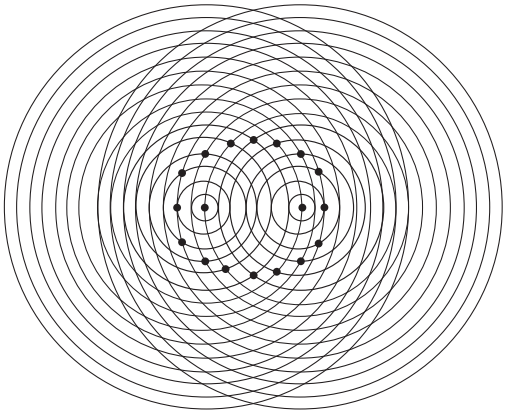

Figure 4

Pólya's objective over a half century ago to focus mathematics instruction on introducing students to the intellectual rewards acquired through problem solving has inspired mathematicians and mathematics educators the world over to create instructional strategies aimed at accomplishing this goal. When we engage students with domain-specific tasks at a high cognitive level, we are well on our way to meeting this challenge, and our students are better positioned to make sense of lines of mathematical reasoning.

References

T. Passmore, Polya's legacy: Fully forgotten or getting a new perspective in theory and practice?, *Australian Senior Mathematics Journal* **21** (2007), 44–53.

G. Pólya, *How to Solve It*, Princeton University Press, Princeton, New Jersey, 1945 (2nd ed., 1957).

_____ , Mathematics and plausible reasoning: Volume 1, *Induction and Analogy in Mathematics*; Volume 2, *Patterns of Plausible Inference*, Princeton University Press, Princeton, New Jersey, 1954.

C. R. Rakes, J. C. Valentine, M. B. McGatha, and R. N. Ronau, Methods of instructional improvement in algebra: A systematic review and meta-analysis, *Review of Educational Research* **80** (2010), 372–400.

A. H. Schoenfield, Learning to think mathematically: Problem solving, metacognition, and sense-making in mathematics, in *Handbook for Research on Mathematics Teaching and Learning*, (D. Grouws, ed.), MacMillan, New York, 1992, 334–370.

M. K. Stein, M. S. Smith, M. A. Henningsen, and E. A. Silver, *Implementing Standards-Based Mathematics Instruction: A Casebook for Professional Development* (2nd ed.), Teachers College Press, New York, 2009.

J. W. Stigler and J. Hiebert, Improving mathematics teaching, *Educational Leadership* **61** (2004), 12–16.

J. Sweller, R. Clark, and P. Kirschner, Teaching general problem-solving skills is not a substitute for, or a viable addition to, teaching mathematics, *Notices of the AMS* **57** (2010), 1303–1304.

J. Sweller and G. Cooper, The use of worked examples as a substitute for problem solving in learning algebra, *Cognition and Instruction* **2** (1985), 59–89.

Why Don't More University Presses Publish Mathematics Books?

David Tranah

Suppose you were a company dedicated to publishing works of scholarship and education that were too specialized or novel for commercial publishers. Wouldn't you be interested in an academic discipline that is well defined, robust, undertaken everywhere (often in English!), and represents a profitable business worth perhaps $50 million annually? Mathematics is just such a business, so of all the university presses, some 150 worldwide, why do only Princeton, Imperial College, Oxford, and Cambridge have substantial programs of publishing academic books in mathematics? Chicago did once have a rather nice series; why no longer? Johns Hopkins does publish a few "trade" mathematics titles; why not more academic ones? Why doesn't Harvard? Why doesn't MIT complement its outstanding computer science list with something comparable in mathematics? Why don't university presses that publish math journals also publish math books? Should mathematicians care that they don't, and could they do anything about it?

In examining these questions, I shall do the traditional thing, namely look at some broader issues affecting academic book publishing and see what they may mean for mathematics.

About two-thirds of all university presses are based in North America: mostly the United States, but ten more exist in Canada, and both Oxford and Cambridge have a substantial U.S. presence. Cambridge was established in 1534 with the right to publish "all manner of books", so nothing was excluded in principle, though Cambridge needed only 118 years to bring out its first book in mathematics!

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Members of the Editorial Board for Scripta Manent *are: Jon Borwein, Thierry Bouche, John Ewing, Andrew Odlyzko, Ann Okerson.*

By contrast, most U.S. university presses were established, in part, to cater to the local population, perhaps academic, perhaps geographic. Apart from forays into natural history or environmental issues, there was no reason that they should publish in science, let alone mathematics.

This reason is compounded by the fact that scientists and mathematicians are much less inclined to write books than their counterparts in the humanities and social sciences (HSS). To a great extent, therefore, in the buyer's market that is HSS publishing, acquisition editors (that is, the people who build programs) benefit from this difference: there is a never-ending stream of manuscripts landing in their inboxes. On the other hand, acquisition editors operating in science and mathematics usually build a list by identifying topics and authors (often with the assistance of academic series editors) and then hunting for, cajoling, persuading people to contribute to it. It is easier to graze rather than hunt, and, just as in nature, the publishing ecosystem can support more grazers than hunters: that is, more HSS than science editors.

A further reason has to do with the ability to reach the market. A mathematics book has global appeal, and for the last seventy years, the language in which mathematics has been conducted, at least at graduate level, is English. There is very little mathematics publishing that is of purely local interest. Dually, if you cannot sell your mathematics book everywhere in the world, then you are missing a considerable fraction of its audience. I estimate that North America represents now probably only about 35 percent of the world market for advanced mathematics books, whereas the comparable figures in literature or philosophy are nearer 50 percent. A science publisher has to have global reach, therefore, not only for sales but also for acquisition. University presses whose existence

could originally have been justified by parochial arguments and whose continued existence is guaranteed by the ability to sell books merely to U.S. universities, academics, and "the educated reader" just may not have had the wherewithal to handle content (print or electronic) of global appeal that requires global attention; and they may have lacked the resources to invest in the infrastructure that would have enabled them to reach the global market. (Interestingly, the same argument applied in the seventeenth century: according to McKitterick's *History of Cambridge University Press*, there was never any question of Newton's *Principia* being published at Cambridge. Distribution to its intended audience demanded resources greater than were available in 1687 to the university press.)

A fourth reason is that, especially in mathematics, the main learned societies have seized the baton of scholarly publishing. SIAM has been publishing books since the early 1970s; the MAA since the early 1920s; and the AMS since 1905 (with a major expansion in the 1990s): it has a longer history of book publishing than most university presses! (All these societies have formed sales and distribution partnerships outside North America.)

Mathematics publishing is therefore a mature business. Most players, whether commercial or nonprofit, are well established. Without an edge, how can university presses that do not have an existing presence enter the fray and successfully compete with those players? Why should they when there's plenty of low-hanging fruit elsewhere and when their business is tuned to a different sort of publishing? Just from these considerations one can see why most university presses do not publish much mathematics. And in my opinion they *need* not, since the natural space they could have occupied has been populated by learned societies.

But will this always be the case? Maybe not. Can we predict the future by examining the past?

Many publishing houses began as printers or booksellers; those that have lasted have adapted and seen that what started out as niche activities—namely working with authors to create a written document and then persuading people to buy it—ultimately become the core, with retail, typesetting, printing, warehousing, and distribution being arranged through third parties.

A bigger development for many publishers, especially in science, has been the migration from book to journal publishing (often on behalf of learned societies), with books being a small, albeit highly visible, side issue. (In fact, many publishers keep books separate from journals as the businesses are so different, and it's not at all uncommon for a publisher to have a strong journal list in an area and yet publish no books in it.) The implications of this development have been profound. For example, about fifteen years ago we started to see journal publishers build online versions of journals, complementing the print. Journal users gradually switched to accessing papers online rather than going to the library. This switch did not happen overnight, and it was enabled by huge and continued investment and experiment, paid for by journal subscription, or in some instances by venture capital, and by reducing costs elsewhere. Some publishers built their own systems for delivering electronic journals; others bought services from platform providers such as High Wire. Digital archivers such as JSTOR appeared. The infrastructure set up for delivering journal content naturally was extended to books—complementary to e-book formats such as Kindle. It's only a matter of time before users start to prefer the Web as the way of accessing research monographs, reference books, and advanced textbooks. What will this mean for academic publishers whose businesses have been built on producing printed books and distributing them?

Publishers will have to reexamine their core activities and even to decide what an academic book is. It certainly won't be the simple thing it is now. Will it be a print-on-demand physical product, an e-book, an online book? Will it be locally sourced or downloaded? Will it be printed by Amazon for the publisher at the point of sale? Will it be "as supplied by author", or will it benefit from peer review and editing? Will editing be part of the publishing process, or will it be crowd sourced? Will it be authored or will it be a Wiki? Will it be flat or enhanced? All these considerations have implications for the existing infrastructures of book publishing—publishers will need to build a whole new IT infrastructure if they are to compete with Amazon, which might perhaps repeat what happened 150 years ago, and expand from bookseller and occasional book printer to publisher.

If the sales and marketing functions were to go the way of printing, warehousing, and distribution, would the only remaining aspect of publishing, editorial service, be enough to maintain a business? And if not, will that also disappear and businesses like Lulu, or repositories, become accepted places to publish one's books?

I like to think not, and not just because I am an editor. Academic publishing may fragment further because of the transition to digital, with the remaining core activities occupying micro-niches such as quality control, archiving, online delivery, usability, information retrieval, document enhancement, or whatever services customers regard as worth paying for in order that next-generation book publishers can survive. Businesses built around these activities will be much smaller and will need much more specific skills, ones that add value to authors' words. Such businesses sound a lot like university presses!

Mathematics People

Holowinsky Awarded 2011 Sastra Ramanujan Prize

ROMAN HOLOWINSKY of Ohio State University has been awarded the 2011 SASTRA Ramanujan Prize. This annual prize is awarded for outstanding contributions to areas influenced by the Indian genius Srinivasa Ramanujan. The age limit for the prize has been set at thirty-two because Ramanujan achieved so much in his brief life of thirty-two years. The prize carries a cash award of US$10,000.

The prize citation reads as follows: "Roman Holowinsky is awarded the 2011 SASTRA Ramanujan Prize for his spectacular work in analytic number theory and the theory of modular forms—contributions that have significant implications in a broad range of areas in mathematics and even in physics. The prize recognizes his seminal paper with Kannan Soundararajan in the *Annals of Mathematics* in 2010, which resolved the well-known quantum unique ergodicity (QUE) conjecture of Zeev Rudnick and Peter Sarnak in the important case of holomorphic modular forms, and his paper on sieve methods and shifted convolution sums in the *Duke Mathematical Journal* in 2009 which developed techniques that were crucial to the final resolution of the QUE conjecture in the holomorphic case. The prize notes that the origins of his work go back to his 2006 Ph.D. thesis on shifted convolution sums and quantum unique ergodicity. The prize also recognizes his related work on sieving for mass equidistribution that appeared in the *Annals of Mathematics* in 2010 and his joint paper with Valentin Blomer on bounding sup-norms of cusp forms of large level in *Inventiones Mathematicae* in 2009. The QUE conjecture was motivated by investigations in physics on quantum correspondence in chaotic systems, and the prize recognizes his research as a fine example of great mathematical work of lasting value inspired by a problem in physics."

Roman Holowinsky was born on July 26, 1979. He obtained a B.S. degree from Rutgers University in 2001. He continued at Rutgers to do his doctorate and received his Ph.D. in 2006 under the direction of Henryk Iwaniec. He held postdoctoral visiting positions at the Institute for Advanced Studies in 2006–2007 and in 2009–2010, at the Fields Institute in 2008, and at the University of Toronto in 2007–2009 before joining the permanent faculty at Ohio State University. He received an Alfred P. Sloan Foundation Fellowship in 2011. At the age of thirty-two, Holowinsky is a major figure in the fields of analytic number theory and the theory of modular forms.

The 2011 SASTRA Ramanujan Prize Committee consisted of Krishnaswami Alladi (chair), Frits Beukers, Benedict Gross, Christian Krattenthaler, Ken Ono, Robert Vaughan, and Akshay Venkatesh. Previous recipients of the SASTRA Ramanujan Prize are Manjul Bhargava and Kannan Soundararajan (2005), Terence Tao (2006), Ben Green (2007), Akshay Venkatesh (2008), Kathrin Bringmann (2009), and Wei Zhang (2010).

—Krishnaswami Alladi

Sheffield Awarded 2011 Loève Prize

SCOTT SHEFFIELD of the Massachusetts Institute of Technology has been awarded the 2011 Line and Michel Loève International Prize in Probability. The prize, which carries a monetary award of US$30,000, will be presented at a forthcoming ceremony in Berkeley.

Sheffield received his Ph.D. in 2003, advised by Amir Dembo at Stanford University. Much of his research has been devoted to development of the theory of the Schramm–Loewner evolution (SLE(κ)) and its connections with other processes. His early result that the harmonic explorer rescales to SLE(4) as the grid gets finer remains one of the most intuitive ways to see how SLE arises as a limit of discrete processes. His work "Gaussian Free Fields (GFF) for Mathematicians" explained how GFFs arise as the limit of many incrementally varying random functions on d-dimensional grids and started development of connections between the GFF and SLE. This theme was continued in subsequent works, in particular proving (with Oded Schramm) that the chordal level lines of the GFF have scaling limits that are variants of SLE(4).

He introduced the topic of conformal loop ensembles CLE(κ), using branching variants of SLE(κ) called exploration trees. CLEs are random collections of loops in a planar domain characterized by certain conformal invariance and Markov properties and conjectured to be scaling limits of various random loop models from statistical physics. Subsequent work with Wendelin Werner produced a deep analysis of CLEs and their relation to two-dimensional Brownian loop-soup. In particular, they showed that the simple CLEs constructed above for $8/3 < \kappa \leq 4$ coincide with the outer-cluster-boundary ensembles of Brownian loop-soups and are the only random loop ensembles satisfying certain conformal restriction axioms.

Another line of work, in part with Bertrand Duplantier, shows that certain interfaces between Liouville quantum gravity random surfaces have SLE descriptions. This work makes rigorous in this setting the KPZ relation between scaling exponents in a Euclidean planar domain and in Liouville quantum gravity.

He has also made substantial contributions in two quite separate fields. The first involves dimer models, spanning

trees, and tilings; the second involves game theory, PDEs, and Lipschitz extension theory.

The Loève Prize commemorates Michel Loève, professor at the University of California Berkeley from 1948 until his untimely death in 1979. The prize was established by his widow, Line, shortly before her death in 1992. Awarded every two years, it is intended to recognize outstanding contributions by researchers in probability who are under forty-five years old.

—David Aldous, University of California Berkeley

Christiansen Awarded First Smale Prize

Snorre H. Christiansen of the University of Oslo has been named the first recipient of the Stephen Smale Prize of the Society for the Foundations of Computational Mathematics (FoCM).

Christiansen was honored for his pioneering work on the foundation of computational mathematics. The prize citation reads: "Christiansen is an original and insightful researcher working on computational problems at the interface between pure and applied mathematics. Most of his work is motivated by the design of numerical methods for various equations arising in physics, and he has made substantial contributions to a number of key areas related to modern scientific computing. In particular, we will mention his use of Calderòn's formulas to construct preconditioners for the electric field equations, his contributions to the development of finite element exterior calculus, and his convergence results for lattice gauge theory. Through his work Christiansen has given many examples on how various topics from pure mathematics, such as homological algebra and algebraic topology, can be used as crucial tools for developing and understanding computational procedures."

The goal of the Smale Prize is to recognize major achievements in furthering the understanding of the connections between mathematics and computation, including the interfaces between pure and applied mathematics, numerical analysis, and computer science. It will be awarded every three years to coincide with the FoCM meeting.

—From a FoCM announcement

PECASE Awards Announced

Mathematicians Amit Singer of Princeton University and Maria G. Westdickenberg of the Georgia Institute of Technology were honored with Presidential Early Career Awards for Scientists and Engineers (PECASE). They are among ninety-four researchers selected from nominations made by sixteen federal agencies. Singer was nominated by the Department of Defense and Westdickenberg by the National Science Foundation.

Awardees are selected for their pursuit of innovative research at the frontiers of science and technology and their commitment to community service as demonstrated through scientific leadership, public education, or community outreach. Each awardee receives a five-year grant to further his or her research and educational efforts.

—From a White House announcement

Prizes of the Australian Mathematical Society

The Australian Mathematical Society has awarded several major prizes for 2011. Todd Oliynyk of Monash University was awarded the Australian Mathematical Society Medal. His work involves partial differential equations: singular limits of symmetric hyperbolic systems and geometric PDEs; general relativity: Newtonian limit, post-Newtonian expansions, Einstein–Yang–Mills, gravitating perfect fluids and elastic bodies; and geometric flows: Ricci flow and renormalization group flow. The medal is awarded to a member of the Society under the age of forty for distinguished research in the mathematical sciences. A significant portion of the research work should be carried out in Australia.

Frances Y. Kuo of the University of New South Wales was awarded the J. H. Michell Medal for outstanding new researchers by ANZIAM (Australia and New Zealand Industrial and Applied Mathematics division). According to the citation, "she is a recognized leader in the theory and applications of high-dimensional integration and approximation, Monte Carlo methods and information-based complexity, interested in applications in finance, statistics and porous media flow."

Peter Sarnak of the Institute for Advanced Study has been awarded the Mahler Lectureship. According to the citation, "he has made major contributions to number theory and to questions in analysis motivated by number theory. His research focuses on the theory of zeta functions and automorphic forms with applications to number theory, combinatorics, and mathematical physics." The prize is awarded every two years to a distinguished mathematician who preferably works in an area of mathematics associated with the work of Kurt Mahler.

—From an Australian Mathematical Society announcement

Royal Society of Canada Elections

The Royal Society of Canada has elected three new fellows and one foreign fellow who work in the mathematical sciences. They are Stephen S. Kudla, University of Toronto; Douglas R. Stinson, University of Waterloo; and Danny Summers, Memorial University of Newfoundland. Louis Nirenberg of the Courant Institute of Mathematical Sciences, New York University, was elected as a foreign fellow.

—From a Royal Society announcement

Mathematics Opportunities

Proposal Due Dates at the DMS

The Division of Mathematical Sciences (DMS) of the National Science Foundation (NSF) has a number of programs in support of mathematical sciences research and education. Listed below are some of the programs and their proposal due dates for the year 2012. Please refer to the program announcement or contact the program director for more information.

January 2, 2012 (letter of intent): Industry/University Cooperative Research Centers Program (I/UCRC)

January 10, 2012 (full proposal): Algorithms for Threat Detection (ATD)

January 13, 2012 (full proposal): Mathematical Biology

January 23, 2012 (full proposal): Computational and Data-Enabled Science and Engineering in Mathematical and Statistical Sciences (CDS&E-MSS)

January 26, 2012 (full proposal): Major Research Instrumentation Program

March 6, 2012 (full proposal): Industry/University Cooperative Research Centers Program (I/UCRC)

May 1, 2012 (letter of intent): Integrative Graduate Education and Research Traineeship Program (IGERT)

June 1, 2012 (full proposal): Research Experiences for Undergraduates (REU)

June 5, 2012 (full proposal): Mentoring through Critical Transition Points in the Mathematical Sciences (MCTP)

June 5, 2012 (full proposal): Research Training Groups in the Mathematical Sciences

June 15, 2012 (full proposal): Workforce Program in the Mathematical Sciences

June 26, 2012 (letter of intent): Industry/University Cooperative Research Centers Program (I/UCRC)

July 2, 2012 (full proposal): Integrative Graduate Education and Research Traineeship Program (IGERT)

July 10, 2012 (full proposal): Research Networks in the Mathematical Sciences

August 17, 2012 (letter of intent): Focused Research Groups in the Mathematical Sciences

August 22, 2012 (full proposal): Research Experiences for Undergraduates (REU)

September 11, 2012 (full proposal): International Research Fellowship Program

September 21, 2012 (full proposal): Focused Research Groups in the Mathematical Sciences

September 26, 2012 (full proposal): Industry/University Cooperative Research Centers Program (I/UCRC)

October 2, 2012 (full proposal): Algebra and Number Theory; Analysis; Combinatorics; Foundations

October 17, 2012 (full proposal): Mathematical Sciences Postdoctoral Research Fellowships

For further information see the website `http://www.nsf.gov/funding/pgm_list.jsp?org=DMS&ord=date`. The mailing address is Division of Mathematical Sciences, National Science Foundation, Room 1025, 4201 Wilson Boulevard, Arlington, VA 22230. The telephone number is 703-292-5111.

—From the DMS website

NSF Major Research Instrumentation Program

The National Science Foundation (NSF) Major Research Instrumentation (MRI) program seeks to increase access to shared scientific and engineering instruments for research and research training in institutions of higher education, museums, science centers, and not-for-profit organizations in the United States. This program especially seeks to improve the quality and expand the scope of research and research training in science and engineering by providing shared instrumentation that fosters the integration of research and education in research-intensive learning environments. Proposals must be for either acquisition or development of a single instrument or for equipment that, when combined, serves as an integrated research instrument (physical or virtual).

Proposals may be submitted only by institutions of higher education in the United States or its territories or possessions or by nonprofit organizations such as museums, science centers, observatories, research laboratories, professional societies, and similar organizations involved in research or educational activities. The deadline for full proposals is **January 26, 2012**. For more information see http://www.nsf.gov/pubs/2011/nsf11503/nsf11503.htm.

—From an NSF announcement

NSF Algorithms for Threat Detection

The Division of Mathematical Sciences (DMS) at the National Science Foundation (NSF) has formed a partnership with the Defense Threat Reduction Agency (DTRA) to develop the next generation of mathematical and statistical algorithms for the detection of chemical and biological threats. Proposals are solicited from the mathematical sciences community in two main areas: mathematical and statistical techniques for genomics and mathematical and statistical techniques for the analysis of data from sensor systems. The deadline for full proposals is **January 10, 2012**. For more details, see http://www.nsf.gov/pubs/2012/nsf12502/nsf12502.htm.

—From an NSF announcement

National Academies Research Associateship Programs

The Policy and Global Affairs Division of the National Academies is sponsoring the 2012 Postdoctoral and Senior Research Associateship Programs. The programs are meant to provide opportunities for Ph.D., Sc.D., or M.D. scientists and engineers of unusual promise and ability to perform research at more than 100 research laboratories throughout the United States and overseas.

Full-time associateships will be awarded for research in the fields of mathematics, chemistry, earth and atmospheric sciences, engineering, applied sciences, life sciences, space sciences, and physics. Most of the laboratories are open to both U.S. and non-U.S. nationals and to both recent doctoral recipients and senior investigators. Amounts of stipends depend on the sponsoring laboratory. Support is also provided for allowable relocation expenses and for limited professional travel during the period of the award.

Awards will be made four times during the year, in February, May, August, and November. The deadline for application materials to be postmarked or for electronic submissions for the February 2012 review is **February 1, 2012**. Materials for the May review are due **May 1, 2012**; for the August review, **August 1, 2012**; and for the November review, **November 1, 2012**. Note that not all sponsors participate in all four reviews. Applicants should refer to the specific information for the laboratory to which they are applying.

For further information and application materials, see the National Academies website at http://sites.nationalacademies.org/PGA/RAP/PGA_050491 or contact Research Associateship Programs, National Research Council, Keck 568, 500 Fifth Street, NW, Washington, DC 20001; telephone 202-334- 2760; fax 202-334-2759; email rap@nas.edu.

—From an NRC announcement

CAIMS/PIMS Early Career Award

The Canadian Applied and Industrial Mathematics Society (CAIMS) and the Pacific Institute for Mathematical Sciences (PIMS) sponsor the Early Career Award in Applied Mathematics to recognize exceptional research in any branch of applied mathematics, interpreted broadly. The nominee's research should have been conducted primarily in Canada or in affiliation with a Canadian university. The prize is to be awarded every year to a researcher less than ten years past the date of Ph.D. at the time of nomination.

The award consists of a cash prize of C$1,000 and a commemorative plaque presented at the CAIMS annual meeting. The recipient will be invited to deliver a plenary lecture at the CAIMS annual meeting in the year of the award. A travel allowance will be provided. The deadline for nominations is **January 31, 2012**. For more information see http://www.pims.math.ca/pims-glance/prizes-awards.

—From a PIMS announcement

Clay Mathematics Institute Summer School

The Clay Mathematics Institute (CMI) Summer School will be held in Obergurgl, Austria, from June 3 to June 30, 2012. The theme of the Summer School is "The Resolution of Singular Algebraic Varieties".

The resolution of singularities is one of the major topics in algebraic geometry. Due to its difficulty and complexity, as well as for certain historical reasons, research to date in the field has been pursued by a relatively small group of mathematicians. However, the field has begun a renaissance over the last twenty years, boosted by many small conferences and schools, with the discovery of more conceptual proofs of the characteristic zero case as well as several brilliant attempts at the still-unresolved prime characteristic case. The school will consist of three weeks of foundational courses supplemented by exercise and problem sessions designed to provide graduate students and young mathematicians with a comprehensive framework for research in this field. The fourth week will consist of minicourses with selected experts, intended to provide

participants with state-of-the-art techniques as well as a survey of some of the main open problems and the most promising approaches now under investigation. Foundational courses include Commutative Algebra for Singular Algebraic Varieties (Orlando Villamayor), Resolution of Singularities: Games and Computations (Josef Schicho), and Resolution Techniques (Herwig Hauser). Graduate students and postdoctoral fellows who are within five years of receipt of their Ph.D. may apply for financial support. The deadline for applications is **February 1, 2012**. For more information and an online application form, see the website `http://www.claymath.org/summerschool`.

—David A. Ellwood, CMI

Deadlines for AWM Programs

Listed below are deadlines for programs of the Association for Women in Mathematics (AWM). For more information see `http://www.awm-math.org`.

January 31, 2012: Entries for Essay Contest.

February 1, 2012: Applications for Travel Grants; Mentoring Travel Grants

February 4, 2012: Applications for Sonia Kovalevsky High School and Middle School Mathematics Days

April 30, 2012: Nominations for Louise Hay Award; M. Gweneth Humphreys Award

May 1, 2012: Applications for Travel Grants

August 1, 2012: Applications for Workshop for Women Graduate Students and Recent Ph.D.'s, 2013 Joint Mathematics Meetings, San Diego, California

August 4, 2012: Applications for Sonia Kovalevsky High School and Middle School Mathematics Days

October 1, 2012: Applications for Travel Grants; nominations for Alice T. Schafer Prize

October 15, 2012: Nominations for Noether Lecture

November 1, 2012: Nominations for AWM-SIAM Sonia Kovalevsky Lecture

November 1, 2012: Applications for Ruth I. Michler Memorial Prize; applications for AWM Workshop for Women Graduate Students and Recent Ph.D.'s, 2013 SIAM Annual Meeting, San Diego, California

—From an AWM announcement

Mathematics of Planet Earth Competition: Virtual Modules

Mathematics of Planet Earth 2013 (MPE2013) is a worldwide initiative that will take place in 2013 and that aims to increase the engagement of mathematicians, researchers, teachers, students, and the public with the role of mathematics in issues affecting our Planet Earth and its future. MPE2013 is sponsoring a competition for an open source exhibition of virtual modules.

The modules can be reproduced and utilized by many users around the world, from science museums to schools under Creative Commons licenses. The exhibition will have a virtual part as well as instructions to realize material parts. Examples of modules or themes to be covered are available on the competition website.

To stimulate imagination in the many domains where mathematics plays a crucial role in planetary issues, the following four themes are proposed although they are not exhaustive:

A Planet to Discover: Oceans, meteorology and climate, mantle processes, natural resources, celestial mechanics.

A Planet Supporting Life: Ecology, biodiversity, evolution.

A Planet Organized by Humans: political, economic, social and financial systems; organization of transport and communications networks; management of resources; energy.

A Planet at Risk: climate change, sustainable development, epidemics, invasive species, natural disasters.

The typical modules submitted to this competition can take any of four forms and should have some scientific explanations for the public:

1) A module explaining how to realize a physical module in a museum.

2) An interactive exhibit to be watched either on the Web or in a museum.

3) A film.

4) Image(s).

The competition will be open from **January 2012 to May 15, 2012**. The prizewinners will be selected by an international jury nominated by MPE2013 and will be announced in August 2012. The judges' decision will be final. The first, second, and third prize winners will receive respective prizes of US$5,000, US$3,000, and US$2,000. The winning modules will occupy a prominent place on the website of the exhibition. Moreover, it is planned to show the modules of the overall winners in exhibitions and museums.

For further information, visit the website of the competition: `http://www.mpe2013.org/competition`.

Editor's Note: For more on MPE, see the Opinion column in this issue of the *Notices*.

—Christiane Rousseau, chair,
Mathematics of Planet Earth 2013

Inside the AMS

2011 Trjitzinsky Memorial Awards Presented

The AMS has made awards to seven undergraduate students through the Waldemar J. Trjitzinsky Memorial Fund. The fund is made possible by a bequest from the estate of Waldemar J., Barbara G., and Juliette Trjitzinsky. The will of Barbara Trjitzinsky stipulates that the income from the bequest should be used to establish a fund in honor of the memory of her husband to assist needy students in mathematics.

For the 2011 awards, the AMS chose seven geographically distributed schools to receive one-time awards of US$3,000 each. The mathematics departments at those schools then chose students to receive the funds to assist them in pursuit of careers in mathematics. The schools are selected in a random drawing from the pool of AMS institutional members.

Waldemar J. Trjitzinsky was born in Russia in 1901 and received his doctorate from the University of California, Berkeley, in 1926. He taught at a number of institutions before taking a position at the University of Illinois, Urbana-Champaign, where he remained for the rest of his professional life. He showed particular concern for students of mathematics and in some cases made personal efforts to ensure that financial considerations would not hinder their studies. Trjitzinsky was the author of about sixty mathematics papers, primarily on quasi-analytic functions and partial differential equations. A member of the AMS for forty-six years, he died in 1973.

Following are the names of the selected schools for 2011, the names of the students receiving Trjitzinsky awards, and brief biographical sketches of the students.

Brooklyn College: MAOCAI WU. Wu, who came to Brooklyn in 2004 from China, plans to major in mathematics and actuarial mathematics programs and minor in economics and finance. He is interested in teaching, and during the past three years he has worked part time as a high school math tutor at the Brooklyn College Educational Talent Search. His goal is to become an actuary.

California State University San Marcos: JEFFREY HART. Hart is a senior mathematics major. After earning his bachelor's degree he plans to attain a Single Subject Credential in Mathematics to teach mathematics at a high school level "to encourage student interest in the subject as they go toward college." He enjoys playing board games and learning about home design and construction; he hopes one day to design and build his own home.

Central Michigan University: TYLER WIPPEL. Wippel is a second-year undergraduate student majoring in mathematics. During his first year at Central Michigan University, he engaged in a collaborative student research project on pedagogical strategies used by high school teachers in advanced placement classes. He is an honors student and is actively involved in the University Honors Program. He wants to become a high school math teacher and to share his knowledge of math with students in an inner-city school.

Colorado State University: DAVID S. ALLEN. Allen attended Phil-Mont High School in Philadelphia, where he focused on the arts. After graduation he founded a video production company. After working in the field for some time, he entered Bucks County Community College as a biology major and discovered a love for mathematics that led him to change his major. He earned his associate's degree and is now completing his bachelor's degree in general mathematics at Colorado State University. His interests include backpacking and skiing, reading, and traveling abroad. He plans to pursue graduate studies in mathematics and eventually work in academia.

University of Minnesota, Twin Cities: XAVIER E. GARCIA. Garcia moved to the United States from Colombia when he was twelve years old. He is now a mathematics major in the university honors program and serves as a tutor in the Multicultural Center for Academic Excellence on campus. He spent the summer of 2011 at Iowa State University in a Research Experience for Undergraduates program on dynamical systems. He intends to pursue a Ph.D. in mathematics.

Ohio Wesleyan University: AMINA S. MENDEZ. Mendez, now a junior mathematics major and computer science minor, comes from the Philippines. In high school she jointly authored a research paper that was published in a university scientific journal and that she presented at a regional science fair. She was awarded national and private scholarships and attended the University of the Philippines, where she was a University Scholar. She will complete her undergraduate studies at Ohio Wesleyan University (focusing on abstract algebra and statistics) and plans to continue her studies in graduate school to pursue a career in academia, partly as a tribute to her third-grade teacher, who inspired her passion for mathematics.

Texas A&M University, Corpus Christi: AMANDA N. RODRIGUEZ. Rodriguez is a first-generation college student pursuing a bachelor's degree in mathematics while tutoring her peers in advanced mathematics. Inspired by her tutoring experiences dating back to high school, she hopes to become a high school calculus teacher "so that I can instill my passion for math in my students and make the subject fun and easy to understand." She also plans to continue her studies and eventually become a mathematics professor.

—Elaine Kehoe

Erdős Memorial Lecture

The Erdős Memorial Lecture is an annual invited address named for the prolific mathematician Paul Erdős (1913–1996). The lectures are supported by a fund created by Andrew Beal, a Dallas banker and mathematics enthusiast. The Beal Prize Fund, now US$100,000, is being held by the AMS until it is awarded for a correct solution to the Beal Conjecture (see `www.math.unt.edu/~mauldin/beal.html`). At Beal's request, the interest from the fund is used to support the Erdős Memorial Lecture.

The Erdős Memorial Lecturer for 2011 was Emmanuel Candes of Stanford University, who delivered a lecture titled "Recovering the Unseen: Some Recent Advances in Low-Rank Matrix Reconstruction" at the Fall Central Section Meeting at the University of Nebraska in Lincoln, Nebraska, on October 15, 2011.

—AMS announcement

From the AMS Public Awareness Office

Joan Hutchinson (center) and Who Wants to Be a Mathematician contestants.

Arnold Ross Lecture: Joan Hutchinson (pictured above, front row, center) gave the 2011 Arnold Ross Lecture, "From Crayons to Color Graphics: How Some Mathematicians Use Color", at the Science Museum of Minnesota in St. Paul. Hutchinson explained many of the ideas and problems in chromatic graph theory to an audience of 100 students and teachers. Following the lecture, eight St. Paul-area high school students (also pictured) played Who Wants to Be a Mathematician, at which more than US$2,000 in cash and prizes was awarded. Read more about the lecture and game at `http://www.ams.org/programs/students/wwtbam/arl2011`.

MathSciNet Tutorials: MathSciNet Tutorials are now available. The tutorials cover publications, authors, journals, and citation searches, as well as the Free Tools and Preferences options, to help users learn how to take full advantage of the rich structure of the database. Researchers may well discover new features and search options to make MathSciNet an even more useful resource. Explore the tutorials at `http://www.mathscinet.info/`.

—Annette Emerson and Mike Breen,
AMS Public Awareness Officers
`paoffice@ams.org`

Deaths of AMS Members

HANS-JÜRGEN BORCHERS, professor, University of Göttingen, died on September 10, 2011. Born on January 24, 1926, he was a member of the Society for 43 years.

ALBRECHT E. DOLD, professor, University of Heidelberg, died on September 26, 2011. Born on August 5, 1928, he was a member of the Society for 54 years.

ARIE GAALSWYK, professor, Augustana College, died on June 21, 2009. Born on June 14, 1918, he was a member of the Society for 62 years.

JOHN G. HOCKING, professor, Michigan State University, died on March 23, 2011. Born on September 26, 1920, he was a member of the Society for 59 years.

LAWRENCE E. PAYNE, professor, Cornell University, died on August 11, 2011. Born on October 2, 1923, he was a member of the Society for 63 years.

JOSEPH A. PIRRAGLIA, of North Providence, Rhode Island, died on September 12, 2011. Born on July 15, 1928, he was a member of the Society for 29 years.

DANIEL G. QUILLEN, professor, University of Oxford, died on April 30, 2011. Born on June 22, 1940, he was a member of the Society for 47 years.

ROY TAKENAGA, of Pasadena, California, died on September 23, 2011. Born on April 21, 1921, he was a member of the Society for 57 years.

ERIK G. F. THOMAS, of Paterswolde, Netherlands, died on September 13, 2011. Born on February 19, 1939, he was a member of the Society for 41 years.

DANIEL B. J. TOMIUK, of Ontario, Canada, died on August 31, 2011. Born on May 15, 1927, he was a member of the Society for 53 years.

For Your Information

Mathematics Library Assistance for Developing Countries

The International Mathematical Union's Commission for Developing Countries (CDC) has launched a new plan to support shipment of textbooks to universities in less economically developed countries. CDC offers limited financial support for shipment costs to individual scientists or institutions wishing to donate books in the mathematical sciences to libraries in developing countries. Libraries in universities or research institutions in developing countries may apply to receive donated books. For more information, see the website http://imuweb.mathunion.org/cdc/further-cdc-activities/library-assistance-scheme/ or contact the CDC Administrator in the IMU Secretariat in Berlin at icmi.cdc.administrator@mathunion.org.

—CDC announcement

Reference and Book List

*The **Reference** section of the* Notices *is intended to provide the reader with frequently sought information in an easily accessible manner. New information is printed as it becomes available and is referenced after the first printing. As soon as information is updated or otherwise changed, it will be noted in this section.*

Contacting the *Notices*

The preferred method for contacting the *Notices* is electronic mail. The editor is the person to whom to send articles and letters for consideration. Articles include feature articles, memorial articles, communications, opinion pieces, and book reviews. The editor is also the person to whom to send news of unusual interest about other people's mathematics research.

The managing editor is the person to whom to send items for "Mathematics People", "Mathematics Opportunities", "For Your Information", "Reference and Book List", and "Mathematics Calendar". Requests for permissions, as well as all other inquiries, go to the managing editor.

The electronic-mail addresses are notices@math.wustl.edu in the case of the editor and notices@ams.org in the case of the managing editor. The fax numbers are 314-935-6839 for the editor and 401-331-3842 for the managing editor. Postal addresses may be found in the masthead.

Upcoming Deadlines

December 16, 2011: Applications for NDSEG Fellowships. See "Mathematics Opportunities" in this issue. For application forms see http://ndseg.asee.org/apply_online; for further information, see http://ndseg.asee.org/.

December 21, 2011: Proposals for AMS Short Courses. Send proposals to Ellen Maycock at ejm@ams.org.

December 21, 2011: Nominations for the Schauder Medal. Contact Lech Gorniewicz, tmna@mat.uni.torun.pl.

December 31, 2011: Nominations for Otto Neugebauer Prize for the History of Mathematics. See http://www.euro-math-soc.eu/node/995.

January 1, 2012: Proposals for MSRI Hot Topic Workshops for 2012. See http://www.msri.org/msri-htw.

January 1, 2012: Proposals for MSRI Summer Graduate Schools for 2012. See http://www.msri.org/msri-sgw.

January 10, 2012: Full proposals for NSF Algorithms for Threat Detection program. See "Mathematics Opportunities" in this issue.

January 10, 2012: Applications for American Association of University Women (AAUW) Selected Professions Fellowships. See http://www.aauw.org/fga/fellowships_grants/selected.cfm; or contact the AAUW Fellowships and Grants, 101 ACT Drive, P. O. Box 4030, Iowa City, IA 52243-4030; 319-337-1716, ext. 60; aauw@act.org.

January 13, 2012: Applications for Jefferson Science Fellows (JSF) program. See http://sites.nationalacademies.org/PGA/Jefferson/PGA_046612; or contact jsf@nas.edu; 202- 334-2643.

January 23, 2012: Proposals for NSF Program in Computational and Data-Enabled Science and Engineering in Mathematical and Statistical Sciences. See http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=504687&WT.mc_id=USNSF_25&WT.mc_ev=click.

January 26, 2012: Proposals for NSF Major Research Instrumentation Program. See "Mathematics Opportunities" in this issue.

January 31, 2012: Nominations for CAIMS/PIMS Early Career Award. See "Mathematics Opportunities" in this issue.

January 31, 2012: Entries for the Association for Women in Mathematics (AWM) essay contest. See http://www.awm-math.org/biographies/contest.html.

February 1, 2012: Applications for Clay Mathematics Institute Summer School. See "Mathematics Opportunities" in this issue.

February 1, 2012: Applications for AWM Travel Grants and Mentoring Travel Grants. See http://www.awm-math.org/travelgrants.html#standard; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030; 703-934- 0163; awm@awm-math.org.

February 1, 2012: Applications for National Academies Research Associateship Programs. See "Mathematics Opportunities" in this issue.

February 12, 2012: Applications for IPAM summer program, Research in Industrial Projects for Students (RIPS). See www.ipam.ucla.edu.

February 15, 2012: Applications for AMS Congressional Fellowship. See http://www.ams.org/programs/ams-fellowships/ams-aaas/ams-aaas-congressional-fellowship or contact the AMS Washington Office at 202-588-1100; amsdc@ams.org.

May 1, 2012: Applications for National Academies Research Associateship Programs. See "Mathematics Opportunities" in this issue.

May 1, 2012: Applications for National Academies Christine Mirzayan Graduate Fellowship Program for fall 2012. See the website http://sites.nationalacademies.org/PGA/policyfellows/index.htm or contact The National Academies Christine Mirzayan Science and Technology Policy Graduate Fellowship Program, 500 Fifth Street, NW, Room 508, Washington, DC 20001; telephone: 202-334-2455; fax: 202- 334-1667; email: policyfellows@nas.edu.

May 1, 2012: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html#standard; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030; 703-934-0163; awm@awm-math.org.

July 10, 2012: Full proposals for NSF Research Networks in the Mathematical Sciences. See http://www.nsf.gov/pubs/2010/nsf10584/nsf10584.htm?WT.mc_id=USNSF_25&WT.mc_ev=click.

August 1, 2012: Applications for National Academies Research Associateship Programs. See "Mathematics Opportunities" in this issue.

October 1, 2012: Applications for AWM Travel Grants. See http://www.awm-math.org/travelgrants.html#standard; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030; 703-934-0163; awm@awm-math.org.

November 1, 2012: Applications for National Academies Research Associateship Programs. See "Mathematics Opportunities" in this issue.

Where to Find It

A brief index to information that appears in this and previous issues of the *Notices*.

AMS Bylaws—*January 2012, p. 73*

AMS Email Addresses—*February 2011, p. 326*

AMS Ethical Guidelines—*June/July 2006, p. 701*

AMS Officers 2010 and 2011 Updates—*May 2011, p. 735*

AMS Officers and Committee Members—*October 2011, p. 1311*

Conference Board of the Mathematical Sciences—*September 2011, p. 1142*

IMU Executive Committee—*December 2011, p. 1606*

Information for *Notices* Authors—*June/July 2011, p. 845*

Mathematics Research Institutes Contact Information—*August 2011, p. 973*

National Science Board—*January 2012, p. 68*

New Journals for 2008—*June/July 2009, p. 751*

NRC Board on Mathematical Sciences and Their Applications—*March 2011, p. 482*

NRC Mathematical Sciences Education Board—*April 2011, p. 619*

NSF Mathematical and Physical Sciences Advisory Committee—*February 2011, p. 329*

Program Officers for Federal Funding Agencies—*October 2011, p. 1306 (DoD, DoE); December 2011, page 1606 (NSF Mathematics Education)*

Program Officers for NSF Division of Mathematical Sciences—*November 2011, p. 1472*

National Science Board

The National Science Board is the policymaking body of the National Science Foundation. Listed below are the current members of the NSB. For further information, visit the website http://www.nsf.gov/nsb/.

Mark R. Abbott
Dean and Professor
College of Oceanic and Atmospheric Sciences
Oregon State University

Dan E. Arvizu
Director and Chief Executive

National Renewable Energy Laboratory

Camilla P. Benbow
Patricia and Rodes Hart Dean of Education and Human Development
Peabody College
Vanderbilt University

Ray M. Bowen (Chair)
President Emeritus
Texas A&M University

John T. Bruer
President
James S. McDonnell Foundation
St. Louis, Missouri

France A. Cordova
President
Purdue University

Kelvin K. Droegemeier
Vice President for Research
University of Oklahoma

Patricia D. Galloway
Chief Executive Officer
Pegasus Global Holding, Inc.

José-Marie Griffiths
Vice President for Academic Affairs
Bryant University

Esin Gulari (Vice Chair)
Dean of Engineering and Science
Clemson University

Alan Leshner
Chief Executive Officer and Executive Publisher, *Science*
American Association for the Advancement of Science

W. Carl Lineberger
E. U. Condon Distinguished Professor of Chemistry
University of Colorado

G. P. Peterson
President
Georgia Institute of Technology

Douglas D. Randall
Professor of Biochemistry and Thomas Jefferson Fellow
Director, Interdisciplinary Plant Group
University of Missouri

Arthur K. Reilly
Retired Senior Director
Cisco Systems, Inc.

Diane L. Souvaine
Professor, Computer Science
Tufts University

Arnold F. Stancell
Emeritus Professor and Turner Leadership Chair
School of Chemical and Biomolecular Engineering
Georgia Institute of Technology

Thomas N. Taylor
Roy A. Roberts Distinguished Professor
Department of Ecology and Evolutionary Biology
Curator of Paleobotany in the Natural History Museum and Biodiversity Research Center
University of Kansas

Richard F. Thompson
Keck Professor of Psychology and Biological Sciences
University of Southern California

Robert J. Zimmer
President
University of Chicago

The contact information for the Board is: National Science Board, National Science Foundation, 4201 Wilson Boulevard, Room 1225N, Arlington, VA 22230; telephone 703-292- 7000; World Wide Web `http://www.nsf.gov/nsb/`.

Book List

The Book List highlights books that have mathematical themes and are aimed at a broad audience potentially including mathematicians, students, and the general public. When a book has been reviewed in the Notices, *a reference is given to the review. Generally the list will contain only books published within the last two years, though exceptions may be made in cases where current events (e.g., the death of a prominent mathematician, coverage of a certain piece of mathematics in the news) warrant drawing readers' attention to older books. Suggestions for books to include on the list may be sent to* `notices-booklist@ams.org`.

*Added to "Book List" since the list's last appearance.

The Adventure of Reason: Interplay between Philosophy of Mathematics and Mathematical Logic, 1900–1940, by Paolo Mancosu. Oxford University Press, January 2011. ISBN-13: 978-01995-465-34.

**Adventures in Group Theory: Rubik's Cube, Merlin's Machine, and Other Mathematical Toys,* by David Joyner. Johns Hopkins University Press (second edition), December 2008. ISBN: 978-08018-9013-0.

At Home with André and Simone Weil, by Sylvie Weil. (Translation of *Chez les Weils*, translated by Benjamin Ivry.) Northwestern University Press, October 2010. ISBN-13: 978-08101-270-43. (Reviewed May 2011.)

The Autonomy of Mathematical Knowledge: Hilbert's Program Revisited, by Curtis Franks. Cambridge University Press, December 2010. ISBN-13: 978-05211-838-95.

The Beginning of Infinity: Explanations That Transform the World, by David Deutsch. Viking Adult, July 2011. ISBN-13: 978-06700-227-55.

The Best Writing on Mathematics: 2010, edited by Mircea Pitici. Princeton University Press, December 2010. ISBN-13: 978-06911-484-10. (Reviewed November 2011.)

The Big Questions: Mathematics, by Tony Crilly. Quercus, April 2011. ISBN-13: 978-18491-624-01.

The Black Swan: The Impact of the Highly Improbable, by Nassim Nicholas Taleb. Random House Trade Paperbacks, second edition, May 2010. ISBN-13: 978-08129-738-15. (First edition reviewed March 2011.)

The Blind Spot: Science and the Crisis of Uncertainty, by William Byers. Princeton University Press, April 2011. ISBN-13:978-06911-468-43.

The Calculus Diaries: How Math Can Help You Lose Weight, Win in Vegas, and Survive a Zombie Apocalypse, by Jennifer Ouellette.

Penguin, reprint edition, August 2010. ISBN-13: 978-01431-173-77.

The Calculus of Selfishness, by Karl Sigmund. Princeton University Press, January 2010. ISBN-13: 978-06911-427-53. (Reviewed in this issue.)

Chasing Shadows: Mathematics, Astronomy, and the Early History of Eclipse Reckoning, by Clemency Montelle. Johns Hopkins University Press, April 2011. ISBN-13: 978-08018-969-10.

The Clockwork Universe: Isaac Newton, the Royal Society, and the Birth of the Modern World, by Edward Dolnick. Harper, February 2011. ISBN-13: 978-00617-195-16. (Reviewed April 2011.)

Complexity: A Guided Tour, by Melanie Mitchell. Oxford University Press, April 2009. ISBN-13: 978-01951-244-15. (Reviewed April 2011.)

Crafting by Concepts: Fiber Arts and Mathematics, by Sarah-Marie Belcastro and Carolyn Yackel. A K Peters/CRC Press, March 2011. ISBN-13: 978-15688-143-53.

Cycles of Time: An Extraordinary New View of the Universe, by Roger Penrose. Knopf, May 2011. ISBN-13: 978-03072-659-06.

Divine Machines: Leibniz and the Sciences of Life, by Justin E. H. Smith. Princeton University Press, May 2011. ISBN-13: 978-06911-417-87.

Duel at Dawn: Heroes, Martyrs, and the Rise of Modern Mathematics, by Amir Alexander. Harvard University Press, April 2010. ISBN-13: 978-06740-466-10. (Reviewed November 2010.)

An Early History of Recursive Functions and Computability from Gödel to Turing, by Rod Adams. Docent Press, May 2011. ISBN-13: 978-09837-004-01.

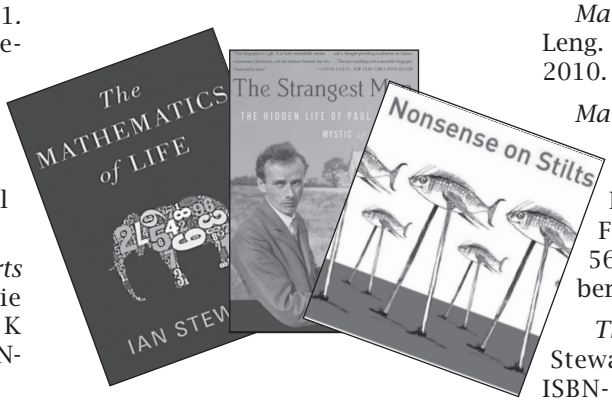
The Evolution of Logic, by W. D. Hart. Cambridge University Press, August 2010. ISBN-13: 978-0-521-74772-1

Fascinating Mathematical People: Interviews and Memoirs, edited by Donald J. Albers and Gerald L. Alexanderson. Princeton University Press, October 2011. ISBN: 978-06911-482-98.

Gottfried Wilhelm Leibniz: The Polymath Who Brought Us Calculus, by M. B. W. Tent. AK Peters/CRC Press, October 2011. ISBN: 978-14398-922-20.

The Grand Design, by Stephen Hawking and Leonard Mlodinow. Bantam, September 2010. ISBN-13: 978-05538-053-76.

Hidden Harmonies (The Lives and Times of the Pythagorean Theorem), by Robert and Ellen Kaplan. Bloomsbury Press, January 2011. ISBN-13: 978-15969-152-20.



The History and Development of Nomography, by H. A. Evesham. Docent Press, December 2010. ISBN-13: 978-14564-796-26.

Hot X: Algebra Exposed, by Danica McKellar. Hudson Street Press, August 2010. ISBN-13: 978-15946-307-05.

I Want to Be a Mathematician: A Conversation with Paul Halmos. A film by George Csicsery. Mathematical Association of America, March 2009. ISBN-13: 978-08838-590-94. (Reviewed June/July 2011.)

**Knots Unravelled: From String to Mathematics,* by Meike Akveld and Andrew Jobbings. Arbelos, October 2011. ISBN: 978-09555-477-20.

Le Operazioni del Calcolo Logico, by Ernst Schröder. Original German version of Operationskreis des Logikkalkuls and Italian translation with commentary and annotations by Davide Bondoni. LED Online, 2010. ISBN-13: 978-88-7916-474-0.

Loving + Hating Mathematics: Challenging the Myths of Mathematical Life, by Reuben Hersh and Vera John-Steiner. Princeton University Press, January 2011. ISBN-13: 978-06911-424-70.

Magical Mathematics: The Mathematical Ideas that Animate Great Magic Tricks, by Persi Diaconis and Ron Graham. Princeton University Press, November 2011. ISBN: 978-06911-516-49.

A Mathematician's Lament: How School Cheats Us Out of Our Most Fascinating and Imaginative Art Form, by Paul Lockhart. Bellevue Literary Press, April 2009. ISBN-13: 978-1-934137-17-8.

Mathematics and Reality, by Mary Leng. Oxford University Press, June 2010. ISBN-13: 978-01992-807-97.

Mathematics Education for a New Era: Video Games as a Medium for Learning, by Keith Devlin. A K Peters/CRC Press, February 2011. ISBN-13: 978-1-56881-431-5. (Reviewed December 2011.)

The Mathematics of Life, by Ian Stewart. Basic Books, June 2011. ISBN-13: 978-04650-223-80. (Reviewed in this issue.)

Mathematics, Religion and Ethics: An Epistemological Study, by Salilesh Mukhopadhyay. Feasible Solution LLC, September 2010. ISBN: 978-1-4507-3558-2.

Mysteries of the Equilateral Triangle, by Brian J. McCartin. Hikari, August 2010. ISBN-13: 978-954-91999-5-6. Electronic copies available for free at `http://www.m-hikari.com/mccartin-2.pdf`.

Newton and the Counterfeiter: The Unknown Detective Career of the World's Greatest Scientist, by Thomas Levenson. Houghton Mifflin Harcourt, June 2009. ISBN-13: 978-01510-127-87.

NIST Handbook of Mathematical Functions, Cambridge University Press, Edited by Frank W. J. Olver, Daniel W. Lozier, Ronald F. Boisvert, and Charles W. Clark. Cambridge University Press, May 2010. ISBN-13: 978-05211-922-55 (hardback plus CD-ROM); ISBN-13: 978-05211-406-38 (paperback plus CD-ROM). (Reviewed September 2011.)

Nonsense on Stilts: How to Tell Science from Bunk, by Massimo Pigliucci. University of Chicago Press, May 2010. ISBN-13: 978-02266-678-67. (Reviewed April 2011.)

Number Freak: From 1 to 200—The Hidden Language of Numbers Revealed, by Derrick Niederman. Perigee Trade, August 2009. ISBN-10: 03995-345-98.

Numbers: A Very Short Introduction, by Peter M. Higgins. Oxford University Press, February 2011. ISBN-13: 978-0-19-958405-5. (Reviewed in this issue.)

One, Two, Three: Absolutely Elementary Mathematics [Hardcover] David Berlinski. Pantheon, May 2011. ISBN-13: 978-03754-233-38.

Origami Inspirations, by Meenakshi Mukerji. A K Peters, September 2010. ISBN-13: 978-1568815848.

The Perfect Swarm: The Science of Complexity in Everyday Life, by Len Fisher. Basic Books, March 2011 (paperback). ISBN-13: 978-04650-202-49.

The Pleasures of Statistics: The Autobiography of Frederick Mosteller. Edited by Stephen E. Fienberg, David C. Hoaglin, and Judith M. Tanur. Springer, January 2010. ISBN-13: 978-03877-795-53.

Problem-Solving and Selected Topics in Number Theory in the Spirit of the Mathematical Olympiads, by Michael Th. Rassias. Springer, 2011. ISBN-13: 978-1-4419-0494-2.

Proof and Other Dilemmas: Mathematics and Philosophy, edited by Bonnie Gold and Roger A. Simons. Mathematical Association of America, July 2008. ISBN-13: 978-08838-556-76. (Reviewed December 2011.)

The Proof is in the Pudding: A Look at the Changing Nature of Mathematical Proof, by Steven G. Krantz. Springer, May 2011. ISBN: 978-03874-890-87.

Proofiness: The Dark Arts of Mathematical Deception, by Charles Seife. Viking, September 2010. ISBN-13: 978-06700-221-68.

The Quants: How a New Breed of Math Whizzes Conquered Wall Street and Nearly Destroyed It, by Scott Patterson. Crown Business, January 2011. ISBN-13: 978-03074-533-89. (Reviewed May 2011.)

Riot at the Calc Exam and Other Mathematically Bent Stories, by Colin Adams. AMS, July 2009. ISBN-13: 978-08218-481-73.

Roads to Infinity: The Mathematics of Truth and Proof, by John C. Stillwell. A K Peters/CRC Press, July 2010. ISBN-13: 978-15688-146-67.

The Shape of Inner Space: String Theory and the Geometry of the Universe's Hidden Dimensions, by Shing-Tung Yau (with Steve Nadis). Basic Books, September 2010. ISBN-13: 978-04650-202-32. (Reviewed February 2011.)

The Strangest Man, by Graham Farmelo. Basic Books, August 2009. ISBN-13: 978-04650-182-77. (Reviewed October 2011.)

Street-Fighting Mathematics: The Art of Educated Guessing and Opportunistic Problem Solving, by Sanjoy Mahajan. MIT Press, March 2010. ISBN-13: 978-0-262-51429-3. (Reviewed August 2011.)

Survival Guide for Outsiders: How to Protect Yourself from Politicians, Experts, and Other Insiders, by Sherman Stein. BookSurge Publishing, February 2010. ISBN-13: 978-14392-532-74.

The Theory That Would Not Die: How Bayes' Rule Cracked the Enigma Code, Hunted Down Russian Submarines, and Emerged Triumphant from Two Centuries of Controversy, by Sharon Bertsch McGrayne. Yale University Press, April 2011. ISBN-13: 978-03001-696-90.

Towards a Philosophy of Real Mathematics, by David Corfield. Oxford University Press, April 2003. ISBN-13: 0-521-81722-6. (Reviewed November 2011.)

Train Your Brain: A Year's Worth of Puzzles, by George Grätzer. A K Peters/CRC Press, April 2011. ISBN-13: 978-15688-171-01.

Viewpoints: Mathematical Perspective and Fractal Geometry in Art, by Marc Frantz and Annalisa Crannell. Princeton University Press, August 2011. ISBN-13: 978-06911-259-23.

Visual Thinking in Mathematics, by Marcus Giaquinto. Oxford University Press, July 2011. ISBN-13: 978-01995-755-34.

What's Luck Got to Do with It? The History, Mathematics and Psychology of the Gambler's Illusion, by Joseph Mazur. Princeton University Press, July 2010. ISBN-13: 978-069-113890-9.

Why Beliefs Matter: Reflections on the Nature of Science, by E. Brian Davies. Oxford University Press, June 2010. ISBN13: 978-01995-862-02.

D. R. Fulkerson Prize

CALL FOR NOMINATIONS

The Fulkerson Prize Committee invites nominations for the Delbert Ray Fulkerson Prize, sponsored jointly by the Mathematical Optimization Society (MOS) and the American Mathematical Society. Up to three awards of US$1,500 each are presented at each (triennial) International Symposium of the MOS. The Fulkerson Prize is for outstanding papers in the area of discrete mathematics. The prize will be awarded at the 21st International Symposium on Mathematical Programming to be held in Berlin, Germany, on August 19-24, 2012.

Eligible papers should represent the final publication of the main result(s) and should have been published in a recognized journal or in a comparable, well-refereed volume intended to publish final publications only, during the six calendar years preceding the year of the Symposium (thus, from January 2006 through December 2011). The prizes will be given for single papers, not series of papers or books, and in the event of joint authorship the prize will be divided.

The term "discrete mathematics" is interpreted broadly and is intended to include graph theory, networks, mathematical programming, applied combinatorics, applications of discrete mathematics to computer science, and related subjects. While research work in these areas is usually not far removed from practical applications, the judging of papers will only be based on their mathematical quality and significance. Further information about the Fulkerson Prize can be found at **www.mathprog.org/?nav=fulkerson** and at **www.ams.org/prizes/fulkerson-prize.html**.

The Fulkerson Prize Committee consists of Karen I. Aardal (Delft Institute of Applied Mathematics), Paul Seymour (Princeton University), chair, and Richard Stanley (Massachusetts Institute of Technology). Please send your nominations (including reference to the nominated article and an evaluation of the work) by February 15, 2012, to the chair of the committee. Electronic submissions to pds@math.princeton.edu are preferred.

Paul Seymour
Department of Mathematics
201 Fine Hall
Washington Road
Princeton University
Princeton, NJ 08544 USA

AMS
AMERICAN MATHEMATICAL SOCIETY

From the AMS Secretary

Bylaws of the American Mathematical Society

Article I

Officers

Section 1. There shall be a president, a president elect (during the even-numbered years only), an immediate past president (during the odd-numbered years only), three vice presidents, a secretary, four associate secretaries, a treasurer, and an associate treasurer.

Section 2. It shall be a duty of the president to deliver an address before the Society at the close of the term of office or within one year thereafter.

Article II

Board of Trustees

Section 1. There shall be a Board of Trustees consisting of eight trustees, five trustees elected by the Society in accordance with Article VII, together with the president, the treasurer, and the associate treasurer of the Society *ex officio*. The Board of Trustees shall designate its own presiding officer and secretary.

Section 2. The function of the Board of Trustees shall be to receive and administer the funds of the Society, to have full legal control of its investments and properties, to make contracts, and, in general, to conduct all business affairs of the Society.

Section 3. The Board of Trustees shall have the power to appoint such assistants and agents as may be necessary or convenient to facilitate the conduct of the affairs of the Society and to fix the terms and conditions of their employment. The Board may delegate to the officers of the Society duties and powers normally inhering in their respective corporative offices, subject to supervision by the Board. The Board of Trustees may appoint committees to facilitate the conduct of the financial business of the Society and delegate to such committees such powers as may be necessary or convenient for the proper exercise of those powers. Agents appointed, or members of committees designated, by the Board of Trustees need not be members of the Board.

Nothing herein contained shall be construed to empower the Board of Trustees to divest itself of responsibility for, or legal control of, the investments, properties, and contracts of the Society.

Article III

Committees

Section 1. There shall be eight editorial committees as follows: committees for the *Bulletin*, for the *Proceedings*, for the *Colloquium Publications*, for the *Journal*, for *Mathematical Surveys and Monographs*, for *Mathematical Reviews*; a joint committee for the *Transactions* and the *Memoirs*; and a committee for *Mathematics of Computation*.

Section 2. The size of each committee shall be determined by the Council.

Article IV

Council

Section 1. The Council shall consist of fifteen members at large and the following *ex officio* members: the officers of the Society specified in Article I, except that it shall include only one associate secretary, the chairman of each of the editorial committees specified in Article III, any former secretary for a period of two years following the terms of office, and members of the Executive Committee (Article V) who remain on the Council by the operation of Article VII, Section 4.

The chairman of any committee designated as a Council member may name a deputy from the committee as substitute. The associate secretary shall be the one charged with the scientific program of the meeting at which the Council meets except that at a meeting associated with no scientific meeting of the Society the secretary may designate the associate secretary.

Section 2. The Council shall formulate and administer the scientific policies of the Society and shall act in an advisory capacity to the Board of Trustees.

Section 3. In the absence of the secretary from any meeting of the Council, a member may be designated as acting secretary for the meeting, either by written authorization of the secretary, or, failing that, by the presiding officer.

Section 4. All members of the Council shall be voting members. Each member, including deputies and the designated associate secretary, shall have one vote. The method for settling matters before the Council at any meeting shall be by majority vote of the members present. If the result of a vote is challenged, it shall be the duty of the presiding officer to determine the true vote by a roll call. In a roll call vote, each Council member shall vote only once (although possibly a member of the Council in several capacities).

Section 5. Any five members of the Council shall constitute a quorum for the transaction of business at any meeting of the Council.

Section 6. Between meetings of the Council, business may be transacted. Votes shall be counted as specified in Section 4 of this Article, "members present" being replaced by "members voting". An affirmative vote on any proposal shall be declared if, and only if, (a) more than half of the total number of possible votes is received by the time announced for the closing of the polls, and (b) at least three-quarters of the votes received by then are affirmative. If five or more members request postponement at the time of voting, action on the matter at issue shall be postponed until the next meeting of the Council, unless either (1) at the discretion of the secretary, the question is made the subject of a second vote, in connection with which brief statements of reason, for and against, are circulated; or (2) the Council places the matter at issue before the Executive Committee for action.

Section 7. The Council may delegate to the Executive Committee certain of its duties and powers. Between meetings of the Council, the Executive Committee shall act for the Council on such matters and in such ways as the Council may specify. Nothing herein contained shall be construed as empowering the Council to divest itself of responsibility for formulating and administering the scientific policies of the Society.

Section 8. The Council shall also have power to speak in the name of the Society with respect to matters affecting the status of mathematics or mathematicians, such as proposed or enacted federal or state legislation; conditions of employment in universities, colleges, or business, research or industrial organizations; regulations, policies, or acts of governmental agencies or instrumentalities; and other items which tend to affect the dignity and effective position of mathematics.

With the exception noted in the next paragraph, a favorable vote of two-thirds of the entire membership of the Council shall be necessary to authorize any statement in the name of the Society with respect to such matters. With the exception noted in the next paragraph, such a vote may be taken only if written notice shall have been given to the secretary by the proposer of any such resolution not later than one month prior to the Council meeting at which the matter is to be presented, and the vote shall be taken not earlier than one month after the resolution has been discussed by the Council.

If, at a meeting of the Council, there are present twelve members, then the prior notification to the secretary may be waived by unanimous consent. In such a case, a unanimous favorable vote by those present shall empower the Council to speak in the name of the Society.

The Council may also refer the matter to a referendum of the entire membership of the Society and shall make such reference if a referendum is requested, prior to final action by the Council, by two hundred or more members. The taking of a referendum shall act as a stay upon Council action until the votes have been canvassed, and thereafter no action may be taken by the Council except in accordance with a plurality of the votes cast in the referendum.

Article V

Executive Committee

Section 1. There shall be an Executive Committee of the Council, consisting of four elected members and the following *ex officio* members: the president, the secretary, the president elect (during even-numbered years), and the immediate past president (during odd-numbered years).

Section 2. The Executive Committee of the Council shall be empowered to act for the Council on matters which have been delegated to the Executive Committee by the Council. If three members of the Executive Committee request that any matter be referred to the Council, the matter shall be so referred. The Executive Committee shall be responsible to the Council and shall report its actions to the Council. It may consider the agenda for meetings of the Council and may make recommendations to the Council.

Section 3. Each member of the Executive Committee shall have one vote. An affirmative vote on any proposal before the Executive Committee shall be declared if, and only if, at least four affirmative votes are cast for the proposal. A vote on any proposal may be determined at a meeting of the Executive Committee, but it shall not be necessary to hold a meeting to determine a vote.

Article VI

Executive Director

Section 1. There shall be an Executive Director who shall be a paid employee of the Society. The Executive Director shall have charge of the offices of the Society, except for the office of the secretary, and shall be responsible for the general administration of the affairs of the Society in accordance with the policies that are set by the Board of Trustees and by the Council.

Section 2. The Executive Director shall be appointed by the Board of Trustees with the consent of the Council. The terms and conditions of employment shall be fixed by the Board of Trustees, and the performance of the Executive Director will be reviewed regularly by the Board of Trustees.

Section 3. The Executive Director shall be responsible to and shall consult regularly with a liaison committee consisting of the president as chair, the secretary, the treasurer, and the chair of the Board of Trustees.

Section 4. The Executive Director shall attend meetings of the Board of Trustees, the Council, and the Executive Committee, but shall not be a member of any of these bodies.

Article VII

Election of Officers and Terms of Office

Section 1. The term of office shall be one year in the case of the president elect and the immediate past president; two years in the case of the president, the secretary, the associate secretaries, the treasurer, and the associate treasurer; three years in the case of vice presidents and members at large of the Council, one vice president and five members at large retiring annually; and five years in the case of the trustees. In the case of members of the editorial committees and appointed members of the communications committees, the term of office shall be determined by the Council. The term of office for elected members of the Executive Committee shall be four years, one of the elected members retiring annually. All terms of office shall begin on February 1 and terminate on January 31, with the exception that the officials specified in Articles I, II, III, IV, and V (excepting the president elect and immediate past president) shall continue to serve until their successors have been duly elected or appointed and qualified.

Section 2. The president elect, the vice presidents, the trustees, and the members at large of the Council shall be elected by ballot. The secretary shall send notification to each member of the Society about the slate of candidates and the voting procedure on or before October 10, and legitimate ballots received by an established deadline at least 30 days later will be counted. Each ballot shall contain one or more names proposed by the Council for each office to be filled, with blank spaces in which the voter may substitute other names. A plurality of all votes cast shall be necessary for election. In case of failure to secure a plurality for any office, the Council shall choose by ballot among the members having the highest number of votes. The secretary, the associate secretaries, the treasurer, and the associate treasurer shall be appointed by the Council in a manner designated by the Council. Each committee named in Article III shall be appointed by the Council in a manner designated by the Council. Each such committee shall elect one of its members as chairman in a manner designated by the Council.

Section 3. The president becomes immediate past president at the end of the term of office and the president elect becomes president.

Section 4. On or before February 15, the secretary shall send to all members of the Council a ballot containing two names for each place to be filled on the Executive Committee. The nominees shall be chosen by a committee appointed by the president. Members of the Council may vote for persons not nominated. Any member of the Council who is not an *ex officio* member of the Executive Committee (see Article V, Section 1) shall be eligible for election to the Executive Committee. In case a member is elected to the Executive Committee for a term extending beyond the regular term on the Council, that person shall automatically continue as a member of the Council during the remainder of that term on the Executive Committee.

Section 5. The president and vice presidents shall not be eligible for immediate re-election to their respective offices. A member at large or an *ex officio* member of the Council shall not be eligible for immediate election (or re-election) as a member at large of the Council.

Section 6. If the president of the Society should die or resign while a president elect is in office, the president elect shall serve as president for the remainder of the year and thereafter shall serve the regular two-year term. If the president of the Society should die or resign when no president elect is in office, the Council, with the approval of the Board of Trustees, shall designate one of the vice presidents to serve as president for the balance of the regular presidential term. If the president elect of the Society should die or resign before becoming president, the office shall remain vacant until the next regular election of a president elect, and the Society shall, at the next annual meeting, elect a president for a two-year term. If the immediate past president should die or resign before expiration of the term of office, the Council, with the approval of the Board of Trustees, shall designate a former president of the Society to serve as immediate past president during the remainder of the regular term of the immediate past president. Such vacancies as may occur at any time in the group consisting of the vice presidents, the secretary, the associate secretaries, the treasurer, and the associate treasurer shall be filled by the Council with the approval of the Board of Trustees. If a member of an editorial or communications committee should take temporary leave from duties, the Council shall then appoint a substitute. The Council shall fill from its own membership any vacancy in the elected membership of the Executive Committee.

Section 7. If any elected trustee should die while in office or resign, the vacancy thus created shall be filled for the unexpired term by the Board of Trustees.

Section 8. If any member at large of the Council should die or resign more than one year before the expiration of the term, the vacancy for the unexpired term shall be filled by the Society at the next annual meeting.

Section 9. In case any officer should die or decline to serve between the time of election and the time to assume office, the vacancy shall be filled in the same manner as if that officer had served one day of the term.

Article VIII

Members and Their Election

Section 1. Election of members shall be by vote of the Council or of its Executive Committee.

Section 2. There shall be four classes of members, namely, ordinary, contributing, corporate, and institutional.

Section 3. Application for admission to ordinary membership shall be made by the applicant on a blank provided

by the secretary. Such applications shall not be acted upon until at least thirty days after their presentation to the Council (at a meeting or by mail), except in the case of members of other societies entering under special action of the Council approved by the Board of Trustees.

Section 4. An ordinary member may become a contributing member by paying the dues for such membership. (See Article IX, Section 3.)

Section 5. A university or college, or a firm, corporation, or association interested in the support of mathematics may be elected a corporate or an institutional member.

Article IX

Dues and Privileges of Members

Section 1. Any applicant shall be admitted to ordinary membership immediately upon election by the Council (Article VIII) and the discharge within sixty days of election of the first annual dues. Dues may be discharged by payment or by remission when the provision of Section 7 of this Article is applicable. The first annual dues shall apply to the year of election, except that any applicant elected after August 15 of any year may elect to have the first annual dues apply to the following year.

Section 2. The annual dues of an ordinary member of the Society shall be established by the Council with the approval of the Trustees. The Council, with the approval of the Trustees, may establish special rates in exceptional cases and for members of an organization with which the Society has a reciprocity agreement.

Section 3. The minimum dues for a contributing member shall be three-halves of the dues of an ordinary member per year. Members may, upon their own initiative, pay larger dues.

Section 4. The minimum dues of an institutional member shall depend on the scholarly activity of that member. The formula for computing these dues shall be established from time to time by the Council, subject to approval by the Board of Trustees. Institutions may pay larger dues than the computed minimum.

Section 5. The privileges of an institutional member shall depend on its dues in a manner to be determined by the Council, subject to approval by the Board of Trustees. These privileges shall be in terms of Society publications to be received by the institution and of the number of persons it may nominate for ordinary membership in the Society.

Section 6. Dues and privileges of corporate members of the Society shall be established by the Council subject to approval by the Board of Trustees.

Section 7. The dues of an ordinary member of the Society shall be remitted for any years during which that member is the nominee of an institutional member.

Section 8. After retirement from active service on account of age or on account of long-term disability, any ordinary or contributing member who is not in arrears of dues and with membership extending over at least twenty years may, by giving proper notification to the secretary, have dues remitted. Such a member shall receive the *Notices* and may request to receive *Bulletin* as privileges of membership during each year until membership ends.

Section 9. An ordinary or contributing member shall receive the *Notices* and *Bulletin* as privileges of membership during each year for which dues have been discharged.

Section 10. The annual dues of ordinary, contributing, and corporate members shall be due by January 1 of the year to which they apply. The Society shall submit bills for dues. If the annual dues of any member remain undischarged beyond what the Board of Trustees deems to be a reasonable time, the name of that member shall be removed from the list of members after due notice. A member wishing to discontinue membership at any time shall submit a resignation in writing to the Society.

Section 11. An eligible member may become a life member by making a one-time payment of dues. The criteria for eligibility and the amount of dues shall be established by the Council, subject to approval by the Board of Trustees. A life member is subsequently relieved of the obligation of paying dues. The status and privileges are those of ordinary members.

An eligible member of the Society by reciprocity who asserts the intention of continuing to be a member by reciprocity may purchase a life membership by a one-time payment of dues. The criteria for eligibility and the amount of dues shall be established by the Council, subject to approval by the Board of Trustees.

Article X

Meetings

Section 1. The annual meeting of the Society shall be held between the fifteenth of December and the tenth of February next following. Notice of the time and place of this meeting shall be sent by the secretary or an associate secretary to each member of the Society. The times and places of the annual and other meetings of the Society shall be designated by the Council.

Section 2. There shall be a business meeting of the Society only at the annual meeting. The agenda for the business meeting shall be determined by the Council. A business meeting of the Society can take action only on items notified to the full membership of the Society in the call for the meeting. A business meeting can act on items recommended to it jointly by the Council and the Board of Trustees; a majority of members present and voting is required for passage of such an item. A business meeting of the Society can place action items on the agenda for a future business meeting. Final action on an item proposed by a previous business meeting can be taken only provided there is a quorum of 400 members, a majority of members at a business meeting with a quorum being required for passage of such an item.

Section 3. Meetings of the Executive Committee may be called by the president. The president shall call a meeting at any time upon the written request of two of its members.

Section 4. The Council shall meet at the annual meeting of the Society. Special meetings of the Council may be called by the president. The president shall call a special meeting at any time upon the written request of five of its members. No special meeting of the Council shall be held unless written notice of it shall have been sent to all

members of the Council at least ten days before the day set for the meeting.

Section 5. The Board of Trustees shall hold at least one meeting in each calendar year. Meetings of the Board of Trustees may be called by the president, the treasurer, or the secretary of the Society upon three days' notice of such meetings sent to each trustee. The secretary of the Society shall call a meeting upon the receipt of a written request of two of the trustees. Meetings may also be held by common consent of all the trustees.

Section 6. Papers intended for presentation at any meeting of the Society shall be passed upon in advance by a program committee appointed by or under the authority of the Council, and only such papers shall be presented as shall have been approved by such committee. Papers in form unsuitable for publication, if accepted for presentation, shall be referred to on the program as preliminary communications or reports.

Article XI

Publications

Section 1. The Society shall publish an official organ called the *Bulletin of the American Mathematical Society*. It shall publish four journals, known as the *Journal of the American Mathematical Society*, the *Transactions of the American Mathematical Society*, the *Proceedings of the American Mathematical Society*, and *Mathematics of Computation*. It shall publish a series of mathematical papers known as the *Memoirs of the American Mathematical Society*. The object of the *Journal*, *Transactions*, *Proceedings*, *Memoirs*, and *Mathematics of Computation* is to make known important mathematical researches. It shall publish a periodical called *Mathematical Reviews*, containing abstracts or reviews of current mathematical literature. It shall publish a series of volumes called *Colloquium Publications* which shall embody in book form new mathematical developments. It shall publish a series of monographs called *Mathematical Surveys and Monographs* which shall furnish expositions of the principal methods and results of particular fields of mathematical research. It shall publish a news periodical known as the *Notices of the American Mathematical Society*, containing programs of meetings, items of news of particular interest to mathematicians, and such other materials as the Council may direct.

Section 2. The editorial management of the publications of the Society listed in Section 1 of this article, with the exception of the *Notices*, shall be in the charge of the respective editorial committees as provided in Article III, Section 1. The editorial management of the *Notices* shall be in the hands of a committee chosen in a manner established by the Council.

Article XII

Indemnification

Any person who at any time serves or has served as a trustee or officer of the Society, or as a member of the Council, or, at the request of the Society, as a director or officer of another corporation, whether for profit or not for profit, shall be indemnified by the Society and be reimbursed against and for expenses actually and necessarily incurred in connection with the defense or reasonable settlement of any action, suit, legal or administrative proceeding, whether civil, criminal, administrative or investigative, threatened, pending or completed, to which that person is made a party by reason of being or having been such trustee, officer or director or Council member, except in relation to matters as to which the person shall be adjudged in such action, suit, or proceeding to be liable for negligence or misconduct in the performance of official duties. Such right of indemnification and reimbursement shall also extend to the personal representatives of any such person and shall be in addition to and not in substitution for any other rights to which such person or personal representatives may now or hereafter be entitled by virtue of the provisions of applicable law or of any other agreement or vote of the Board of Trustees, or otherwise.

Article XIII

Amendments

These bylaws may be amended or suspended on recommendation of the Council and with the approval of the membership of the Society, the approval consisting of an affirmative vote by two-thirds of the members present at a business meeting or of two-thirds of the members voting in a mail ballot in which at least ten percent of the members vote, whichever alternative shall have been designated by the Council, and provided notice of the proposed action and of its general nature shall have been given in the call for the meeting or accompanies the ballot in full.

As amended December 2003

AMS Lecturers, Officers, Prizes, and Funds

Colloquium Lecturers
James Pierpont, 1896
Maxime Bôcher, 1896
W. F. Osgood, 1898
A. G. Webster, 1898
Oskar Bolza, 1901
E. W. Brown, 1901
H. S. White, 1903
F. S. Woods, 1903
E. B. Van Vleck, 1903
E. H. Moore, 1906
E. J. Wilczynski, 1906
Max Mason, 1906
G. A. Bliss, 1909
Edward Kasner, 1909
L. E. Dickson, 1913
W. F. Osgood, 1913
G. C. Evans, 1916
Oswald Veblen, 1916
G. D. Birkhoff, 1920
F. R. Moulton, 1920
L. P. Eisenhart, 1925
Dunham Jackson, 1925
E. T. Bell, 1927
Anna Pell-Wheeler, 1927
A. B. Coble, 1928
R. L. Moore, 1929
Solomon Lefschetz, 1930
Marston Morse, 1931
J. F. Ritt, 1932
R. E. A. C. Paley, 1934
Norbert Wiener, 1934
H. S. Vandiver, 1935
E. W. Chittenden, 1936
John von Neumann, 1937
A. A. Albert, 1939
M. H. Stone, 1939
G. T. Whyburn, 1940
Oystein Ore, 1941
R. L. Wilder, 1942
E. J. McShane, 1943
Einar Hille, 1944
Tibor Radó, 1945
Hassler Whitney, 1946
Oscar Zariski, 1947
Richard Brauer, 1948
G. A. Hedlund, 1949
Deane Montgomery, 1951
Alfred Tarski, 1952
Antoni Zygmund, 1953
Nathan Jacobson, 1955
Salomon Bochner, 1956
N. E. Steenrod, 1957
J. L. Doob, 1959
S. S. Chern, 1960
G. W. Mackey, 1961
Saunders Mac Lane, 1963
C. B. Morrey, Jr., 1964
A. P. Calderón, 1965
Samuel Eilenberg, 1967
D. C. Spencer, 1968
J. W. Milnor, 1968
Raoul H. Bott, 1969
Harish-Chandra, 1969
R. H. Bing, 1970
Lipman Bers, 1971
Armand Borel, 1971
Stephen Smale, 1972
John T. Tate, 1972
M. F. Atiyah, 1973
E. A. Bishop, 1973
F. E. Browder, 1973
Louis Nirenberg, 1974
John G. Thompson, 1974
H. Jerome Keisler, 1975
Ellis R. Kolchin, 1975
Elias M. Stein, 1975
I. M. Singer, 1976
Jürgen K. Moser, 1976
William Browder, 1977
Herbert Federer, 1977
Hyman Bass, 1978
Philip A. Griffiths, 1979
George D. Mostow, 1979
Julia B. Robinson, 1980
Wolfgang M. Schmidt, 1980
Mark Kac, 1981
Serge Lang, 1981
Dennis Sullivan, 1982
Morris W. Hirsch, 1982
Charles L. Fefferman, 1983
Bertram Kostant, 1983
Barry Mazur, 1984
Paul H. Rabinowitz, 1984
Daniel Gorenstein, 1985
Karen K. Uhlenbeck, 1985
Shing-Tung Yau, 1986
Peter D. Lax, 1987
Edward Witten, 1987
Victor W. Guillemin, 1988
Nicholas Katz, 1989
William P. Thurston, 1989
Shlomo Sternberg, 1990
Robert D. MacPherson, 1991
Robert P. Langlands, 1992
Luis A. Caffarelli, 1993
Sergiu Klainerman, 1993
Jean Bourgain, 1994
Clifford H. Taubes, 1995
Andrew W. Wiles, 1996
Daniel W. Stroock, 1997
Gian-Carlo Rota, 1998
Helmut H. Hofer, 1999
Curtis T. McMullen, 2000
János Kollár, 2001
L. Craig Evans, 2002
Peter Sarnak, 2003
Sun-Yung Alice Chang, 2004
Robert K. Lazarsfeld, 2005
Hendrik W. Lenstra Jr., 2006
Andrei Okounkov, 2007
Wendelin Werner, 2008
Gregory Margulis, 2009
Richard P. Stanley, 2010
Alexander Lubotsky, 2011

Gibbs Lecturers
M. I. Pupin, 1923
Robert Henderson, 1924
James Pierpont, 1925
H. B. Williams, 1926
E. W. Brown, 1927
G. H. Hardy, 1928
Irving Fisher, 1929
E. B. Wilson, 1930
P. W. Bridgman, 1931
R. C. Tolman, 1932
Albert Einstein, 1934
Vannevar Bush, 1935
H. N. Russell, 1936
C. A. Kraus, 1937
Theodore von Kármán, 1939
Sewall Wright, 1941
Harry Bateman, 1943
John von Neumann, 1944
J. C. Slater, 1945
S. Chandrasekhar, 1946
P. M. Morse, 1947
Hermann Weyl, 1948
Norbert Wiener, 1949
G. E. Uhlenbeck, 1950
Kurt Gödel, 1951
Marston Morse, 1952
Wassily Leontief, 1953
K. O. Friedrichs, 1954
J. E. Mayer, 1955
M. H. Stone, 1956
H. J. Muller, 1958
J. M. Burgers, 1959
Julian Schwinger, 1960
J. J. Stoker, 1961
C. N. Yang, 1962
C. E. Shannon, 1963
Lars Onsager, 1964
D. H. Lehmer, 1965
Martin Schwarzschild, 1966
Mark Kac, 1967
E. P. Wigner, 1968
R. L. Wilder, 1969
W. H. Munk, 1970
E. F. F. Hopf, 1971
F. J. Dyson, 1972
J. K. Moser, 1973
Paul A. Samuelson, 1974

Fritz John, 1975
Arthur S. Wightman, 1976
Joseph B. Keller, 1977
Donald E. Knuth, 1978
Martin D. Kruskal, 1979
Kenneth G. Wilson, 1980
Cathleen Synge Morawetz, 1981
Elliott W. Montroll, 1982
Samuel Karlin, 1983
Herbert A. Simon, 1984
Michael O. Rabin, 1985
L. E. Scriven, 1986
Thomas C. Spencer, 1987
David P. Ruelle, 1988
Elliott H. Lieb, 1989
George B. Dantzig, 1990
Michael F. Atiyah, 1991
Michael E. Fisher, 1992
Charles S. Peskin, 1993
Robert M. May, 1994
Andrew J. Majda, 1995
Steven Weinberg, 1996
Persi Diaconis, 1997
Edward Witten, 1998
Nancy Kopell, 1999
Roger Penrose, 2000
Ronald L. Graham, 2001
Michael V. Berry, 2002
David B. Mumford, 2003
Eric Lander, 2004
Ingrid Daubechies, 2005
Michael Savageau, 2006
Peter D. Lax, 2007
Avi Wigderson, 2008
Percy Deift, 2009
Petre W. Shor, 2010
George Papanicolaou, 2011

Presidents
J. H. Van Amringe, 1889, 1890
J. E. McClintock, 1891-1894
G. W. Hill, 1895, 1896
Simon Newcomb, 1897, 1898
R. S. Woodward, 1899, 1900
E. H. Moore, 1901, 1902
T. S. Fiske, 1903, 1904
W. F. Osgood, 1905, 1906
H. S. White, 1907, 1908
Maxime Bôcher, 1909, 1910
H. B. Fine, 1911, 1912
E. B. Van Vleck, 1913, 1914
E. W. Brown, 1915, 1916
L. E. Dickson, 1917, 1918
Frank Morley, 1919, 1920
G. A. Bliss, 1921, 1922
Oswald Veblen, 1923, 1924
G. D. Birkhoff, 1925, 1926
Virgil Snyder, 1927, 1928
E. R. Hedrick, 1929, 1930
L. P. Eisenhart, 1931, 1932
A. B. Coble, 1933, 1934
Solomon Lefschetz, 1935, 1936
R. L. Moore, 1937, 1938
G. C. Evans, 1939, 1940
Marston Morse, 1941, 1942
M. H. Stone, 1943, 1944
T. H. Hildebrandt, 1945, 1946
Einar Hille, 1947, 1948
J. L. Walsh, 1949, 1950
John von Neumann, 1951, 1952
G. T. Whyburn, 1953, 1954
R. L. Wilder, 1955, 1956
Richard Brauer, 1957, 1958
E. J. McShane, 1959, 1960
Deane Montgomery, 1961, 1962
J. L. Doob, 1963, 1964
A. A. Albert, 1965, 1966
C. B. Morrey, Jr., 1967, 1968
Oscar Zariski, 1969, 1970
Nathan Jacobson, 1971, 1972
Saunders Mac Lane, 1973, 1974
Lipman Bers, 1975, 1976
R. H. Bing, 1977, 1978
Peter D. Lax, 1979, 1980
Andrew M. Gleason, 1981, 1982
Julia B. Robinson, 1983, 1984
Irving Kaplansky, 1985, 1986
George Daniel Mostow, 1987, 1988
William Browder, 1989, 1990
Michael Artin, 1991, 1992
Ronald L. Graham, 1993, 1994
Cathleen Synge Morawetz, 1995, 1996
Arthur M. Jaffe, 1997, 1998
Felix E. Browder, 1999, 2000
Hyman Bass, 2001, 2002
David Eisenbud, 2003, 2004
James G. Arthur, 2005, 2006
James G. Glimm, 2007, 2008
George E. Andrews, 2009, 2010
Eric M. Friedlander, 2011, 2012

Secretaries
T. S. Fiske, 1888-1895
F. N. Cole, 1896-1920
R. G. D. Richardson, 1921-1940
J. R. Kline, 1941-1950
E. G. Begle, 1951-1956
J. W. Green, 1957-1966
Everett Pitcher, 1967-1988
Robert M. Fossum, 1989-1998
Robert J. Daverman, 1999-

Treasurers
T. S. Fiske, 1890, 1891
Harold Jacoby, 1892-1894
R. S. Woodward, 1895, 1896
Harold Jacoby, 1897-1899
W. S. Dennett, 1900-1907
J. H. Tanner, 1908-1920
W. B. Fite, 1921-1929
G. W. Mullins, 1930-1936
P. A. Smith, 1937
B. P. Gill, 1938-1948
A. E. Meder, Jr., 1949-1964
W. T. Martin, 1965-1973
Franklin P. Peterson, 1974-1998
John M. Franks, 1999-2010
Jane M. Hawkins, 2011-

Prizes

The George David Birkhoff Prize in Applied Mathematics

This prize was established in 1967 in honor of Professor George David Birkhoff. The initial endowment was contributed by the Birkhoff family and there have been subsequent additions by others. It is awarded for an outstanding contribution to "applied mathematics in the highest and broadest sense." Currently, the prize amount is US$5,000, and it is awarded every three years. The award is made jointly by the American Mathematical Society and the Society for Industrial and Applied Mathematics.

First award, 1968: To Jürgen K. Moser for his contributions to the theory of Hamiltonian dynamical systems, especially his proof of the stability of periodic solutions of Hamiltonian systems having two degrees of freedom and his specific applications of the ideas in connection with this work.

Second award, 1973: To Fritz John for his outstanding work in partial differential equations, in numerical analysis, and, particularly, in nonlinear elasticity theory; the latter work has led to his study of quasi–isometric mappings as well as functions of bounded mean oscillation, which have had impact in other areas of analysis.

Third award, 1973: To James B. Serrin for his fundamental contributions to the theory of nonlinear partial differential equations, especially his work on existence

and regularity theory for nonlinear elliptic equations, and applications of his work to the theory of minimal surfaces in higher dimensions.

Fourth award, 1978: To Garrett Birkhoff for bringing the methods of algebra and the highest standards of mathematics to scientific applications.

Fifth award, 1978: To Mark Kac for his important contributions to statistical mechanics and to probability theory and its applications.

Sixth award, 1978: To Clifford A. Truesdell for his outstanding contributions to our understanding of the subjects of rational mechanics and nonlinear materials, for his efforts to give precise mathematical formulation to these classical subjects, for his many contributions to applied mathematics in the fields of acoustic theory, kinetic theory, and nonlinear elastic theory, and the thermodynamics of mixtures, and for his major work in the history of mechanics.

Seventh award, 1983: To Paul R. Garabedian for his important contributions to partial differential equations, to the mathematical analysis of problems of transonic flow and airfoil design by the method of complexification, and to the development and application of scientific computing to problems of fluid dynamics and plasma physics.

Eighth award, 1988: To Elliott H. Lieb for his profound analysis of problems arising in mathematical physics.

Ninth award, 1994: To Ivo Babuška for important contributions to the reliability of finite element methods, the development of a general framework for finite element error estimation, and the development of p and h-p finite element methods; and to S. R. S. Varadhan for important contributions to the martingale characterization of diffusion processes, to the theory of large deviations for functionals of occupation times of Markov processes, and to the study of random media.

Tenth award, 1998: To Paul H. Rabinowitz for his deep influence on the field of nonlinear analysis.

Eleventh award, 2003: To John Mather for being a mathematician of exceptional depth, power, and originality; and to Charles S. Peskin for devoting much of his career to understanding the dynamics of the human heart and bringing an extraordinarily broad range of expertise to bear on this problem.

Twelfth award, 2006: To Cathleen Synge Morawetz for her deep and influential work in partial differential equations, most notably in the study of shock waves, transonic flow, scattering theory, and conformally invariant estimates for the wave equation.

Thirteenth award, 2009: To Joel Smoller for his leadership, originality, depth, and breadth of work in dynamical systems, differential equations, mathematical biology, shock wave theory, and general relativity.

Next award: January 2012

The Bôcher Memorial Prize

This prize, the first to be offered by the AMS, was founded in memory of Professor Maxime Bôcher, who served as president of the AMS 1909–1910. The original endowment was contributed by members of the Society. It is awarded for a notable paper in analysis published during the preceding six years. To be eligible, the author should be a member of the American Mathematical Society or the paper should have been published in a recognized North American journal. Currently, the US$5,000 prize is awarded every three years.

First (preliminary) award, 1923: To G. D. Birkhoff for his memoir *Dynamical systems with two degrees of freedom*. Transactions of the American Mathematical Society **18** (1917), pp. 199–300.

Second award, 1924: To E. T. Bell for his memoir *Arithmetical paraphrases. I, II*, Transactions of the American Mathematical Society **22** (1921), pp. 1–30, 198–219; and to Solomon Lefschetz for his memoir *On certain numerical invariants with applications to Abelian varieties*, Transactions of the American Mathematical Society **22** (1921), pp. 407–482.

Third award, 1928: To J. W. Alexander for his memoir *Combinatorial analysis situs*, Transactions of the American Mathematical Society **28** (1926), pp. 301–329.

Fourth award, 1933: To Marston Morse for his memoir *The foundations of a theory of the calculus of variations in the large in m-space*, Transactions of the American Mathematical Society **31** (1929), pp. 379–404; and to Norbert Wiener for his memoir, *Tauberian theorems*, Annals of Mathematics, Series 2, **33** (1932), pp. 1–100.

Fifth award, 1938: To John von Neumann for his memoir *Almost periodic functions and groups. I, II*, Transactions of the American Mathematical Society **36** (1934), pp. 445–492; and **37** (1935), pp. 21–50.

Sixth award, 1943: To Jesse Douglas for his memoirs *Green's function and the problem of Plateau*, American Journal of Mathematics **61** (1939), pp. 545–589; *The most general form of the problem of Plateau*, American Journal of Mathematics **61** (1939), pp. 590–608; and *Solution of the inverse problem of the calculus of variations*, Proceedings of the National Academy of Sciences **25** (1939), pp. 631–637.

Seventh award, 1948: To A. C. Schaeffer and D. C. Spencer for their memoir *Coefficients of schlicht functions. I, II, III, IV*, Duke Mathematical Journal **10** (1943), pp. 611–635; **12** (1945), pp. 107–125; and the Proceedings of the National Academy of Sciences **32** (1946), pp. 111–116; **35** (1949), pp. 143–150.

Eighth award, 1953: To Norman Levinson for his contributions to the theory of linear, nonlinear, ordinary, and partial differential equations contained in his papers of recent years.

Ninth award, 1959: To Louis Nirenberg for his work in partial differential equations.

Tenth award, 1964: To Paul J. Cohen for his paper *On a conjecture of Littlewood and idempotent measures*, American Journal of Mathematics **82** (1960), pp. 191–212.

Eleventh award, 1969: To I. M. Singer in recognition of his work on the index problem, especially his share in two joint papers with Michael F. Atiyah, *The index of elliptic operators. I, III*, Annals of Mathematics, Series 2, **87** (1968), pp. 484–530, 546–604.

Twelfth award, 1974: To Donald S. Ornstein in recognition of his paper *Bernoulli shifts with the same*

entropy are isomorphic, Advances in Mathematics **4** (1970), pp. 337–352.

Thirteenth award, 1979: To Alberto P. Calderón in recognition of his fundamental work on the theory of singular integrals and partial differential equations, and in particular for his paper *Cauchy integrals on Lipschitz curves and related operators*, Proceedings of the National Academy of Sciences, USA, **74** (1977), pp. 1324–1327.

Fourteenth award, 1984: To Luis A. Caffarelli for his deep and fundamental work in nonlinear partial differential equations, in particular his work on free boundary problems, vortex theory, and regularity theory.

Fifteenth award, 1984: To Richard B. Melrose for his solution of several outstanding problems in diffraction theory and scattering theory and for developing the analytical tools needed for their resolution.

Sixteenth award, 1989: To Richard M. Schoen for his work on the application of partial differential equations to differential geometry, in particular his completion of the solution to the Yamabe Problem in *Conformal deformation of a Riemannian metric to constant scalar curvature*, Journal of Differential Geometry **20** (1984), pp. 479–495.

Seventeenth award, 1994: To Leon Simon for his profound contributions toward understanding the structure of singular sets for solutions of variational problems.

Eighteenth award, 1999: To Demetrios Christodoulou for his contributions to the mathematical theory of general relativity, to Sergiu Klainerman for his contributions to nonlinear hyperbolic equations, and to Thomas Wolff for his work in harmonic analysis.

Nineteenth award, 2002: To Daniel Tataru for his fundamental paper *On global existence and scattering for the wave maps equations*, Amer. Jour. Math. **123** (2001), no. 1, pp. 37–77; and to Terence Tao for his recent fundamental breakthrough on the problem of critical regularity in Sobolev spaces of the wave maps equations, *Global regularity of wave maps I. Small critical Sobolev norm in high dimensions*, Int. Math. Res. Notices (2001), no. 6, pp. 299–328, and *Global regularity of wave maps II. Small energy in two dimensions*, to appear in Comm. Math. Phys. (2001 or early 2002); and to Fanghua Lin for his fundamental contributions to our understanding of the Ginzburg-Landau (GL) equations with a small parameter.

Twentieth award, 2005: To Frank Merle for his fundamental work in the analysis of nonlinear dispersive equations.

Twenty-first award, 2008: To Alberto Bressan for his fundamental works on hyperbolic conservation laws; and to Charles Fefferman for his many fundamental contributions to different areas of analysis; and to Carlos Kenig for his important contributions to harmonic analysis, partial differential equations, and nonlinear dispersive PDE.

Twenty-second award, 2011: To Gunther Uhlmann for his fundamental work on inverse problems; and to Assaf Naor for introducing new invariants of metric spaces and for applying his new understanding of the distortion between various metric structures to theoretical computer science.

Next award: January 2014.

The Frank Nelson Cole Prize in Algebra

This prize (and the Frank Nelson Cole Prize in Number Theory) was founded in honor of Professor Frank Nelson Cole on the occasion of his retirement as secretary of the American Mathematical Society after twenty-five years of service and as editor-in-chief of the *Bulletin* for twenty-one years. The original fund was donated by Professor Cole from moneys presented to him on his retirement and was augmented by contributions from members of the Society. The fund was later doubled by his son, Charles A. Cole. The prize is for a notable paper in algebra published during the preceding six years. To be eligible, the author should be a member of the American Mathematical Society or the paper should have been published in a recognized North American journal. Currently, the US$5,000 prize is awarded every three years.

First award, 1928: To L. E. Dickson for his book *Algebren und ihre Zahlentheorie*, Orell Füssli, Zürich and Leipzig, 1927.

Second award, 1939: To A. Adrian Albert for his papers on the construction of Riemann matrices published in the Annals of Mathematics, Series 2, **35** (1934) and **36** (1935).

Third award, 1944: To Oscar Zariski for four papers on algebraic varieties published in the American Journal of Mathematics **61** (1939) and **62** (1940), and in the Annals of Mathematics, Series 2, **40** (1939) and **41** (1940).

Fourth award, 1949: To Richard Brauer for his paper *On Artin's L-series with general group characters*, Annals of Mathematics, Series 2, **48** (1947), pp. 502–514.

Fifth award, 1954: To Harish–Chandra for his papers on representations of semisimple Lie algebras and groups, and particularly for his paper *On some applications of the universal enveloping algebra of a semisimple Lie algebra*, Transactions of the American Mathematical Society **70** (1951), pp. 28–96.

Sixth award, 1960: To Serge Lang for his paper *Unramified class field theory over function fields in several variables*, Annals of Mathematics, Series 2, **64** (1956), pp. 285–325; and to Maxwell A. Rosenlicht for his papers *Generalized Jacobian varieties*, Annals of Mathematics, Series 2, **59** (1954), pp. 505–530, and *A universal mapping property of generalized Jacobians*, Annals of Mathematics, Series 2, **66** (1957), pp. 80–88.

Seventh award, 1965: To Walter Feit and John G. Thompson for their joint paper *Solvability of groups of odd order*, Pacific Journal of Mathematics **13** (1963), pp. 775–1029.

Eighth award, 1970: To John R. Stallings for his paper *On torsion-free groups with infinitely many ends*, Annals of Mathematics, Series 2, **88** (1968), pp. 312–334; and to Richard G. Swan for his paper *Groups of cohomological dimension one*, Journal of Algebra **12** (1969), pp. 585–610.

Ninth award, 1975: To Hyman Bass for his paper *Unitary algebraic K-theory*, Springer Lecture Notes in Mathematics 343, 1973; and to Daniel G. Quillen for his paper *Higher algebraic K-theories*, Springer Lecture Notes in Mathematics 341, 1973.

Tenth award, 1980: To Michael Aschbacher for his paper *A characterization of Chevalley groups over fields of odd order*, Annals of Mathematics, Series 2, **106** (1977),

pp. 353–398; and to Melvin Hochster for his paper *Topics in the homological theory of commutative rings*, CBMS Regional Conference Series in Mathematics, Number 24, American Mathematical Society, 1975.

Eleventh award, 1985: To George Lusztig for his fundamental work on the representation theory of finite groups of Lie type. In particular for his contributions to the classification of the irreducible representations in characteristic zero of the groups of rational points of reductive groups over finite fields, appearing in *Characters of Reductive Groups over Finite Fields*, Annals of Mathematics Studies 107, Princeton University Press, 1984.

Twelfth award, 1990: To Shigefumi Mori for his outstanding work on the classification of algebraic varieties and, in particular, for his paper *Flip theorem and the existence of minimal models for 3-folds*, Journal of the American Mathematical Society **1** (1988), pp. 117–253.

Thirteenth award, 1995: To Michel Raynaud and David Harbater for their solution of Abhyankar's conjecture. This work appeared in the papers *Revêtements de la droite affine en caractéristique $p > 0$*, Invent. Math. **116** (1994), pp. 425–462 (Raynaud); and *Abhyankar's conjecture on Galois groups over curves*, Invent. Math. **117** (1994), pp. 1–25 (Harbater).

Fourteenth award, 2000: To Andrei Suslin for his work on motivic cohomology, and to Aise Johan de Jong for his important work on the resolution of singularities by generically finite maps.

Fifteenth award, 2003: To Hiraku Nakajima for his work in representation theory and geometry.

Sixteenth award, 2006: To János Kollár for his outstanding achievements in the theory of rationally connected varieties and for his illuminating work on a conjecture of Nash.

Seventeenth award, 2009: To Christopher Hacon and James McKernan for their groundbreaking joint work on higher-dimensional birational algebraic geometry.

Next award: January 2012.

The Frank Nelson Cole Prize in Number Theory

This prize (and the Frank Nelson Cole Prize in Algebra) was founded in honor of Professor Frank Nelson Cole on the occasion of his retirement as secretary of the American Mathematical Society after twenty-five years of service and as editor-in-chief of the *Bulletin* for twenty-one years. The original fund was donated by Professor Cole from moneys presented to him on his retirement and was augmented by contributions from members of the Society. The fund was later doubled by his son, Charles A. Cole. The prize is for a notable paper in number theory published during the preceding six years. To be eligible, the author should be a member of the American Mathematical Society or the paper should have been published in a recognized North American journal. Currently, the US$5,000 prize is awarded every three years.

First award, 1931: To H. S. Vandiver for his several papers on Fermat's last theorem published in the *Transactions of the American Mathematical Society* and in the *Annals of Mathematics* during the preceding five years, with special reference to a paper entitled *On Fermat's last theorem*, Transactions of the American Mathematical Society 31 (1929), pp.-613–642.

Second award, 1941: To Claude Chevalley for his paper *La théorie du corps de classes*, Annals of Mathematics, Series 2, 41 (1940), pp.-394–418.

Third award, 1946: To H. B. Mann for his paper *A proof of the fundamental theorem on the density of sums of sets of positive integers*, Annals of Mathematics, Series 2, 43 (1942), pp.-523–527.

Fourth award, 1951: To Paul Erdős for his many papers in the theory of numbers, and in particular for his paper *On a new method in elementary number theory which leads to an elementary proof of the prime number theorem*, Proceedings of the National Academy of Sciences 35 (1949), pp.-374–385.

Fifth award, 1956: To John T. Tate for his paper *The higher dimensional cohomology groups of class field theory*, Annals of Mathematics, Series 2, **56** (1952), pp. 294–297.

Sixth award, 1962: To Kenkichi Iwasawa for his paper *Gamma extensions of number fields*, Bulletin of the American Mathematical Society **65** (1959), pp. 183–226; and to Bernard M. Dwork for his paper *On the rationality of the zeta function of an algebraic variety*, American Journal of Mathematics **82** (1960), pp. 631–648.

Seventh award, 1967: To James B. Ax and Simon B. Kochen for a series of three joint papers: *Diophantine problems over local fields. I, II, III*, American Journal of Mathematics **87** (1965), pp. 605–630, 631–648; and Annals of Mathematics, Series 2, **83** (1966), pp. 437–456.

Eighth award, 1972: To Wolfgang M. Schmidt for the following papers: *On simultaneous approximation of two algebraic numbers by rationals*, Acta Mathematica (Uppsala) **119** (1967), pp. 27–50; *T-numbers do exist*, Symposia Mathematica, IV, Academic Press, 1970, pp. 1–26; *Simultaneous approximation to algebraic numbers by rationals*, Acta Mathematica (Uppsala) **125** (1970), pp. 189–201; *On Mahler's T-numbers*, Proceedings of Symposia in Pure Mathematics 20, American Mathematical Society, 1971, pp. 275–286.

Ninth award, 1977: To Goro Shimura for his two papers *Class fields over real quadratic fields and Heche operators*, Annals of Mathematics, Series 2, **95** (1972), pp. 130–190; and *On modular forms of half integral weight*, Annals of Mathematics, Series 2, **97** (1973), pp. 440–481.

Tenth award, 1982: To Robert P. Langlands for pioneering work on automorphic forms, Eisenstein series and product formulas, particularly for his paper *Base change for GL(2)*, Annals of Mathematics Studies 96, Princeton University Press, 1980; and to Barry Mazur for outstanding work on elliptic curves and Abelian varieties, especially on rational points of finite order, and his paper *Modular curves and the Eisenstein ideal*, Publications Mathematiques de l'Institut des Hautes Études Scientifiques **47** (1977), pp. 33–186.

Eleventh award, 1987: To Dorian M. Goldfeld for his paper *Gauss's class number problem for imaginary quadratic fields*, Bulletin of the American Mathematical Society **13** (1985), pp. 23–37; and to Benedict H. Gross and Don B.

Zagier for their paper *Heegner points and derivatives of L-series*, Inventiones Mathematicae **84** (1986), pp. 225–320.

Twelfth award, 1992: To Karl Rubin for his work in the area of elliptic curves and Iwasawa theory, with particular reference to his papers *Tate-Shafarevich groups and L-functions of elliptic curves with complex multiplication* and *The "main conjectures" of Iwasawa theory for imaginary quadratic fields;* and to Paul Vojta for his work on Diophantine problems, with particular reference to his paper *Siegel's theorem in the compact case*.

Thirteenth award, 1997: To Andrew J. Wiles for his work on the Shimura-Taniyama conjecture and Fermat's Last Theorem, published in *Modular elliptic curves and Fermat's Last Theorem*, Ann. of Math. 141 (1995), pp. 443–551.

Fourteenth award, 2002: To Henryk Iwaniec for his fundamental contributions to analytic number theory, and to Richard Taylor for several outstanding advances in algebraic number theory.

Fifteenth award, 2005: To Peter Sarnak for his fundamental contributions to number theory and in particular his book *Random Matrices, Frobenius Eigenvalues and Monodromy*, written jointly with his Princeton colleague Nicholas Katz.

Sixteenth award, 2008: To Manjul Bhargava for his revolutionary work on higher composition laws.

Seventeenth award, 2011: To Chandrashekhar Khare and Jean-Pierre Wintenberger for their remarkable proof of Serre's modularity conjecture.

Next award: January 2014.

The Levi L. Conant Prize

This prize was established in 2000 in honor of Levi L. Conant to recognize the best expository paper published in either the *Notices of the AMS* or the *Bulletin of the AMS* in the preceding five years. Levi L. Conant was a mathematician at Worcester Polytechnic Institute. His will provided for funds to be donated to the AMS upon his wife's death. The US$1,000 prize is awarded annually.

First award, 2001: To Carl Pomerance for his paper "A tale of two sieves", *Notices of the AMS* **43**, no. 12 (1996), pp. 1473–1485.

Second award, 2002: To Elliott H. Lieb and Jakob Yngvason for their article "A guide to entropy and the Second Law of Thermodynamics", *Notices of the AMS* **45**, no. 5 (1998), pp. 571–581.

Third award, 2003: To Nicholas Katz and Peter Sarnak for their expository paper "Zeroes of zeta functions and symmetry", *Bulletin of the AMS* **36** (1999), pp. 1–26.

Fourth award, 2004: To Noam D. Elkies for his enlightening two-part article "Lattices, linear codes, and invariants", *Notices of the AMS* **47**, no. 10 (2000), Part I, pp. 1238–1245; no. 11, Part II, pp. 1382–1391.

Fifth award, 2005: To Allen Knutson and Terence Tao for their stimulating article "Honeycombs and sums of Hermitian matrices", *Notices of the AMS* **48**, no. 2 (2001), pp. 175–186.

Sixth award, 2006: To Ronald Solomon for his article "A brief history of the classification of the finite simple groups", *Bulletin of the AMS* **38** (2001), no. 3, 315–352.

Seventh award, 2007: To Jeffrey Weeks for his article "The Poincare dodecahedral space and the mystery of the missing fluctuations," *Notices of the AMS* **51** (2004) no. 6, 610–619.

Eighth award, 2008: To J. Brian Conrey for his article "The Riemann Hypothesis", *Notices of the AMS* **50** (2003) no. 3, 341-353; and to Shlomo Hoory, Nathan Linial, and Avi Wigderson for their article "Expander graphs and their applications", *Bulletin of the AMS* **43** (2006), no. 4, 439-561.

Ninth award, 2009: To Jeffrey Weeks for his article "The Poincaré dodecahedral space and the mystery of the missing fluctuations", *Notices of the AMS* **51** (2004) no. 6, 610-619.

Ninth award, 2009: To Jeffrey Weeks for his article "The Poincaré dodecahedral space and the mystery of the missing fluctuations", *Notices of the AMS* **51** (2004) no. 6, 610-619.

Tenth award, 2010: To Bryna Kra for her article, "The Green-Tao Theorem on arithmetic progressions in the primes: An ergodic point of view", *Bull. Amer. Math. Soc. (N.S.)* **43** (2006), no. 1, 3–23.

Eleventh award, 2011: To David Vogan for his article, "The character table for E8", *Notices of the AMS* **54** (2007), no. 9, 1122-1134.

Next award: January 2012.

Joseph L. Doob Prize

This prize was established by the AMS in 2003 to recognize a single, relatively recent, outstanding research book that makes a seminal contribution to the research literature, reflects the highest standards of research exposition, and promises to have a deep and long-term impact in its area. The book must have been published within the six calendar years preceding the year in which it is nominated. Books may be nominated by members of the Society, by members of the selection committee, by members of AMS editorial committees, or by publishers. The US$5,000 prize is awarded every three years.

The prize (originally called the Book Prize) was endowed in 2005 by Paul and Virginia Halmos and renamed in honor of Joseph L. Doob. Paul Halmos (Professor Emeritus at Santa Clara University) was Doob's first Ph.D. student. Doob received his Ph.D. from Harvard in 1932 and three years later joined the faculty at the University of Illinois, where he remained until his retirement in 1978. He worked in probability theory and measure theory, served as AMS president in 1963–1964, and received the AMS Steele Prize in 1984 "for his fundamental work in establishing probability as a branch of mathematics." Doob passed away on June 7, 2004, at the age of ninety-four.

First award, 2005: To William P. Thurston for his book *Three-Dimensional Geometry and Topology*, edited by Silvio Levy.

Second award, 2008: To Enrico Bombieri and Walter Gubler for their book *Heights in Diophantine Geometry* (Cambridge University Press, 2006).

Third award, 2011: To Peter Kronheimer and Tomasz Mrowka for their book *Monopoles and Three-Manifolds* (Cambridge University Press, 2007).

Next award: January 2014.

Leonard Eisenbud Prize for Mathematics and Physics

This prize was established in 2006 in memory of the mathematical physicist, Leonard Eisenbud (1913–2004), by his son and daughter-in-law, David and Monika Eisenbud. Leonard Eisenbud was a student of Eugene Wigner. He was particularly known for the book, *Nuclear Structure* (1958), which he co-authored with Wigner. A friend of Paul Erdős, he once threatened to write a dictionary of "English to Erdős and Erdős to English." He was one of the founders of the Physics Department at SUNY Stony Brook, where he taught from 1957 until his retirement in 1983. In later years he became interested in the foundations of quantum mechanics and in the interaction of physics with culture and politics, teaching courses on the anti-science movement. His son, David, was President of the American Mathematical Society 2003–2004.

The prize will honor a work or group of works that brings the two fields closer together. Thus, for example, the prize might be given for a contribution to mathematics inspired by modern developments in physics or for the development of a physical theory exploiting modern mathematics in a novel way.

The US$5,000 prize will be awarded every three years for a work published in the preceding six years.

First award, 2008: To Hirosi Ooguri, Andrew Strominger, and Cumrun Vafa for their paper "Black hole attractors and the topological string", *Physical Review D* (3) **70** (2004), 106007.

Second award, 2011: To Herbert Spohn for his group of works on stochastic growth processes.

Next award: January 2014.

The Delbert Ray Fulkerson Prize

The Fulkerson Prize for outstanding papers in the area of discrete mathematics is sponsored jointly by the Mathematical Programming Society (MPS) and the American Mathematical Society (AMS). Up to three awards of US$1,500 each are presented at each (triennial) International Symposium of the MPS. Originally, the prizes were paid out of a memorial fund administered by the AMS that was established by friends of the late Delbert Ray Fulkerson to encourage mathematical excellence in the fields of research exemplified by his work. The prizes are now funded by an endowment administered by the MPS.

First award, 1979: To Richard M. Karp for *On the computational complexity of combinatorial problems*, Networks, **5** (1975), pp. 45–68; to Kenneth Appel and Wolfgang Haken for *Every planar map is four colorable*, Part I: *Discharging*, Illinois Journal of Mathematics **21** (1977), pp. 429–490; and to Paul D. Seymour for *The matroids with the max-flow min-cut property*, Journal of Combinatorial Theory, Series B, **23** (1977), pp. 189–222.

Second award, 1982: To D. B. Judin and A. S. Nemirovskii for *Informational complexity and effective methods of solution for convex extremal problems*, Ekonomika i Matematicheskie Metody **12** (1976), pp. 357–369; to L. G. Khachiyan for *A polynomial algorithm in linear programming*, Akademiia Nauk SSSR. Doklady **244** (1979), pp. 1093–1096; to G. P. Egorychev for *The solution of van der Waerden's problem for permanents*, Akademiia Nauk SSSR. Doklady **258** (1981), pp. 1041–1044; D. I. Falikman for *A proof of the van der Waerden conjecture on the permanent of a doubly stochastic matrix*, Matematicheskie Zametki **29** (1981), pp. 931–938; and to M. Grötschel, L. Lovasz, and A. Schrijver for *The ellipsoid method and its consequences in combinatorial optimization*, Combinatorica **1** (1981), pp. 169–197.

Third award, 1985: To Jozsef Beck, for *Roth's estimate of the discrepancy of integer sequences is nearly sharp*, Combinatorica **1** (4) (1981), pp. 319–325; to H. W. Lenstra Jr. for *Integer programming with a fixed number of variables*, Mathematics of Operations Research **8** (4) (1983), pp. 538–548; and to Eugene M. Luks for *Isomorphism of graphs of bounded valence can be tested in polynomial time*, Journal of Computer and System Sciences **25** (1) (1982), pp. 42–65.

Fourth award, 1988: To Éva Tardos for *A strongly polynomial minimum cost circulation algorithm*, Combinatorica **5** (1985), pp. 247–256; and to Narendra Karmarkar for *A new polynomial-time algorithm for linear programming*, Combinatorica **4** (1984), pp. 373–395.

Fifth award, 1991: To Martin Dyer, Alan Frieze, and Ravi Kannan for *A random polynomial time algorithm for approximating the volume of convex bodies*, Journal of the Association for Computing Machinery **38**/1 (1991), pp. 1–17; to Alfred Lehman for *The width-length inequality and degenerate projective planes*, W. Cook and P. D. Seymour (eds.), *Polyhedral Combinatorics*, DIMACS Series in Discrete Mathematics and Theoretical Computer Science 1, American Mathematical Society, 1990, pp. 101–105; and to Nikolai E. Mnev for *The universality theorems on the classification problem of configuration varieties and convex polytope varieties*, O. Ya. Viro (ed.), *Topology and Geometry–Rohlin Seminar*, Lecture Notes in Mathematics 1346, Springer–Verlag, Berlin, 1988, pp. 527–544.

Sixth Award, 1994: To Lou Billera for *Homology of smooth splines: Generic triangulations and a conjecture of Strang*, Transactions of the AMS **310** (1988), pp. 325–340; to Gil Kalai for *Upper bounds for the diameter and height of graphs of the convex polyhedra*, Discrete and Computational Geometry **8** (1992), pp. 363–372; and to Neil Robertson, Paul D. Seymour, and Robin Thomas for *Hadwiger's conjecture for K6; free graphs*, Combinatorica **13** (1993), pp. 279–361.

Seventh award, 1997: To Jeong Han Kim for *The Ramsey number $R(3,t)$ has order of magnitude*, which appeared in Random Structures and Algorithms **7** (1995) no. 3, pp. 173–207.

Eighth award, 2000: To Michel X. Goemans and David P. Williamson for *Improved approximation algorithms for the maximum cut and satisfiability problems using semi-definite programming*, Journal of the Association for Computing Machinery **42** (1995), no. 6, pp. 1115–1145; and to Michele Conforti, Gerard Cornuejols, and M. R. Rao for *Decomposition of balanced matrices*, Journal of Combinatorial Theory, Series B **77** (1999), no. 2, pp. 292–406.

Ninth award, 2003: To J. F. Geelen, A. M. H. Gerards, and A. Kapoor for *The excluded minors for GF(4)-representable matroids*, Journal of Combinatorial Theory Series B, **79** (2000), no. 2, pp. 247–299; to Bertrand Guenin for *A characterization of weakly bipartite graphs*, Journal

of Combinatorial Theory Series B, **83** (2001), no. 1, pp. 112–168; to Satoru Iwata, Lisa Fleischer, and Satoru Fujishige for *A combinatorial strongly polynomial algorithm for minimizing submodular functions*, Journal of the ACM, **48** (July 2001), no. 4, pp. 761–777; and to Alexander Schrijver for *A combinatorial algorithm minimizing submodular functions in strongly polynomial time,* Journal of Combinatorial Theory, Series B, **80** (2000), no. 2, pp. 346–355.

Tenth award, 2006: To Manindra Agrawal, Neeraj Kayal and Nitin Saxena, *PRIMES is in P*, Annals of Mathematics, Volume 160, issue 2, 2004, Pp. 781–793; and to Mark Jerrum, Alistair Sinclair and Eric Vigoda, *A polynomial-time approximation algorithm for the permanent of a matrix with nonnegative entries*, J. ACM, Volume 51, Issue 4, 2004, pp. 671–697; and to Neil Robertson and Paul D. Seymour, *Graph Minors. XX. Wagner's conjecture*, Journal of Combinatorial Theory, Series B, **92** (2004), no. 2, pp. 325–357.

Eleventh award, 2009: To M. Chudnovsky, N. Robertson, P. Seymour, and R. Thomas, *The strong perfect graph theorem*, Annals of Mathematics **164** (2006) 51-229; and to D. A. Spielman and S.-H. Teng, *Smoothed analysis of algorithms: Why the simplex algorithm usually takes polynomial time*, Journal of ACM **51** (2004) 385-463; and to Thomas C. Hales, *A proof of the Kepler conjecture*, Annals of Mathematics **162** (2005) 1063-1183; and to Samuel P. Ferguson, *Sphere Packings, V. Pentahedral Prisms*, Discrete and Computational Geometry **33** (2006) 167-204.

Next award: August 2012.

E. H. Moore Research Article Prize

This prize was established in 2002 in honor of E. H. Moore. Among other activities, Moore founded the Chicago branch of the American Mathematical Society, served as the Society's sixth president (1901–1902), delivered the Colloquium Lectures in 1906, and founded and nurtured the *Transactions of the AMS*. The US$5,000 prize will be awarded every three years for an outstanding research article to have appeared in one of the AMS primary research journals (namely, the *Journal of the AMS*, *Proceedings of the AMS*, *Transactions of the AMS*, *Memoirs of the AMS*, *Mathematics of Computation*, *Electronic Journal of Conformal Geometry and Dynamics*, and *Electronic Journal of Representation Theory*) during the six calendar years ending a full year before the meeting at which the prize is awarded.

First award, 2004: To Mark Haiman for *Hilbert schemes, polygraphs, and the Macdonald positivity conjecture*, Journal of the AMS **14** (2001), pp. 941–1006.

Second award, 2007: To Ivan Shestakov and Ualbai Umirbaev for their two ground-breaking papers, both published in the Journal of the American Mathematical Society: *The tame and the wild automorphisms of polynomial rings in three variables*, **17** (2004), no. 1, 197–227; and *Poisson brackets and two-generated subalgebras of rings of polynomials*, **17** (2004), no. 1, 181–196.

Third award, 2010: To Sorin Popa for his article "On the superrigidity of malleable actions with spectral gap", *J. Amer. Math. Soc.* **21** (2008), no. 4, 981–1000.

Next award: January 2013.

The Frank and Brennie Morgan Prize for Outstanding Research in Mathematics by an Undergraduate Student

This prize, which was established in 1995, is to be awarded to an undergraduate student (or students having submitted joint work) for outstanding research in mathematics. It is entirely endowed by a gift from Mrs. Frank (Brennie) Morgan. Any student who is an undergraduate in a college or university in Canada, Mexico, or the United States or its possessions is eligible to be considered for this US$1,200 prize, which is to be awarded annually. The award is made jointly by the American Mathematical Society, the Mathematical Association of America, and the Society for Industrial and Applied Mathematics.

First award, 1995: To Kannan Soundararajan for truly exceptional research in analytic number theory. Honorable mention: Kiran Kedlaya.

Second award, 1996: To Manjul Bhargava for truly outstanding mathematical research in algebra. Honorable mention: Lenhard L. Ng.

Third award, 1997: To Jade Vinson for wide-ranging research in analysis and geometry. Honorable mention: Vikaas Sohal.

Fourth award, 1998: To Daniel Biss for his remarkable breadth, as well as depth. The most exciting aspect of his submission was his extension of a category which more closely binds the associations between combinatorial group theory and combinatorial topology. Honorable mention: Aaron E. Archer.

Fifth award, 1999: To Sean McLaughlin for his proof of the Dodecahedral Conjecture, a major problem in discrete geometry related to, but distinct from, Kepler's sphere-packing problem and a conjecture that has resisted the efforts of the strongest workers in this area for nearly sixty years. Honorable mention: Samit Dasgupta.

Sixth award, 2000: To Jacob Lurie for his paper "On simply laced Lie algebras and their miniscule representations". Honorable mention: Wai Ling Yee.

Seventh award, 2001: To Ciprian Manolescu for making a fundamental advance in the field by giving an elegant construction of Floer homology. Honorable mention: Michael A. Levin.

Eighth award, 2002: To Joshua Greene for his work in combinatorics.

Ninth award, 2003: To Melanie Wood for research on Belyi-extending maps and *P*-orderings. Honorable mention: Karen Yeats.

Tenth award, 2004: To Reid W. Barton for his paper "Packing densities of patterns". Honorable mention: Po-Shen Loh.

Eleventh award, 2006: To Jacob Fox for a most astounding collection of research papers by any undergraduate mathematician.

Twelfth award, 2007: To Daniel Kane for establishing a research record that would be the envy of many professional mathematicians.

Thirteenth award, 2008: To Aaron Pixton for five impressive papers he has written, in addition to his Princeton senior thesis.

Fourteenth award, 2009: To Nathan Kaplan for four impressive papers in algebraic number theory.

Fifteenth award, 2010: To Scott Duke Kominers for his outstanding and prolific record of undergraduate research spanning a broad range of topics, including number theory, computational geometry, and mathematical economics.

Sixteenth award, 2011: To Maria Monks for her impressive work in combinatorics and number theory, which has appeared in *Advances in Applied Mathematics*, *Proceedings of the AMS*, *Electronic Journal of Combinatoric*s, *Discrete Mathematics*, and *Journal of Combinatorial Theory, Series A*.

Next award: January 2012.

David P. Robbins Prize

This prize was established in 2005 in memory of David P. Robbins by members of his family. Robbins, who died in 2003, received his Ph.D. in 1970 from MIT. He was a long-time member of the Institute for Defense Analysis Center for Communications Research and a prolific mathematician whose work (much of it classified) was in discrete mathematics. The prize is for a paper with the following characteristics: it shall report on novel research in algebra, combinatorics, or discrete mathematics and shall have a significant experimental component; and it shall be on a topic which is broadly accessible and shall provide a simple statement of the problem and clear exposition of the work. The US$5,000 prize will be awarded every three years.

First award, 2007: To Samuel P. Ferguson and Thomas C. Hales, for the paper *A proof of the Kepler conjecture*, by Thomas C. Hales, Annals of Mathematics, **162** (2005), 1065–1185 (Section 5 of this paper is jointly authored with Ferguson).

Second award, 2010: To Ileana Streinu of Smith College for her paper "Pseudo-triangulations, rigidity and motion planning", *Discrete Comput. Geom.* **34** (2005), no. 4, 587–635.

Next award: January 2013.

The Ruth Lyttle Satter Prize in Mathematics

The prize was established in 1990 using funds donated by Joan S. Birman in memory of her sister, Ruth Lyttle Satter. Professor Birman requested that the prize be established to honor her sister's commitment to research and to encouraging women in science. The US$5,000 prize is awarded every two years to recognize an outstanding contribution to mathematics research by a woman in the previous six years.

First award, 1991: To Dusa McDuff for her outstanding work during the past five years on symplectic geometry.

Second award, 1993: To Lai-Sang Young for her leading role in the investigation of the statistical (or ergodic) properties of dynamical systems.

Third award, 1995: To Sun-Yung Alice Chang for her deep contributions to the study of partial differential equations on Riemannian manifolds and in particular for her work on extremal problems in spectral geometry and the compactness of isospectral metrics within a fixed conformal class on a compact 3-manifold.

Fourth award, 1997: To Ingrid Daubechies for her deep and beautiful analysis of wavelets and their applications.

Fifth award, 1999: To Bernadette Perrin-Riou for her number theoretical research on *p*-adic *L*-functions and Iwasawa Theory.

Sixth award, 2001: To Karen E. Smith for her outstanding work in commutative algebra, and to Sijue Wu for her work on a long-standing problem in the water wave equation.

Seventh award, 2003: To Abigail Thompson for her outstanding work in 3-dimensional topology.

Eighth award, 2005: To Svetlana Jitomirskaya for her pioneering work on nonpertubative quasiperiodic localization, in particular for results in her papers (1) *Metal-insulator transition for the almost Mathieu operator*, Ann. of Math. (2) **150** (1999), no. 3, pp. 1159–1175; and (2) with J. Bourgain, *Absolutely continuous spectrum for 1D quasiperiodic operators*, Invent. Math. **148** (2002), no. 3, pp. 453–463.

Ninth award, 2007: To Claire Voisin for her deep contributions to algebraic geometry, and in particular for her recent solutions to two long-standing open problems: the Kodaira problem (*On the homotopy types of compact Kähler and complex projective manifolds*, Inventiones Mathematicae, **157** (2004), no. 2, 329–343) and Green's Conjecture (*Green's canonical syzygy conjecture for generic curves of odd genus*, Compositio Mathematica, **141** (2005), no. 5, 1163–1190; and *Green's generic syzygy conjecture for curves of even genus lying on a K3 surface*, Journal of the European Mathematical Society, **4** (2002), no. 4, 363–404).

Tenth award, 2009: To Laure Saint-Raymond for her fundamental work on the hydrodynamic limits of the Boltzmann equation in the kinetic theory of gases.

Eleventh award, 2011: To Amie Wilkinson for her remarkable contributions to the field of ergodic theory of partially hyperbolic dynamical systems.

Next award: January 2013.

The Leroy P. Steele Prize for Lifetime Achievement
The Leroy P. Steele Prize for Mathematical Exposition
The Leroy P. Steele Prize for Seminal Contribution to Research

These prizes were established in 1970 in honor of George David Birkhoff, William Fogg Osgood, and William Caspar Graustein and are endowed under the terms of a bequest from Leroy P. Steele. From 1970 to 1976 one or more prizes were awarded each year for outstanding published mathematical research; most favorable consideration was given to papers distinguished for their exposition and covering broad areas of mathematics. In 1977 the Council of the AMS modified the terms under which the prizes are awarded. Since then, up to three prizes have been awarded each year in the following categories: (1) for the cumulative influence of the total mathematical work of the recipient, high level of research over a period of time, particular influence on the development of a field, and influence on mathematics through Ph.D. students; (2) for a book or substantial survey or expository research paper; (3) for a paper, whether recent or not, that has proved to be of fundamental or lasting importance in its field,

or a model of important research. In 1993 the Council formalized the three categories of the prize by naming each of them: (1) The Leroy P. Steele Prize for Lifetime Achievement, (2) The Leroy P. Steele Prize for Mathematical Exposition, and (3) The Leroy P. Steele Prize for Seminal Contribution to Research. Each of these three US$5,000 prizes is awarded annually.

Special Note: Beginning with the 1994 prize, there has been a five-year cycle of fields for the Seminal Contribution to Research Award. That cycle would have the 2008 prize awarded in discrete mathematics (discrete mathematics alternates with logic every five years), then analysis in 2009, algebra in 2010, applied mathematics in 2011, geometry/topology in 2012, and then logic in 2013, renewing the cycle.

August 1970: To Solomon Lefschetz for his paper *A page of mathematical autobiography*, Bulletin of the American Mathematical Society **74** (1968), pp. 854–879.

August 1971: To James B. Carrell for his paper, written jointly with Jean A. Dieudonne, *Invariant theory, old and new*, Advances in Mathematics **4** (1970), pp. 1–80.

August 1971: To Jean A. Dieudonné for his paper *Algebraic geometry*, Advances in Mathematics **3** (1969), pp. 223–321; and for his paper, written jointly with James B. Carrell, *Invariant theory, old and new*, Advances in Mathematics **4** (1970), pp. 1–80.

August 1971: To Phillip A. Griffiths for his paper *Periods of integrals on algebraic manifolds*, Bulletin of the American Mathematical Society **76** (1970), pp. 228–296.

August 1972: To Edward B. Curtis for his paper *Simplicial homotopy theory*, Advances in Mathematics **6** (1971), pp. 107–209.

August 1972: To William J. Ellison for his paper *Waring's problem*, American Mathematical Monthly **78** (1971), pp. 10–36.

August 1972: To Lawrence F. Payne for his paper *Isoperimetric inequalities and their applications*, SIAM Review **9** (1967), pp. 453–488.

August 1972: To Dana S. Scott for his paper *A proof of the independence of the continuum hypothesis*, Mathematical Systems Theory **1** (1967), pp. 89–111.

January 1975: To Lipman Bers for his paper *Uniformization, moduli, and Kleinian groups*, Bulletin of the London Mathematical Society **4** (1972), pp. 257–300.

January 1975: To Martin D. Davis for his paper *Hilbert's tenth problem is unsolvable*, American Mathematical Monthly **80** (1973), pp. 233–269.

January 1975: To Joseph L. Taylor for his paper *Measure algebras*, CBMS Regional Conference Series in Mathematics, Number 16, American Mathematical Society, 1972.

August 1975: To George W. Mackey for his paper *Ergodic theory and its significance for statistical mechanics and probability theory*, Advances in Mathematics **12** (1974), pp. 178–286.

August 1975: To H. Blaine Lawson for his paper *Foliations*, Bulletin of the American Mathematical Society **80** (1974), pp. 369–418.

1976, 1977, 1978: No awards were made.

January 1979: To Salomon Bochner for his cumulative influence on the fields of probability theory, Fourier analysis, several complex variables, and differential geometry.

January 1979: To Hans Lewy for three fundamental papers: *On the local character of the solutions of an atypical linear differential equation in three variables and a related theorem for regular functions of two complex variables*, Annals of Mathematics, Series 2, **64** (1956), pp. 514–522; *An example of a smooth linear partial differential equation without solution*, Annals of Mathematics, Series 2, **66** (1957), pp. 155–158; and *On hulls of holomorphy*, Communications in Pure and Applied Mathematics **13** (1960), pp. 587–591.

August 1979: To Antoni Zygmund for his cumulative influence on the theory of Fourier series, real variables, and related areas of analysis.

August 1979: To Robin Hartshorne for his expository research article *Equivalence relations on algebraic cycles and subvarieties of small codimension*, Proceedings of Symposia in Pure Mathematics, volume 29, American Mathematical Society, 1975, pp. 129–164; and his book *Algebraic Geometry*, Springer–Verlag, Berlin and New York, 1977.

August 1979: To Joseph J. Kohn for his fundamental paper *Harmonic integrals on strongly convex domains. I, II*, Annals of Mathematics, Series 2, **78** (1963), pp. 112–248; and 79 (1964), pp.-450–472.

August 1980: To André Weil for the total effect of his work on the general course of twentieth-century mathematics, especially in the many areas in which he has made fundamental contributions.

August 1980: To Harold M. Edwards for mathematical exposition in his books *Riemann's Zeta Function*, Pure and Applied Mathematics, number 58, Academic Press, New York and London, 1974; and *Fermat's Last Theorem*, Graduate Texts in Mathematics, number 50, Springer-Verlag, New York and Berlin, 1977.

August 1980: To Gerhard P. Hochschild for his significant work in homological algebra and its applications.

August 1981: To Oscar Zariski for his work in algebraic geometry, especially his fundamental contributions to the algebraic foundations of this subject.

August 1981: To Eberhard Hopf for three papers of fundamental and lasting importance: *Abzweigung einer periodischen Lösung von einer stationären Lösung eines Differential systems*, Berichte über die Verhandlungen der Sächsischen Akademie der Wissenschaften zu Leipzig. Mathematisch–Naturwissenschaftliche Klasse **95** (1943), pp. 3–22; *A mathematical example displaying features of turbulence*, Communications on Applied Mathematics **1** (1948), pp. 303–322; and *The partial differential equation* $u_t+uu_x=u_{xx}$, Communications on Pure and Applied Mathematics **3** (1950), pp. 201–230.

August 1981: To Nelson Dunford and Jacob T. Schwartz for their expository book *Linear Operators*, Part I, *General Theory*, 1958; Part II, *Spectral Theory*, 1963; Part III, *Spectral Operators*, 1971, Interscience Publishers, New York.

August 1982: To Lars V. Ahlfors for his expository work in *Complex Analysis,* McGraw-Hill Book Company, New York, 1953; and in *Lectures on Quasiconformal Mappings,*

D. Van Nostrand Co., Inc., New York, 1966; and *Conformal Invariants,* McGraw-Hill Book Company, New York, 1973.

August 1982: To Tsit-Yuen Lam for his expository work in his book *Algebraic Theory of Quadratic Forms* (1973), and four of his papers: *K_0 and K_1—an introduction to algebraic K-theory* (1975), *Ten lectures on quadratic forms over fields* (1977), *Serre's conjecture* (1978), and *The theory of ordered fields* (1980).

August 1982: To John W. Milnor for a paper of fundamental and lasting importance, *On manifolds homeomorphic to the -sphere*, Annals of Mathematics (2) **64** (1956), pp. 399–405.

August 1982: To Fritz John for the cumulative influence of his total mathematical work, high level of research over a period of time, particular influence on the development of a field, and influence on mathematics through Ph.D. students.

August 1983: To Paul R. Halmos for his many graduate texts in mathematics and for his articles on how to write, talk, and publish mathematics.

August 1983: To Steven C. Kleene for three important papers which formed the basis for later developments in generalized recursion theory and descriptive set theory: *Arithmetical predicates and function quantifiers*, Transactions of the American Mathematical Society **79** (1955), pp. 312–340; *On the forms of the predicates in the theory of constructive ordinals (second paper)*, American Journal of Mathematics **77** (1955), pp. 405–428; and *Hierarchies of number-theoretic predicates*, Bulletin of the American Mathematical Society **61** (1955), pp. 193–213.

August 1983: To Shiing-Shen Chern for the cumulative influence of his total mathematical work, high level of research over a period of time, particular influence on the development of the field of differential geometry, and influence on mathematics through Ph.D. students.

August 1984: To Elias M. Stein for his book *Singular Integrals and the Differentiability Properties of Functions*, Princeton University Press, 1970.

August 1984: To Lennart Carleson for his papers *An interpolation problem for bounded analytic functions*, American Journal of Mathematics **80** (1958), pp. 921– 930; *Interpolation by bounded analytic functions and the Corona problem*, Annals of Mathematics (2) **76** (1962), pp. 547–559; and *On convergence and growth of partial sums of Fourier series*, Acta Mathematica **116** (1966), pp. 135–157.

August 1984: To Joseph L. Doob for his fundamental work in establishing probability as a branch of mathematics and for his continuing profound influence on its development.

August 1985: To Michael Spivak for his five-volume set *A Comprehensive Introduction to Differential Geometry* (second edition), Publish or Perish, 1979.

August 1985: To Robert Steinberg for three papers on various aspects of the theory of algebraic groups: *Representations of algebraic groups*, Nagoya Mathematical Journal **22** (1963), pp. 33–56; *Regular elements of semisimple algebraic groups*, Institut des Hautes Études Scientifiques Publications Mathématiques **25** (1965), pp. 49–80; and *Endomorphisms of linear algebraic groups*, Memoirs of the American Mathematical Society **80** (1968).

August 1985: To Hassler Whitney for his fundamental work on geometric problems, particularly in the general theory of manifolds, in the study of differentiable functions on closed sets, in geometric integration theory, and in the geometry of the tangents to a singular analytic space.

January 1986: To Donald E. Knuth for his expository work *The Art of Computer Programming*, 3 volumes (first edition, 1968; second edition, 1973).

January 1986: To Rudolf E. Kalman for his two fundamental papers: *A new approach to linear filtering and prediction problems*, Journal of Basic Engineering **82** (1960), pp. 35–45; and *Mathematical description of linear dynamical systems,* SIAM Journal on Control and Optimization **1** (1963), pp. 152–192; and for his contribution to a third paper (with R. S. Bucy), *New results in linear filtering and prediction theory*, Journal of Basic Engineering **83D** (1961), pp. 95–108.

January 1986: To Saunders Mac Lane for his many contributions to algebra and algebraic topology, and in particular for his pioneering work in homological and categorical algebra.

August 1987: To Martin Gardner for his many books and articles on mathematics and particularly for his column "Mathematical Games" in *Scientific American*.

August 1987: To Herbert Federer and Wendell Fleming for their pioneering paper *Normal and integral currents*, Annals of Mathematics **72** (1960), pp. 458–520.

August 1987: To Samuel Eilenberg for his fundamental contributions to topology and algebra, in particular for his classic papers on singular homology and his work on axiomatic homology theory, which had a profound influence on the development of algebraic topology.

August 1988: To Sigurdur Helgason for his books *Differential Geometry and Symmetric Spaces*, Academic Press, 1962; *Differential Geometry, Lie Groups, and Symmetric Spaces,* Academic Press, 1978; and *Groups and Geometric Analysis,* Academic Press, 1984.

August 1988: To Gian-Carlo Rota for his paper *On the foundations of combinatorial theory, I. Theory of Möbius functions*, Zeitschrift für Wahrscheinlichkeitstheorie und Verwandte Gebiete, volume 2 (1964), pp. 340–368.

August 1988: To Deane Montgomery for his lasting impact on mathematics, particularly mathematics in America. He is one of the founders of the modern theory of transformation groups and is particularly known for his contributions to the solution of Hilbert's fifth problem.

August 1989: To Daniel Gorenstein for his book *Finite Simple Groups, An Introduction to Their Classification,* Plenum Press, 1982; and his two survey articles, *The classification of finite simple groups* and *Classifying the finite simple groups*, Bulletin of the American Mathematical Society **1** (1979), pp. 43–199; and **14** (1986), pp. 1–98, respectively.

August 1989: To Alberto P. Calderón for his paper *Uniqueness in the Cauchy problem for partial differential equations*, American Journal of Mathematics **80** (1958), pp. 16–36.

August 1989: To Irving Kaplansky for his lasting impact on mathematics, particularly mathematics in America. By

his energetic example, his enthusiastic exposition, and his overall generosity, he has made striking changes in mathematics and has inspired generations of younger mathematicians.

August 1990: To R. D. Richtmyer for his book *Difference Methods for Initial-Value Problems*, Interscience, first edition, 1957; and second edition, with K. Morton, 1967.

August 1990: To Bertram Kostant for his paper *On the existence and irreducibility of certain series of representations*, Lie Groups and Their Representations (1975), pp. 231–329.

August 1990: To Raoul Bott for having been instrumental in changing the face of geometry and topology with his incisive contributions to characteristic classes, *K*-theory, index theory, and many other tools of modern mathematics.

August 1991: To Jean-François Trèves for *Pseudodifferential and Fourier Integral Operators*, Volumes 1 and 2, Plenum Press, 1980.

August 1991: To Eugenio Calabi for his fundamental work on global differential geometry, especially complex differential geometry.

August 1991: To Armand Borel for his extensive contributions in geometry and topology, the theory of Lie groups, their lattices and representations and the theory of automorphic forms, the theory of algebraic groups and their representations, and extensive organizational and educational efforts to develop and disseminate modern mathematics.

January 1993: To Jacques Dixmier for his books *von Neumann Algebras* (*Algèbres de von Neumann*), Gauthier-Villars, Paris, 1957; *C*-Algebras* (*Les C*-Algèbres et leurs Representations*), Gauthier-Villars, Paris, 1964; and *Enveloping Algebras* (*Algèbres Enveloppantes*), Gauthier-Villars, Paris, 1974.

January 1993: To James Glimm for his paper *Solution in the large for nonlinear hyperbolic systems of conservation laws*, Communications on Pure and Applied Mathematics, **XVIII** (1965), pp. 697–715.

January 1993: To Peter D. Lax for his numerous and fundamental contributions to the theory and applications of linear and nonlinear partial differential equations and functional analysis, for his leadership in the development of computational and applied mathematics, and for his extraordinary impact as a teacher.

August 1993 – Mathematical Exposition: To Walter Rudin for his books *Principles of Mathematical Analysis*, McGraw-Hill, 1953, 1964, and 1976; and *Real and Complex Analysis*, McGraw-Hill, 1966, 1974, and 1976.

August 1993 – Seminal Contribution to Research: To George Daniel Mostow for his paper *Strong rigidity of locally symmetric spaces*, Annals of Mathematics Studies, number **78**, Princeton University Press, 1973.

August 1993 – Lifetime Achievement: To Eugene B. Dynkin for his foundational contributions to Lie algebras and probability theory over a long period and his production of outstanding research students in both Russia and the United States, countries to whose mathematical life he has contributed so richly.

August 1994 – Mathematical Exposition: To Ingrid Daubechies for her book *Ten Lectures on Wavelets*, CBMS, volume 61, SIAM, 1992.

August 1994 – Seminal Contribution to Research: To Louis de Branges for his proof of the Bieberbach Conjecture.

August 1994 – Lifetime Achievement: To Louis Nirenberg for his numerous basic contributions to linear and nonlinear partial differential equations and their application to complex analysis and differential geometry.

August 1995 – Mathematical Exposition: To Jean-Pierre Serre for his 1970 book *Cours d'Arithmétique*, with its English translation, published in 1973 by Springer Verlag, *A Course in Arithmetic*.

August 1995 – Seminal Contribution to Research: To Edward Nelson for the following two papers in mathematical physics, characterized by leaders of the field as extremely innovative: *A quartic interaction in two dimensions* in *Mathematical Theory of Elementary Particles*, MIT Press, 1966, pp. 69–73; and *Construction of quantum fields from Markoff fields* in Journal of Functional Analysis **12** (1973), pp. 97–112. In these papers he showed for the first time how to use the powerful tools of probability theory to attack the hard analytic questions of constructive quantum field theory, controlling renormalizations with estimates in the first paper, and in the second turning Euclidean quantum field theory into a subset of the theory of stochastic processes.

August 1995 – Lifetime Achievement: To John T. Tate for scientific accomplishments spanning four and a half decades. He has been deeply influential in many of the important developments in algebra, algebraic geometry, and number theory during this time.

August 1996 – Mathematical Exposition: To Bruce C. Berndt for the four volumes, *Ramanujan's Notebooks*, Parts I, II, III, and IV (Springer, 1985, 1989, 1991, and 1994).

August 1996 – Mathematical Exposition: To William Fulton for his book *Intersection Theory*, Springer-Verlag, Ergebnisse series, 1984.

August 1996 – Seminal Contribution to Research: To Daniel Stroock and S. R. S. Varadhan for their four papers: *Diffusion processes with continuous coefficients I and II*, Comm. Pure Appl. Math. **22** (1969), pp. 345–400, pp. 479–530; *On the support of diffusion processes with applications to the strong maximum principle*, Sixth Berkeley Sympos. Math. Statist. Probab., vol. III, 1970, pp. 333–360; *Diffusion processes with boundary conditions*, Comm. Pure Appl. Math. **34** (1971), pp. 147–225; *Multidimensional diffusion processes*, Springer-Verlag, 1979.

August 1996 – Lifetime Achievement: To Goro Shimura for his important and extensive work on arithmetical geometry and automorphic forms; concepts introduced by him were often seminal and fertile ground for new developments, as witnessed by the many notations in number theory that carry his name and that have long been familiar to workers in the field.

January 1997 – Mathematical Exposition: To Anthony W. Knapp for his book *Representation Theory of Semisimple Groups (An overview based on examples)*, Princeton University Press, 1986, a beautifully written book which starts from scratch but takes the reader far into a highly developed subject.

January 1997 – Seminal Contribution to Research: To Mikhael Gromov for his paper *Pseudo-holomorphic curves in symplectic manifolds*, Inventiones Math. **82** (1985), pp. 307–347, which revolutionized the subject of symplectic geometry and topology and is central to much current research activity, including quantum cohomology and mirror symmetry.

January 1997 – Lifetime Achievement: To Ralph S. Phillips for being one of the outstanding analysts of our time. His early work was in functional analysis: his beautiful theorem on the relation between the spectrum of a semigroup and its infinitesimal generator is striking as well as very useful in the study of PDEs. His extension theory for dissipative linear operators predated the interpolation approach to operator theory and robust control. He made major contributions to acoustical scattering theory in his joint work with Peter Lax, proving remarkable results on local energy decay and the connections between poles of the scattering matrix and the analytic properties of the resolvent. He later extended this work to a spectral theory for the automorphic Laplace operator, relying on the Radon transform on horospheres to avoid Eisenstein series. In the last fifteen years, Ralph Phillips has done brilliant work, in collaboration with others, on spectral theory for the Laplacian on symmetric spaces, on the existence and stability of cusp forms for general noncompact quotients of the hyperbolic plane, on the explicit construction of sparse optimal expander graphs, and on the structure of families of isospectral sets in two dimensions (the collection of drums that sound the same).

January 1998 – Lifetime Achievement: To Nathan Jacobson for his many contributions to research, teaching, exposition, and the mathematical profession. Few mathematicians have been as productive over such a long career or have had as much influence on the profession as has Professor Jacobson.

January 1998 – Seminal Contribution to Research: To Herbert Wilf and Doron Zeilberger for their joint paper *Rational functions certify combinatorial identities*, Journal of the American Mathematical Society **3** (1990), pp. 147–158.

January 1998 – Mathematical Exposition: To Joseph Silverman for his books *The Arithmetic of Elliptic Curves*, Graduate Texts in Mathematics, volume 106, Springer-Verlag, New York and Berlin, 1986; and *Advanced Topics in the Arithmetic of Elliptic Curves*, Graduate Texts in Mathematics, volume 151, Springer-Verlag, New York, 1994.

January 1999 – Lifetime Achievement: To Richard V. Kadison. For almost half a century, Professor Kadison has been one of the world leaders in the subject of operator algebras, and the tremendous flourishing of this subject in the last thirty years is largely due to his efforts.

January 1999 – Seminal Contribution to Research: To Michael G. Crandall for two seminal papers: *Viscosity solutions of Hamilton-Jacobi equations* (joint with P.-L. Lions), Trans. Amer. Math. Soc. **277** (1983), pp. 1–42; and *Generation of semi-groups of nonlinear transformations on general Banach spaces* (joint with T. M. Liggett), Amer. J. Math. **93** (1971), pp. 265–298.

January 1999 – Seminal Contribution to Research: To John F. Nash for his remarkable paper *The embedding problem for Riemannian manifolds*, Ann. of Math. (2) **63** (1956), pp. 20–63.

January 1999 – Mathematical Exposition: To Serge Lang for his many books. Among Lang's most famous texts are *Algebra*, Addison-Wesley, Reading, MA, 1965; second edition, 1984; third edition, 1993; and *Algebraic Number Theory,* Addison-Wesley, Reading, MA, 1970; second edition, Graduate Texts in Mathematics, volume 110, Springer-Verlag, New York, 1994.

January 2000 – Lifetime Achievement: To Isadore M. Singer. Singer's series of five papers with Michael F. Atiyah on the Index Theorem for elliptic operators (which appeared in 1968–71) and his three papers with Atiyah and V. K. Patodi on the Index Theorem for manifolds with boundary (which appeared in 1975–76) are among the great classics of global analysis.

January 2000 – Seminal Contribution to Research: To Barry Mazur for his paper *Modular curves and the Eisenstein ideal* in Publications Mathematiques de l'Institut des Hautes Études Scientifiques, **47** (1978), pp. 33–186.

January 2000 – Mathematical Exposition: To John H. Conway in recognition of his many expository contributions in automata, the theory of games, lattices, coding theory, group theory, and quadratic forms.

January 2001 – Lifetime Achievement: To Harry Kesten for his many and deep contributions to probability theory and its applications.

January 2001 – Seminal Contribution to Research: To Leslie F. Greengard and Vladimir Rokhlin for the paper *A fast algorithm for particle simulations*, J. Comput. Phys. **73**, no. 2 (1987), pp. 325–348.

January 2001 – Mathematical Exposition: To Richard P. Stanley in recognition of the completion of his two-volume work *Enumerative Combinatorics*.

January 2002 – Lifetime Achievement: To Michael Artin for helping to weave the fabric of modern algebraic geometry and to Elias Stein for making fundamental contributions to different branches of analysis.

January 2002 – Seminal Contribution to Research: To Mark Goresky and Robert MacPherson for the papers *Intersection homology theory*, Topology **19** (1980), no. 2, pp. 135–162 (IH1); and *Intersection homology. II*, Invent. Math. **72** (1983), no. 1, pp. 77–129 (IH2).

January 2002 – Mathematical Exposition: To Yitzhak Katznelson for his book on harmonic analysis.

January 2003 – Lifetime Achievement: To Ron Graham for being one of the principal architects of the rapid development worldwide of discrete mathematics in recent years and to Victor Guillemin for playing a critical role in the development of a number of important areas in analysis and geometry.

January 2003 – Seminal Contribution to Research: To Ronald Jensen for his paper *The fine structure of the constructible hierarchy*, Annals of Mathematical Logic **4** (1972), 229–308 pp.; and to Michael Morley for his paper *Categoricity in power*, Transactions of the AMS **114** (1965), pp. 514–538.

January 2003 – Mathematical Exposition: To John B. Garnett for his book *Bounded Analytic Functions*, Pure and Applied Mathematics, volume 96, Academic Press, Inc. [Harcourt Brace Jovanovich, Publishers], New York and London, 1981.

January 2004 – Lifetime Achievement: To Cathleen Synge Morawetz for greatly influencing mathematics in the broad sense throughout her long and distinguished career.

January 2004 – Seminal Contribution to Research: To Lawrence C. Evans and Nicolai V. Krylov for the "Evans-Krylov theorem", as first established in the papers: Lawrence C. Evans, *Classical solutions of fully nonlinear convex, second order elliptic equations*, Communications in Pure and Applied Mathematics **35** (1982), no. 3, pp. 333–363; and N. V. Krylov, *Boundedly inhomogeneous elliptic and parabolic equations*, Izvestiya Akad. Nauk SSSR, Ser. Mat. **46** (1982), no. 3, pp. 487–523; translated in Mathematics of the USSR, Izvestiya **20** (1983), no. 3, pp. 459–492.

January 2004 – Mathematical Exposition: To John W. Milnor in recognition of a lifetime of expository contributions ranging across a wide spectrum of disciplines, including topology, symmetric bilinear forms, characteristic classes, Morse theory, game theory, algebraic K-theory, iterated rational maps,…and the list goes on.

January 2005 – Lifetime Achievement: To Israel M. Gelfand for profoundly influencing many fields of research through his own work and through his interactions with other mathematicians and students.

January 2005 – Seminal Contribution to Research: To Robert P. Langlands for his paper *Problems in the theory of automorphic forms*, Springer Lecture Notes in Math., volume 170, 1970, pp. 18–86. This is the paper that introduced what are now known as the Langlands conjectures.

January 2005 – Mathematical Exposition: To Branko Grünbaum for his book *Convex Polytopes*.

January 2006 – Lifetime Achievement: To Frederick W. Gehring for being a leading figure in the theory of quasiconformal mappings for over fifty years; and to Dennis P. Sullivan for his fundamental contributions to many branches of mathematics.

January 2006 – Seminal Contribution to Research: To Clifford S. Gardner, John M. Greene, Martin D. Kruskal, and Robert M. Miura for their paper *KortewegdeVries equation and generalizations. VI. Methods for exact solution*, Comm. Pure Appl. Math. **27** (1974), 97–133.

January 2006 – Mathematical Exposition: To Lars V. Hörmander for his book, *The Analysis of Linear Partial Differential Operators*.

January 2007 – Lifetime Achievement: To Henry P. McKean for his rich and magnificent mathematical career and for his work in analysis, which has a strong orientation towards probability theory.

January 2007 – Seminal Contribution to Research: To Karen Uhlenbeck for her foundational contributions in analytic aspects of mathematical gauge theory. These results appeared in the two papers: *Removable singularities in Yang-Mills fields*, Communications in Mathematical Physics, **83** (1982), 11–29 and *Connections with L:P bounds on curvature*, Communications in Mathematical Physics, **83** (1982), 31–42.

January 2007 – Mathematical Exposition: To David Mumford for his beautiful expository accounts of a host of aspects of algebraic geometry, including *The Red Book of Varieties and Schemes* (Springer, 1988).

January 2008 – Lifetime Achievement: To George Lusztig for entirely reshaping representation theory, and, in the process, changing much of mathematics.

January 2008 – Seminal Contribution to Research: To Endre Szemerédi for his paper *On sets of integers containing no k elements in arithmetic progression*, Acta Arithmetica XXVII (1975), 199-245.

January 2008 – Mathematical Exposition: To Neil Trudinger for his book *Elliptic Partial Differential Equations of Second Order*, written with the late David Gilbarg.

January 2009 – Lifetime Achievement: To Luis Caffarelli, one of the world's greatest mathematicians studying nonlinear partial differential equations (PDE).

January 2009 – Seminal Contribution to Research: To Richard Hamilton for his paper *Three-manifolds with positive Ricci curvature*, J. Differential Geom. **17** (1982), 255-306.

January 2009 – Mathematical Exposition: To I. G. MacDonald for his book *Symmetric Functions and Hall Polynomials* (second edition, Clarendon Press, Oxford University Press, 1995).

January 2010 – Lifetime Achievement: To William Fulton for playing a pivotal role in shaping the direction of algebraic geometry, forging and strengthening ties between algebraic geometry and adjacent fields, and teaching and mentoring several generations of younger mathematicians.

January 2010 – Seminal Contribution to Research: To Robert L. Griess Jr. for his construction of the "Monster" sporadic finite simple group, which he first announced in "A construction of F1 as automorphisms of a 196,883-dimensional algebra" (*Proc. Nat. Acad. Sci. U.S.A.* **78** (1981), no. 2, part 1, 686–691) with details published in "The friendly giant" (*Invent. Math.* **69** (1982), no. 1, 1–102).

January 2010 – Mathematical Exposition: To David Eisenbud for his book, *Commutative Algebra: With a View Toward Algebraic Geometry* (Graduate Texts in Mathematics, 150, Springer-Verlag, New York, 1995. xvi+785 pp.).

January 2011 – Lifetime Achievement: To John W. Milnor for standing out from the list of great mathematicians in terms of his overall achievements and his influence on mathematics in general, both through his work and through his excellent books.

January 2011 – Seminal Contribution to Research: To Ingrid Daubechies for her paper, "Orthonormal bases of compactly supported wavelets" (*Communications on Pure and Applied Mathematics* **41** (1988), no. 7, 909-996).

January 2011 – Mathematical Exposition: To Henryk Iwaniec for his long record of excellent exposition, both in books and in classroom notes.

Next awards: January 2012.

The Oswald Veblen Prize in Geometry

This prize was established in 1961 in memory of Professor Oswald Veblen through a fund contributed by former students and colleagues. The fund was later doubled by the widow of Professor Veblen. It is awarded in recogni-

tion of a notable research memoir in geometry or topology published in the preceding six years. To be considered, either the nominee should be a member of the Society or the memoir should have been published in a recognized North American journal. Currently, the US$5,000 prize is awarded every three years.

First award, 1964: To C. D. Papakyriakopoulos for his papers *On solid tori*, Annals of Mathematics, Series 2, **66** (1957), pp. 1–26; and *On Dehn's lemma and the asphericity of knots*, Proceedings of the National Academy of Sciences **43** (1957), pp. 169–172.

Second award, 1964: To Raoul Bott for his papers *The space of loops on a Lie group*, Michigan Mathematical Journal **5** (1958), pp. 35–61; and *The stable homotopy of the classical groups*, Annals of Mathematics, Series 2, **70** (1959), pp. 313–337.

Third award, 1966: To Steven Smale for his contributions to various aspects of differential topology.

Fourth award, 1966: To Morton Brown and Barry Mazur for their work on the generalized Schoenflies theorem.

Fifth award, 1971: To Robion C. Kirby for his paper *Stable homeomorphisms and the annulus conjecture*, Annals of Mathematics, Series 2, **89** (1969), pp. 575–582.

Sixth award, 1971: To Dennis P. Sullivan for his work on the Hauptvermutung summarized in the paper *On the Hauptvermutung for manifolds*, Bulletin of the American Mathematical Society **73** (1967), pp. 598–600.

Seventh award, 1976: To William P. Thurston for his work on foliations.

Eighth award, 1976: To James Simons for his work on minimal varieties and characteristic forms.

Ninth award, 1981: To Mikhael Gromov for his work relating topological and geometric properties of Riemannian manifolds.

Tenth award, 1981: To Shing-Tung Yau for his work in nonlinear partial differential equations, his contributions to the topology of differentiable manifolds, and for his work on the complex Monge-Ampère equation on compact complex manifolds.

Eleventh award, 1986: To Michael H. Freedman for his work in differential geometry and, in particular, the solution of the four-dimensional Poincaré conjecture.

Twelfth award, 1991: To Andrew J. Casson for his work on the topology of low-dimensional manifolds and to Clifford H. Taubes for his foundational work in Yang-Mills theory.

Thirteenth award, 1996: To Richard Hamilton for his continuing study of the Ricci flow and related parabolic equations for a Riemannian metric, and to Gang Tian for his contributions to geometric analysis.

Fourteenth award, 2001: To Jeff Cheeger for his work in differential geometry, to Yakov Eliashberg for his work in symplectic and contact topology, and to Michael J. Hopkins for his work in homotopy theory.

Fifteenth award, 2004: To David Gabai in recognition of his work in geometric topology, in particular, the topology of 3-dimensional manifolds.

Sixteenth award, 2007: To Peter Kronheimer and Tomasz Mrowka for their joint contributions to both three- and four-dimensional topology through the development of deep analytical techniques and applications; and to Peter Ozsváth and Zoltán Szabó for their contributions to 3- and 4-dimensional topology through their Heegaard Floer homology theory.

Seventeenth award, 2010: To Tobias H. Colding and William P. Minicozzi II for their profound work on minimal surfaces; and to Paul Seidel for his fundamental contributions to symplectic geometry.

Next award: January 2013.

The Albert Leon Whiteman Memorial Prize

This prize was established in 1998 using funds donated by Mrs. Sally Whiteman in memory of her husband, Albert Leon Whiteman, to recognize notable exposition and exceptional scholarship in the history of mathematics. Starting in 2009, the US$5,000 prize will be awarded every three years.

First award, 2001: To Thomas Hawkins to recognize an outstanding historian of mathematics whose current research and numerous publications display the highest standards of mathematical and historical sophistication.

Second award, 2005: To Harold M. Edwards to pay tribute to his many publications over several decades that have fostered a greater understanding and appreciation of the history of mathematics, expecially the theory of algebraic numbers.

Third award, 2009: To Jeremy John Gray for his many historical works, which have not only shed great light on the history of modern mathematics but also have given an example of the ways in which historical scholarship can contribute to the understanding of mathematics and its philosophy.

Next award: January 2012.

The Norbert Wiener Prize in Applied Mathematics

This prize was established in 1967 in honor of Professor Norbert Wiener and was endowed by a fund from the Department of Mathematics of the Massachusetts Institute of Technology. The prize is awarded for an outstanding contribution to "applied mathematics in the highest and broadest sense". The award is made jointly by the American Mathematical Society and the Society for Industrial and Applied Mathematics. The recipient must be a member of one of these societies and a resident of the United States, Canada, or Mexico. Beginning in 2004, the US$5,000 prize will be awarded every three years.

First award, 1970: To Richard E. Bellman for his pioneering work in the area of dynamic programming and for his related work on control, stability, and differential-delay equations.

Second award, 1975: To Peter D. Lax for his broad contributions to applied mathematics, in particular, for his work on numerical and theoretical aspects of partial differential equations and on scattering theory.

Third award, 1980: To Tosio Kato for his distinguished work in the perturbation theory of quantum mechanics.

Fourth award, 1980: To Gerald B. Whitham for his broad contributions to the understanding of fluid dynamical phenomena and his innovative contributions to the methodology through which that understanding can be constructed.

Fifth award, 1985: To Clifford S. Gardner for his contributions to applied mathematics in the areas of supersonic aerodynamics, plasma physics and hydromagnetics, and especially for his contributions to the truly remarkable development of inverse scattering theory for the solution of nonlinear partial differential equations.

Sixth award, 1990: To Michael Aizenman for his outstanding contribution of original and nonperturbative mathematical methods in statistical mechanics, by means of which he was able to solve several long open important problems concerning critical phenomena, phase transitions, and quantum field theory; and to Jerrold E. Marsden for his outstanding contributions to the study of differential equations in mechanics: he proved the existence of chaos in specific classical differential equations; his work on the momentum map, from abstract foundations to detailed applications, has had great impact.

Seventh award, 1995: To Hermann Flaschka for deep and original contributions to our understanding of completely integrable systems, and to Ciprian Foias for basic contributions to operator theory, analysis, and dynamics and their applications.

Eighth award, 2000: To Alexandre J. Chorin in recognition of his seminal work in computational fluid dynamics, statistical mechanics, and turbulence; and to Arthur T. Winfree in recognition of his profound impact on the field of biological rhythms, otherwise known as coupled nonlinear oscillators.

Ninth award, 2004: To James A. Sethian for his seminal work on the computer representation of the motion of curves, surfaces, interfaces, and wave fronts, and for his brilliant applications of mathematical and computational ideas to problems in science and engineering.

Tenth award, 2007: To Craig Tracy and Harold Widom for their deep and original work on Random Matrix Theory, a subject which has remarkable applications across the scientific spectrum, from the scattering of neutrons off large nuclei to the behavior of the zeros of the Riemann zeta-function.

Eleventh award, 2010: To David L. Donoho for introducing novel fundamental and powerful mathematical tools in signal processing and image analysis.

Next award: January 2013.

Awards

AMS Centennial Fellowships

A Research Fellowship Fund was established by the AMS in 1973 to provide one-year fellowships for research in mathematics. In 1988 the Fellowship was renamed to honor the AMS Centennial. The number of fellowships granted each year depends on the contributions received; the Society supplements contributions as needed. The primary selection criterion for the Centennial Fellowship is the excellence of the candidate's research. A recipient of the fellowship shall have held his or her doctoral degree for at least three years and not more than twelve years at the inception of the award. Applications will be accepted from those currently holding a tenured, tenure-track, postdoctoral, or comparable (at the discretion of the selection committee) position at an institution in North America. The amount of the fellowship varies each year. See the last entry on the list below to find the amount and number of fellowships awarded most recently. To make a contribution to the Centennial Fellowship Fund, see `http://www.ams.org/development/centennialfund.html`. To apply for a Centennial Fellowship, see `http://www.ams.org/employment/centflyer.html`.

First award, 1974–1975: Fred G. Abramson, James Li-Ming Wang.

Second award, 1975–1976: Terence J. Gaffney, Paul Nèvai, George M. Reed.

Third award, 1976–1977: Fredric D. Ancel, Joseph A. Sgro.

Fourth award, 1977–1978: Steven Kalikow, Charles Patton, Duong-Hong Phong, David Vogan.

Fifth award, 1978–1979: Alan Dankner, David Harbater, Howard Hiller, Steven P. Kerckhoff, Robert C. McOwen.

Sixth award, 1979–1980: Scott W. Brown, Jeffrey E. Hoffstein, Jeffry N. Kahn, James E. McClure, Rick L. Smith, Mark Steinberger.

Seventh award, 1980–1981: Robert K. Lazarsfeld, Thomas H. Parker, Robert Sachs.

Eighth award, 1981–1982: Lawrence Man-Hou Ein, Mark Williams.

Ninth award, 1982–1983: Nicholas J. Kuhn.

Tenth award, 1983–1984: Russell David Lyons.

Eleventh award, 1984–1985: Richard Timothy Durrett.

Twelfth award, 1985–1986: R. Michael Beals.

Thirteenth award, 1986–1987: Dinakar Ramakrishnan.

Fourteenth award, 1987–1988: Richard Hain, Bill Jacob.

Fifteenth award, 1988–1989: Steven R. Bell, Don M. Blasius, David Gabai.

Sixteenth award, 1989–1990: Isaac Y. Efrat, John M. Lee, Ralf J. Spatzier.

Seventeenth award, 1990–1991: Michael Anderson, Carolyn Gordon, Steven Mitchell.

Eighteenth award, 1991–1992: Daniel Bump, Kari Vilonen.

Nineteenth award, 1992–1993: Krzysztof Burdzy, William Menasco, David Morrison.

Twentieth award, 1993–1994: Jacques Hurtubise, Andre Scedrov, David Webb.

Twenty-first award, 1994–1995: Patricia E. Bauman, David E. Marker.

Twenty-second award, 1995–1996: Rafael de la Llave, William Gordon McCallum, Kent Edward Orr.

Twenty-third award, 1996–1997: Yi Hu, Robert McCann, Alexander Voronov, Jiaping Wang.

Twenty-fourth award, 1997–1998: Ovidiu Costin, Fred Diamond, Gang Liu, Zhongwei Shen, Stephanie Frank Singer.

Twenty-fifth award, 1998–1999: Mark Andrea A. de Cataldo, Stavros Garoufalidis, Sándor Kovács, Yanguang Li.

Twenty-sixth award, 1999–2000: Charles W. Rezk, Bin Wang, Changyou Wang, Tonghai Yang.

Twenty-seventh award, 2000–2001: Siqi Fu, Christopher Herald, Wei-Dong Ruan, Vasily Strela.

Twenty-eighth award, 2001–2002: Ivan Dimitrov, Ravi Vakil, Jiahong Wu, Meijun Zhu.

Twenty-ninth award, 2002–2003: Albert C. Fannjiang, Wee Teck Gan, Ravi Kumar Ramakrishna.

Thirtieth award, 2003–2004: Henry H. Kim, John E. Meier.

Thirty-first award, 2004–2005: Jinho Baik, Nitu Kitchloo.

Thirty-second award, 2005–2006: Yuan-Pin Lee, Mihnea Popa.

Thirty-third award, 2006–2007: Christopher Hacon, Bryna Kra.

Thirty-fourth award, 2007–2008: Martin Kassabov.

Thirty-fifth award, 2008–2009: Christopher Hoffman.

Thirty-sixth award, 2009–2010: Antonio Montalban.

Thirty-seventh award, 2010–2011: Joel Bellaiche.

Thirty-eighth award, 2011–2012: Andrew S. Toms.

Next award (for 2012–2013 academic year): June 2012.

JPBM Communications Award

This award was established by the Joint Policy Board for Mathematics (JPBM) in 1988 to reward and encourage communicators who, on a sustained basis, bring mathematical ideas and information to nonmathematical audiences. Both mathematicians and nonmathematicians are eligible. Currently, the US$1,000 award is made annually. JPBM is a collaborative effort of the American Mathematical Society, the Mathematical Association of America, the Society for Industrial and Applied Mathematics, and the American Statistical Association.

First award, 1988: To James Gleick for sustained and outstanding contributions in communicating mathematics to the general public.

Second award, 1990: To Hugh Whitemore for contributions to communicating mathematics to the public in his play *Breaking the Code*, which chronicles the brilliant but troubled life of British mathematician Alan Turing.

Third award, 1991: To Ivars Peterson for exceptional skill in communicating mathematics to the general public over the last decade.

Fourth award, 1993: To Joel Schneider for *Square One TV*.

Fifth award, 1994: To Martin Gardner, for authoring numerous books and articles about mathematics, including his long-running *Scientific American* column "Mathematical Games", and his books *Fads and Fallacies in the Name of Science* and *Mathematical Carnival*.

Sixth award, 1996: To Gina Kolata for consistently giving outstanding coverage to many of the most exciting breakthroughs in mathematics and computer science over the past twenty years.

Seventh award, 1997: To Philip J. Davis for being a prolific communicator of mathematics to the general public.

Eighth award, 1998: To Constance Reid for writing about mathematics with grace, knowledge, skill, and clarity.

Ninth award, 1999: To Ian Stewart for communicating the excitement of science and mathematics to millions of people around the world for more than twenty years. Also a "Special Communications Award" to John Lynch and Simon Singh for their exceptional contributions to public understanding of mathematics through their documentary on Andrew Wiles and the Fermat Conjecture, entitled *Fermat's Last Theorem* (shown on *NOVA* as "The Proof").

Tenth award, 2000: To Sylvia Nasar for *A Beautiful Mind*, her biography of John Forbes Nash Jr.

Eleventh award, 2001: To Keith J. Devlin for his many contributions to public understanding of mathematics through great numbers of radio and television appearances; public talks; books; and articles in magazines, newsletters, newspapers, journals, and online.

Twelfth award, 2002: To Helaman and Claire Ferguson for dazzling the mathematical community and a far wider public with exquisite sculptures embodying mathematical ideas, along with artful and accessible essays and lectures elucidating the mathematical concepts.

Thirteenth award, 2003: To Robert Osserman for being an erudite spokesman for mathematics, communicating its charm and excitement to thousands of people from all walks of life.

2004: No award given.

Fourteenth award, 2005: To Barry Cipra for writing about mathematics of every kind—from the most abstract to the most applied—for nearly twenty years. His lucid explanations of complicated ideas at the frontiers of research have appeared in dozens of articles in newspapers, magazines, and books.

Fifteenth award, 2006: To Roger Penrose for the discovery of Penrose tilings, which have captured the public's imagination, and for an extraordinary series of books that brought the subject of consciousness to the public in mathematical terms.

Sixteenth award, 2007: To Steven H. Strogatz for making a consistent effort to reach out to a wider audience. He has made significant contact with the wider scientific community. The style of his book, *Sync: The Emerging Science of Spontaneous Order* (2003), and its sales indicate that it is intended for and has reached an even wider audience. The volume of this work is impressive, but the quality and breadth are spectacular as well.

Seventeenth award, 2008: To Carl Bialik for increasing the public's understanding of mathematical concepts.

Eighteenth award, 2009: To George Csicsery for communicating the beauty and fascination of mathematics and the passion of those who pursue it.

Nineteenth award, 2010: To Marcus du Sautoy for complementing his love of mathematical discovery with a passion for communicating mathematics to a broad public.

Twentieth award, 2011: To Nicolas Falacci and Cheryl Heuton for their positive portrayal of the power and fun of mathematics through their hit TV series, *Numb3rs*.

Next award: January 2012.

AMS Epsilon Awards for Young Scholars Programs

In 1999 the American Mathematical Society started the Epsilon Fund to help support existing summer programs for mathematically talented high school students. The name for the fund was chosen in remembrance of the late Paul Erdős, who was fond of calling children "epsilons". At its meeting in November 2000, the AMS Board of Trustees approved the Society's engagement in a sustained effort to raise an endowment for the Epsilon Fund. In addition, a Board-designated fund of US$500,000 was created as a

start for the endowment. As a start for the program, the AMS used money from its Program Development Fund to award Epsilon grants for activities during summers 2000, 2001, 2002, and 2003. The Epsilon Fund now stands at a level where it can annually provide grants to support ten separate programs that touch approximately 600 talented and highly motivated mathematics students every year. To make a contribution to the Epsilon Fund, see `http://www.ams.org/about-us/support-ams/giving_op/epsilon`. To apply for an Epsilon grant, see `http://www.ams.org/programs/edu-support/epsilon/emp-epsilon`.

First awards, 2000: To All Girls/All Math (University of Nebraska, Lincoln), Hampshire College Summer Studies in Mathematics, Mathcamp, PROMYS (Boston University), Ross Young Scholars Program (Ohio State University), SWT Honors Summer Math Camp (Southwest Texas State University), and the University of Michigan Math Scholars.

Second awards, 2001: To All Girls/All Math (University of Nebraska), Mathcamp (Port Huron, Michigan), Michigan Math & Science Scholars (University of Michigan, Ann Arbor), Mathematics Scholars Academy (Oklahoma State University), Hampshire College Summer Studies in Mathematics (Hampshire College), PROMYS (Boston University), Young Scholars Program (University of Chicago), and Ross Mathematics Program (The Ohio State University).

Third awards, 2002: To All Girls/All Math (University of Nebraska), Hampshire College Summer Studies in Mathematics (Amherst, Massachusetts), Mathcamp (Mathematics Foundation of America), Michigan Math and Science Scholars (University of Michigan, Ann Arbor), PROMYS (Boston University), Ross Mathematics Program (The Ohio State University), SWT Honors Summer Math Camp (Southwest Texas State University), and University of Chicago Young Scholars Program.

Fourth awards, 2003: To All Girls/All Math (University of Nebraska), Canada/USA Mathcamp (Mathematics Foundation of America), Hampshire College Summer Studies in Mathematics (Amherst, Massachusetts), PROMYS (Boston University), Ross Mathematics Program (The Ohio State University), Stanford University Mathematics Camp (Stanford University), SWT Honors Summer Math Camp (Southwest Texas State University), and University of Chicago Young Scholars Program.

Fifth awards, 2004: To Ross Mathematics Program (The Ohio State University), Texas State University Honors Summer Math Camp, PROMYS (Boston University), Canada/USA Mathcamp (Mathematics Foundation of America), Hampshire College Summer Studies in Mathematics (Amherst, Massachusetts), All Girls/All Math (University of Nebraska), University of Chicago Young Scholars Program, and MathPath (MathPath Foundation).

Sixth awards, 2005: To All Girls/All Math Summer Camp for High School Girls (University of Nebraska, Lincoln), Canada/USA Mathcamp (Reed College, Portland, Oregon), Hampshire College Summer Studies in Mathematics (Hampshire College, Amherst, Massachusetts), MathPath, (Colorado College, Colorado Springs), Michigan Math and Science Scholars Program (University of Michigan, Ann Arbor), PROMYS (Boston University), Ross Mathematics Program (The Ohio State University), Texas State Honors Summer Math Camp (Texas State University, San Marcos), and University of Chicago Young Scholars Program.

Seventh awards, 2006: To All Girls/All Math Summer Camp for High School Girls (University of Nebraska, Lincoln), Canada/USA Mathcamp (University of Puget Sound, Tacoma, Washington), Hampshire College Summer Studies in Mathematics (Hampshire College, Amherst, Massachusetts), MathPath, (University of California, Santa Cruz), Michigan Math and Science Scholars Program (University of Michigan, Ann Arbor), PROMYS (Boston University), Puerto Rico Opportunities for Talented Students in Mathematics (PROTaSM) (University of Puerto Rico, Mayaguez), Ross Mathematics Program (Ohio State University, Columbus), Summer Explorations and Research Collaborations for High School Girls (SEARCH) (Mount Holyoke College, South Hadley, Massachusetts), Texas State Honors Summer Math Camp (Texas State University, San Marcos), Texas Tech University Summer Mathematics Academy (Texas Tech University, Lubbock), and University of Chicago Young Scholars Program (University of Chicago).

Eighth awards, 2007: Hampshire College Summer Studies in Mathematics, Amherst, Massachusetts; Michigan Math and Science Scholars Summer Program, University of Michigan, Ann Arbor; PROMYS, Boston University; Ross Mathematics Program, Ohio State University, Columbus; Summer Explorations and Research Collaborations for High School Girls (SEARCH), Mount Holyoke College, South Hadley, Massachusetts; and Texas State University Honors Summer Math Camp, Texas State University, San Marcos.

Ninth awards, 2008: All Girls/All Math, University of Nebraska, Lincoln; Hampshire College Summer Studies in Mathematics, Amherst, Massachusetts; MathPath, University of Vermont, Burlington; Michigan Math and Science Scholars Summer Program, University of Michigan, Ann Arbor; PROMYS, Boston University; PROTaSM (Puerto Rico Opportunities for Talented Students in Mathematics), University of Puerto Rico, Mayaguez; Ross Mathematics Program, Ohio State University, Columbus; and Texas State University Honors Summer Math Camp, Texas State University, San Marcos.

Tenth awards, 2009: Achievement in Mathematics Program (AMP), Lamar University; All Girls/All Math, University of Nebraska, Lincoln; Hampshire College Summer Studies in Mathematics (HCSSiM), Hampshire College; MathPath, Colorado College, Colorado Springs; Michigan Math and Science Scholars Summer Program, University of Michigan, Ann Arbor; PROMYS (Program in Mathematics for Young Scientists), Boston University; PROTaSM (Puerto Rico Opportunities for Talented Students in Mathematics), University of Puerto Rico, Mayagüez Campus; Research Science Institute, Massachusetts Institute of Technology; Ross Mathematics Program, Ohio State University, Columbus; Texas State University Honors Summer Math Camp, Texas State University, San Marcos.

Eleventh awards, 2010: All Girls/All Math, University of Nebraska, Lincoln; Lamar Achievement in Mathematics Program (LAMP), Lamar University; MathPath, Macalester College; PROMYS (Program in Mathematics for Young Scientists), Boston University; PROTaSM (Puerto Rico Opportunities for Talented Students in Mathematics),

University of Puerto Rico, Mayagüez Campus; Research Science Institute, Massachusetts Institute of Technology; Stanford University Mathematics Camp (SUMaC), Stanford University; Stony Brook Mathematics Camp, State University of New York at Stony Brook; Texas State Honors Summer Math Camp, Texas State University; Young Scholars Program, University of Chicago.

Twelfth awards, 2011: All Girls/All Math, University of Nebraska, Lincoln; Canada/USA Mathcamp, Reed College, Portland, Oregon; Lamar Achievement in Mathematics Program (LAMP), Lamar University, Beaumont, Texas; MathPath, Colorado College, Colorado Springs; PROMYS, Boston University; PROTaSM (Puerto Rico Opportunities for Talented Students in Mathematics), University of Puerto Rico, Mayagüez Campus; Research Science Institute, Massachusetts Institute of Technology; Ross Mathematics Program, The Ohio State University; Texas State Honors Summer Math Camp, Texas State University, San Marcos; Young Scholars Program, University of Chicago.
Next awards (for summer 2012): May 2012.

Award for an Exemplary Program or Achievement in a Mathematics Department

This award was established in 2004 to recognize a department which has distinguished itself by undertaking an unusual or particularly effective program of value to the mathematics community, internally or in relation to the rest of society. Examples might include a department that runs a notable minority outreach program, a department that has instituted an unusually effective industrial mathematics internship program, a department that has promoted mathematics so successfully that a large fraction of its university's undergraduate population majors in mathematics, or a department that has made some form of innovation in its research support to faculty and/or graduate students or which has created a special and innovative environment for some aspect of mathematics research. Departments of mathematical sciences in North America that offer at least a bachelor's degree in mathematical sciences are eligible. The prize is awarded annually. For the first three awards (2006-2008), the prize amount was US$1,200. The prize was endowed by an anonymous donor in 2008, and, starting with the 2009 prize, the amount is US$5,000.

Nomination process: A letter of nomination may be submitted by one or more individuals. Nomination of the writer's own institution is permitted. The letter should describe the specific program(s) for which the department in being nominated as well as the achievements which make the program(s) an outstanding success and may include any ancillary documents which support the success of the program(s). The letter should not exceed two pages, with supporting documentation not to exceed an additional three pages. Nominations should be submitted to the Office of the Secretary. Nominations received by September 15 will be considered for the award presented the following January.

First award, 2006: Harvey Mudd College.

Second award, 2007: University of California, Los Angeles (UCLA).

Third award, 2008: University of Iowa. See also `http://www.ams.org/notices/200805/tx080500599p.pdf`.

Fourth award, 2009: University of Nebraska-Lincoln. See also `http://www.ams.org/notices/200905/rtx090500622p.pdf`.

Fifth award, 2010: North Carolina State University. See also `http://www.ams.org/notices/201005/rtx100500653p.pdf`.

Sixth award, 2011: University of Arizona. See also `http://www.ams.org/notices/201105/rtx110500718p.pdf`.

Next award: Spring 2012.

Mathematical Art Exhibition Award

This award "for aesthetically pleasing works that combine mathematics and art" was established in 2008 through an endowment provided by an anonymous donor who wishes to acknowledge those whose works demonstrate the beauty and elegance of mathematics expressed in a visual art form. The exhibition takes place every January at the Joint Mathematics Meetings. First (US$500), second (US$300), and third place (US$200) awards are made annually. For further information about this award, email the AMS Public Awareness Office.

First Awards, 2009: First place award to Goran Konjevod, for his origami work, "Wave (32), 2006"; second place award to Carlo Séquin, for his sculpture, "Figure-8 Knot, 2007"; and third place award to Robert Fathauer, for "Twice Iterated Knot No. 1, 2008".

Second Awards, 2010: First place award to Robert Bosch for "Embrace"; second place award to Harry Benke for "The Vase"; and third place award to Richard Werner for "Meditations on f(x,y) = x2/2 + xy/2 - y4/8".

Third Awards, 2011: First place award to to Margaret Kepner for "Magic Square 25 Study"; second place award to Carlo H. Séquin for "Torus Knot (5,3)"; and third place award to Anne Burns for "Circles on Orthogonal Circles".
Next Award: January 2012.

The Award for Mathematics Programs that Make a Difference

This award was established in 2005 in response to a recommendation from the AMS's Committee on the Profession that the AMS compile and publish a series of profiles of programs that:
1) aim to bring more persons from underrepresented minority backgrounds into some portion of the pipeline beginning at the undergraduate level and leading to advanced degrees in mathematics and professional success, or retain them once in the pipeline;
2) have achieved documentable success in doing so; and are replicable models.

Preference will be given to programs with significant participation by underrepresented minorities. Two programs are highlighted annually.

First award, 2006: Summer Institute in Mathematics for Undergraduates (SIMU), Universidad de Puerto Rico, Humacao; and Graduate Program, Department of Mathematics, University of Iowa.

Second award, 2007: Enhancing Diversity in Graduate Education (EDGE), Bryn Mawr College and Spelman College; and Mathematical Theoretical Biology Institute (MTBI), Arizona State University.

Third award, 2008: Summer Undergraduate Mathematical Science Research Institute (SUMSRI), Miami University (Ohio) and Mathematics Summer Program in Research and Learning (Math SPIRAL), University of Maryland, College Park. See citations and descriptions of programs. See *Notices of the AMS* article.

Fourth award, 2009: Department of Mathematics at the University of Mississippi and the Department of Statistics at North Carolina State University. See citations and description of programs.

Fifth award, 2010: Department of Computational and Applied Mathematics (CAAM) at Rice University and the Summer Program in Quantitative Sciences at the Harvard School of Public Health. See citations and descriptions of programs. See *Notices of the AMS* article, May 2010, p. 650.

Sixth award, 2011: Department of Mathematics at North Carolina State University and the Center for Women in Mathematics and the Center's Post-baccalaureate Program at Smith College. See citations and descriptions of programs. See *Notices of the AMS* article, May 2011, p. 713.

Next award: Spring 2012. For information about the nomination process, please see `www.ams.org/programs/diversity/emp-makeadiff` or contact Dr. Ellen Maycock, AMS Executive Director for Meetings & Professional Services, at `ejm@ams.org` or phone (800-321-4267).

The Karl Menger Memorial Awards

Family members of the late Karl Menger were the major contributors to a fund established at Duke University. The majority of the income from this fund is to be used by the Society for annual awards at the International Science and Engineering Fair.

First award, 1990: Daniel K. Dugger, Joshua Erlich, Joshua B. Fischman, Min-Horng Chen, Matthew Baker, Michael L. Harrison, Virginia A. DiDomizio.

Second award, 1991: Monwhea Jeng, Hans Christian Gromoll, Jesse L. Tseng, Andrew Olstrom Dittmer, Matthew A. Neimark, Rageshree Ramachandran, Jeb E. Willenbring.

Third award, 1992: Mahesh Kalyana Mahanthappa, Harrison Kwei Tsai, Andrew Olstrom Dittmer, Jonobie Dale Baker, Joshua Brody, Yen-Hsiang Li, Robert Jordon Pollack.

Fourth award, 1993: Mahesh Kalyana Mahanthappa, Steve Shaw-Tang Chien, Andrew Olstrom Dittmer, Moon Duchin, Robert Michael Kirby II, Sarah Ann Lord, Anna Ruth Terry.

Fifth award, 1994: Davesh Maulik, Eric Matthew Dennis, Sarah Ann Lord, Timothy Stephen Eller, Rahul Manu Kohli, Fam-ye Lin, Benedek Valko, Mary Kathleen Clavenna, Vinay Kumak Goyal-Singhal, Jan Kristian Haugland, Wes Andres Watters, Ian George Zacharia.

Sixth award, 1995: Davesh Maulik, Benjamin Michael Goetz, Jacob Lurie, Daniel Kalman Biss, Samit Dasgupta, Yueh-Hsing Lin, Claus Mazanti Sorensen, Theodore Haw-Yun Hwa, Samuel Jacob Klein Jr., Katherine Anne Paur, Bridget Helen Penny, Scott Nicholas Sanders.

Seventh award, 1996: Davesh Maulik, Nicholas Karl Eriksson, Logan Joseph Kleinwaks, Eric Jon Landquist, Vanesa Miranda-Diaz, Jason Charles Stone, Lauren Kiyomi Williams, Ryan Thomas Hebert, Kendrick Norris Kay, Scott Nicholas Sanders, Claus Mazanti Sorensen, Yvette Karen Wood.

Eighth award, 1997: Davesh Maulik, Nicholas Eriksson, Jeremy Rahe, Jennifer Pelka, Yen-Jen Chen, Sylvain Halle, Melanie Schechter, Matthew Seligman, Thomas Mack, Susannah Rutherglen, Jy-Ying Janet Chen, Chun-Hsiang Fu, Daniel Ying-Jeh Little.

Ninth award, 1998: Jonathan Adam Kelner, Michael Yanchee Lee, Daniel Yamins, Alexey Evgenjevitch Eroshin, Sarah Flannery, Jeremy Ryan Rahe, Jennifer Rose Walk, Richard Lee Barnes, Matthew Christopher Ong, David Carl Rennard, Anna Welling Salamon, Hui Yu.

Tenth award, 1999: Amit Kumar Sabharwal, Andrew Chi, Jennifer Lynn Pelka, Ching-Tang Chen, C. Andrew McManus, Jennifer Rose Walk, Heidi Lee Williams, Jack Nelson Bewley, Adam Douglas Bryant, Jason A. Loy, John William Pope, Bryce Leitner Roberts.

Eleventh award, 2000: Jayce R. Getz, Aadel Ahmed Chaudhuri, Zachary Howard Cohn, Ching Tang Chen, Elaine Pei-San Gee, Siarhei Markouski, Ilya Malakhovsky, Vassily Vladimirovich Starodubtsev, Daniel Richard Green, Daniyar Z. Kamenov, Craig Allan Schroeder.

Twelfth award, 2001: Abdur Rasheed Sabar, Yuri Georgievich Kudryashov, Serge A. Tishchenko, Jason Wah Lone Chiu, Craig Allen Schroeder, Hasuk Francis Song, Daniel Wichs, Jennifer Shyamala Sayaka Balakrishnan, Christopher Ryan Bruner, Lindsey Jo Cable, Michael Harry Kaleta, Matthew Howard Stemm, Heon Joon Choe, Jesse Scott Trana.

Thirteenth awards, 2002: Jacob Licht, Matthew Aaron Tesch, Andrew Michael Korth, Chun-Chen Yeh, Liang Chen, Ashum Karahanovich Kaibhanov, Amanda Bryce Shaw, Mary Augusta Brazelton, Nikita Rozenblyum, Jonathan Charles Zweig, Boris O. Figovsky, Ronli Phyllis Diakow.

Fourteenth awards, 2003: Andrew Michael Leifer, Raymund Chun-Hung To, David Guillaume Pothier, Alexandr V. Medvedev, Ethan James Street, Hyeyoun Chung, Anatoly Preygel, Lester Wayne Mackey, Evgeniy E. Loharu, Sergey O. Ivanov, Robert Shea Bracco, Brian Todd Rice, Alexey V. Baran, Evgeny A. Amosov, Artem G. Viktorov, Jeremy Takashi Warshauer, Alan Craig Taylor, Hannah Chung.

Fifteenth awards, 2004: Brett Alexander Harrison, Ilya Gurwich, Brian Todd Rice, Sam Jay Lewallen, Brianna Rachel Satinoff, Huan-Chun Yeh, Ning Zhang, Carolos Eduardo Arreche-Aguayo, Tair Assangali, Nurlan Bakitzhanov, Allison Paige Berke, Ginger Beardslee Howell, Nimish P. Ramanlal.

Sixteenth awards, 2005: Scott Duke Kominers, Samuel Mohun Bhagwat, Matthew Ryan Tierney, Elad Oster, John Michael Sillcox, Carlos Manuel Fonseca, Manuel Luis Rivera, Niket Ranjan Pandey, Robert Thomas Cordwell, Paul Francis Jacobs, Valentina N. Dobrovolskaya, Vladimir N. Trubnikov, Oleg V. Mikhaylovsky, Mikhail A. Ptichkin.

Seventeenth awards, 2006: Michael Anthony Viscardi, Daniel Abraham Litt, Brett Alexander Harrison, Anarghya A. Vardhana, Gleb A. Pogudin, Nicholas Michael Wage, Sohan Venkat, Meelap Vijay Shah, Manuel Luis Rivera-Morales, Bakhytzhan Baizhanov.

Eighteenth awards, 2007: Dmitry Vaintrob, Cheng-Tao Chung, Daniel K. Bezdek, Christopher Lopez, Hagai Helman, Albert C. Liu, Nikita M. Savushkin, Lado Meskhishvili, Almas U. Abdulla, Avi W. Levy, Ardit Kroni, Alexey S. Telishev.

Nineteenth awards, 2008: Alexander Lee Churchill, Shravani Mikkilineni, David Alex Rosengarten, Eric Kerner Larson, Alex Hao Chen, Paul Myer Kominers, Matthew Michael Wage, Swara Satya Kopparty, Sana Raoof, Nurlan Taiganov, Artem A. Timoshenko, Sarah Lee Sellers.

Twentieth awards, 2009: Joshua Vekhter, Andrei Triffo, Yale Wang Fan, Almas Abdulla, Sarah Lee Sellers, Sohini Sengupta, Sameer Kirtikumar Deshpande, Jeffrey Chan, Alicia Zhang, Martin Augustine Camacho, Michael Christopher Yurko, Wenhan Cui, Matthew Henry Stoffregen, Nilesh Tripuraneni.

Twenty-first awards, 2010: Yale Wang Fan, Joshua W. Pfeffer, Anirudha Balasubramanian, Kate A. Geschwind, Almas Abdulla, Jacob B. Hurwitz, Evgenia I. Alekseeva, Akhil Mathew, Jonathan F. Li.

Twenty-second awards, 2011: Manosij G. Dastidar, John Tilla Parish IV, Tzu-Hsuan Su, Vasily Sergeevich Bolbachan, Benjamin Jerome Kraft, Anirudh Prabhu, Ryan Thomas Baker, Rebecca Chen, Kate Alexandra Geschwind, Georgiy Vladimirovich Kolyshev, Aaron Lawrence Zweig.

Next awards: June 2012.

Public Policy Award

This award was established in 2007 by the American Mathematical Society (AMS) to recognize a public figure for sustained and exceptional contributions to public policies that foster support for research, education, and innovation. The award will be given annually, starting in 2009.

The Award for Distinguished Public Service

This award was established by the AMS Council in response to a recommendation from their Committee on Science Policy. The US$4,000 award is presented every two years to a research mathematician who has made a distinguished contribution to the mathematics profession during the preceding five years.

First award, 1990: To Kenneth M. Hoffman for his outstanding leadership in establishing channels of communication between the mathematical community and makers of public policy as well as the general public.

Second award, 1992: To Harvey B. Keynes for his multifaceted efforts to revitalize mathematics education, especially for young people.

Third award, 1993: To Isadore M. Singer in recognition of his outstanding contributions to his profession, to science more broadly, and to the public good by bringing the best of mathematics and his own insights to bear on the activities of the National Academy of Sciences; on committees of the National Research Council, including the two so-called David Committees on the health of the mathematical sciences, and the Committee on Science, Engineering, and Public Policy; on the President's Science Advisory Council; on decisions of Congress, through testimony concerning the support of mathematics and mathematical research; and on a host of critical situations over many years in which his wisdom and intervention helped gain a hearing for the problems of his community and the contributions it makes to the nation.

Fourth award, 1995: To Donald J. Lewis for his many contributions to mathematical education, mathematics policy, and mathematical research and administration during a career that has spanned several decades.

Fifth award, 1997: No award made.

Sixth award, 1998: To Kenneth C. Millett for his work devoted to underrepresented minority students in the mathematical sciences. Professor Millett founded the University of California, Santa Barbara, Achievement Program and directed the mathematics component of the Summer Academic Research Internship and the Summer Institute in Mathematics and Science at UCSB.

Seventh award, 2000: To Paul J. Sally Jr. for the quality of his research, for his service to the [American Mathematical] Society as trustee, but more importantly for his many efforts in improvement of mathematics education for the nation's youth and especially for members of minority and underrepresented groups and for his longitudinal mentoring of students, in particular the mathematics majors at Chicago.

Eighth award, 2002: To Margaret H. Wright for notable contributions to the federal government and the scientific community and for encouraging women and minority students.

Ninth award, 2004: To Richard A. Tapia for inspiring and teaching thousands of people (from elementary school students to senior citizens) to study and appreciate the mathematical sciences.

Tenth award, 2006: To Roger Howe for his multifaceted contributions to mathematics and to mathematics education.

Eleventh award, 2008: To Herbert Clemens for his superb research in complex algebraic geometry, his continuing efforts in education, and his seminal role in the founding and continuation of the Park City/IAS Mathematics Institute.

Twelfth award, 2010: To Carlos Castillo-Chavez for having a major impact with his efforts and activities in improving the representation in the broad mathematical sciences of the nation's traditionally underrepresented and economically disadvantaged students.

Next award: January 2012.

Citation for Public Service

To provide encouragement and recognition for contributions to public service activities in support of mathematics, the Council of the Society established the Citation for Public Service. The award is no longer being made.

First award, 1991: Andre Z. Manitius for the contributions he made to the mathematical community while employed in the Division of Mathematical Sciences at the National Science Foundation.

Second award, 1992: Marcia P. Sward for her contributions toward establishing and directing the Mathematical Sciences Education Board from its inception in the fall of 1985 until August 1989.

Third award, 1998: Liang-Shin Hahn and Arnold E. Ross. Liang-Shin Hahn for carrying forward and developing the New Mexico High School Mathematics Contest and for exposition and popularization of mathematics attractive to and suitable for potential candidates for the contest and others with similar intellectual interests. Arnold E. Ross for inspiring generations of young people through the summer mathematics programs he created and has continued to run for nearly 40 years.

AAS-AMS-APS Public Service Award

This award was established in 1999 by the American Mathematical Society (AMS), the American Astronomical Society (AAS), and the American Physical Society (APS) to recognize a public figure for his or her sustained and exceptional contributions to public policies that foster support for research, education, and industrial innovation in the physical sciences and mathematics. As of January 2007, the AMS no longer participates in this award, but instead offers the AMS Public Policy Award.

First award, 2000: To William Frist, Joseph L. Lieberman, and Harold Varmus.

Second award, 2001: To Vernon Ehlers and Neal Lane.

Third award, 2002: To James T. Walsh and Barbara Mikulski.

Fourth award, 2003: To Sherwood L. Boehlert, Alan B. Mollohan, and Pete V. Domenici.

2004: No award made.

2005: No award made.

2006: No award made.

Waldemar J. Trjitzinsky Memorial Awards

The Society received a bequest from the estate of Waldemar J., Barbara G., and Juliet Trjitzinsky, the income from which is used to assist students who have declared a major in mathematics at a college or university that is an institutional member of the AMS. These funds help support students who lack adequate financial resources and who may be in danger of not completing the degree program in mathematics for financial reasons. Each year the Society selects a number of geographically distributed schools who in turn make one-time awards to beginning mathematical students to assist them in pursuit of careers in mathematics. The amount of each scholarship is currently US$3,000, and the number of scholarships awarded each year varies.

First award, 1991: Duke University (Robert Lane Bassett, Linie Yunwen Chang, Kara Lee Lavender), University of Scranton (Thomas A. Shimkus), Montana State University (Melissa Cockerill, Deborah Fagan, Sherry Heis), Howard Payne University (Pamela Jo Chaney).

Second award, 1992: Allegheny College (Julianne Stile), Memphis State University (Cassandra Burns), University of California at Irvine (James Anthony Nunez), University of Puerto Rico (Juan Ramon Romero-Oliveras).

Third award, 1993: University of California at Los Angeles (Michelle L. Lanir), State University of New York at Geneseo (Jodi C. Wright), Eastern New Mexico University (Rebecca K. Moore), University of Virginia (Mikhail Krichman).

Fourth award, 1994: Boise State University (William Hudson and Margaret Norris), Illinois Institute of Technology (Guanghong Xu), Temple University (Coleen Clemetson), University of Maryland at College Park (Mikhail G. Konikov).

Fifth award, 1995: University of Arizona (Mark Robert Moseley), Arkansas State University (Donna J. Shepherd), Mississippi State University (Clayton T. Hester), Montclair State College (James R. Jarrell III).

Sixth award, 1996: Murray State University (Christie M. Safin), Stanford University (Andreea Nicoara), Union College (Allison Pacelli), Western Illinois University (Lorna Renee Sanders).

Seventh award, 1997: Georgetown University (Martin Akguc), Loyola Marymount University (Laura Steiner, Claudia Catalan, Elizabeth Madrigal), New York University (Emily Press), Southern Illinois University at Carbondale (Laura Wasser).

Eighth award, 1998: Stevens Institute of Technology (Kelly Cornish), Georgia State University (Kevin A. Wilson), Iowa State University (Matthew A. Halverson), University of Nevada at Las Vegas (Dumitru C. Tutuianu).

Ninth award, 1999: City University of New York (Hulya Cebeciouglu), Reed College (Jeremy Copeland), University of Texas at San Antonio (Danielle Lyles), Western Kentucky University (Marcia Jean Mercer).

Tenth award, 2000: California State University at Long Beach (Yen Hai Le), Case Western Reserve University (Alexander Statnikov), Clarkson University (Matthew Bartholomew), University of Houston (Alyssa Burns).

Eleventh award, 2001: Columbia University (Alexander Ivanov Sotirov), Florida Atlantic University (Gregory Nevil Leuchiali Maxwell), Henderson State University (Ann Smith), John Carroll University (Andrea C. Forney), Seattle University (Sinead Pollom), University of Texas at Austin (Virginia Roberts), University of Utah (Paul T. Watkins), Worcester Polytechnic Institute (Yakov Kronrod and Megan Lally).

Twelfth award, 2002: Stephen F. Austin State University (Marcus A. Arreguin), Bates College (Challis Kinnucan), Brigham Young University (Julie Brinton), The College of William and Mary (Suzanne L. Robertson), Furman University (Kevin L. Smith), University of Hartford (Aimee J. Groudas), University of Southern California (Peter Kirkpatrick), University of Texas at Dallas (Kevin R. Pond).

Thirteenth award, 2003: Bryn Mawr College (Thida S. Aye), Minnesota State University at Mankato (Andrew Richard Tackmann), University of Maryland at Baltimore County (Maria Christin Llewellyn), Colorado College (Rahbar Virk), California State University, Hayward (Sarah Deiwert and Angela Martinho), Lehigh University (Timothy P. Lewis), State University of New York at Potsdam (Bishal Thapa).

Fourteenth award, 2004: Beloit College (Laura Wolfram), Lafayette College (Prince Chidyagwai, Ekaterina Jager, Blerta Shtylla), Michigan State University (Antonio Veloz), University of Pennsylvania (Daniel Pomerleano), Portland State University (Kathryn Carr and Cass Bath), Santa Clara University (Olivia Gistand).

Fifteenth award, 2005: Abilene Christian University (Carissa Joy Strawn), Amherst College (Jennifer A. Roberge), Arizona State University (Yukiko Kozakai), University of Missouri, Kansas City (Melanie Marie Meyer), University of North Carolina at Greensboro (Christian Sykes), University of Rhode Island (Christopher Piecuch), Ohio State University (Sophia Leibman and Gabor Revesz).

Sixteenth award, 2006: California State University, San Bernardino (Lorena Pulido and Jennifer Renee Winter), University of Missouri, Rolla (Sean Michael Eagan), University of Central Missouri (Khadijah Shadeed), Boston College (Elizabeth Rini), Eckerd College (Elizabeth R. Morra), University of California, San Diego (John Roosevelt Quinn), Swarthmore College (Adam Joseph Lizzi).

清華大學 —— 数学科学中心
Tsinghua University — Mathematical Sciences Center

Positions:

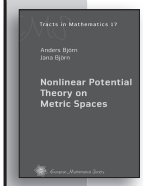
Distinguished Professorship; Professorship; Associate Professorship; Assistant Professorship (tenure-track).

Applications in all areas of mathematics are invited for the above positions. The current annual salary range is between 0.15-1.0 million RMB. Salary will be determined by applicants' qualification. Strong promise/track record in research and teaching are required. Completed applications must be electronically submitted, and must contain curriculum vitae, research statement, teaching statement, selected reprints and/or preprints, three reference letters on academic research and one reference letter on teaching, sent electronically to msc-recruitment@math.tsinghua.edu.cn

Applications are welcome at any time. The review process starts in December 2010, and closes by April 30, 2012. Applicants are encouraged to submit their applications before November 30th.

AMERICAN MATHEMATICAL SOCIETY

New AMS-Distributed Publications



Nonlinear Potential Theory on Metric Spaces

Anders Björn and **Jana Björn**

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

EMS Tracts in Mathematics, Volume 17; 2011; 415 pages; Hardcover; ISBN: 978-3-03719-099-9; List US$84; AMS members US$67.20; Order code EMSTM/17

Invariant Manifolds and Dispersive Hamiltonian Evolution Equations

Kenji Nakanishi and **Wilhelm Schlag**

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Zurich Lectures in Advanced Mathematics, Volume 14; 2011; 258 pages; Softcover; ISBN: 978-3-03719-095-1; List US$52; AMS members US$41.60; Order code EMSZLEC/14

Exploring New Structures and Natural Constructions in Mathematical Physics

Koji Hasegawa, **Takahiro Hayashi**, **Shinobu Hosono**, and **Yasuhiko Yamada**

Published for the Mathematical Society of Japan by Kinokuniya, Tokyo, and distributed worldwide, except in Japan, by the AMS.

Advanced Studies in Pure Mathematics, Volume 61; 2011; 441 pages; Hardcover; ISBN: 978-4-931469-64-8; List US$78; AMS members US$62.40; Order code ASPM/61

AMS AMERICAN MATHEMATICAL SOCIETY BOOKSTORE www.ams.org/bookstore

Seventeenth award, 2007: Susan Christine Massey (University of Washington), Amy Streifel (Lewis and Clark College), Rosemary Holguin (SUNY at New Paltz), Emily Jean Ognacevic (Saint Louis University), Betsy Kay Barr (University of Tennessee Knoxville), Kayla Rose Boyle (University of Northern Iowa).

Eighteenth award, 2008: Aaron Peterson (Luther College), Faith L. Buell (Wright State University), Phillip David Lorren (Georgia Southern University), Daksha Shakya (Ithaca College), Joseph Zancocchio (College of Staten Island (CUNY)), Amanda J. Mueller (University of Wisconsin Milwaukee), Hans Parshall (Humboldt State University).

Nineteenth award, 2009: Alison Lynette Ashe (University of Vermont); Kendall Olivia Brown (Truman State University); Zehui Chen (Smith College); Jonathan Jordan Edwards (Kenyon College); David Hassan (University of California, Santa Barbara); Ana-Cristina Cerda Jimenez (California State University, Fresno); Mantatisi S. Walker (Jackson State University).

Twentieth award, 2010: Vianey Carolina Leos Barajas (California State University, Bakersfield); Langston W. Joiner (University of Cincinnati); Michelle Chu (Emory University); Perla Salazar (Kansas State University); Dana C. Haymon (University of Oklahoma); James S. Wratten Jr. (Rochester Institute of Technology); Bebi Z. G. Rajendra (York College).

Twenty-first award, 2011: David Samuel Allen (Colorado State University); Xavier Eduardo Garcia (University of Minnesota Twin Cities); Jeffrey Hart (California State University San Marcos); Amina S. Mendez (Ohio Wesleyan University); Amanda Nicole Rodriguez (Texas A&M University Corpus Christi); Tyler Wippel (Central Michigan University); Maocai Wu (Brooklyn College-CUNY).

Next awards: Fall 2012.

Mathematics Calendar

Please submit conference information for the Mathematics Calendar through the Mathematics Calendar submission form at `http://www.ams.org/cgi-bin/mathcal-submit.pl`.
The most comprehensive and up-to-date Mathematics Calendar information is available on the AMS website at `http://www.ams.org/mathcal/`.

January 2012

* 4–5 **Seminar on Applications of Cutting-edge Statistical Methods in Research**, Universiti Putra Malaysia, UPM Serdang, Selangor, Malaysia.
Description: Seminar on Applications of Cutting-Edge Statistical Methods in Research is jointly organized by Laboratory of Statistical Services & Computing and Laboratory of Computational Statistics & Operations Research, Institute for Mathematical Research, Universiti Putra Malaysia.
Aim: Of the seminar is to provide a discussion platform for cutting-edge statistical methods in research in the areas of medicine, biotechnology, agriculture, forestry, engineering, social science and so on.
Scope: Regression diagnostics, environmental statistics, survival analysis, robust statistics, social survey, medical statistics, educational statistics, time series and forecasting and all other areas of statistics.
Speakers: Prof. Dr. Rahmatullah Imon (Ball State University, USA), Prof. Dr. Aziz Jemain (UKM), Prof. Dr. Noor Akma Ibrahim (UPM), Prof. Dr. Habshah Midi (UPM). Other renowned speakers to be confirmed later.
Information: `http://einspem.upm.edu.my/aces2012`.

* 16–20 **I Winter School on Stochastic Dynamics and Control in Finance and Economics**, ISEG, Technical University of Lisbon, Lisbon, Portugal.
Description: The 1st Winter School on Stochastic Dynamics and Control in Finance and Economics will be held from January 16 to January 20 2012 at CEMAPRE, the Centre for Applied Mathematics and Economics, based at the Mathematics Department of ISEG, the School of Economics and Management of the Technical University of Lisbon. The school will be focused on short courses, given by invited distinguished researchers, which are supplemented by contributed short talks by other participants. The subjects to be addressed include, but are not restricted to, Random Dynamical Systems, Stochastic Optimal Control and Optimization, Game Theory, and applications of these mathematical theories to the fields of Finance and Economics.
Information: `http://cemapre.iseg.utl.pt/~sdc2012/`.

* 30–February 11 **XII Winter Diffiety School**, Conference center "Pomorski Park Naukowo-Technologiczny", Gdynia, Al. Zwyciestwa, 96/98, 81-451, Gdynia, Poland.
Description: The aim of the school is to introduce undergraduate and graduate students in Mathematics and Physics, as well as post-doctoral researchers and other mathematicians into a recently emerged area of mathematics and theoretical physics, called "Secondary Calculus". Secondary calculus is the result of a natural evolution of the classical geometrical theory of partial differential equations (PDE) originated by Sophus Lie. In particular, it allows the construction of a general theory of PDE, in the same manner as algebraic geometry does with respect to algebraic equations. There are strong indications that secondary calculus may become a natural

This section contains announcements of meetings and conferences of interest to some segment of the mathematical public, including ad hoc, local, or regional meetings, and meetings and symposia devoted to specialized topics, as well as announcements of regularly scheduled meetings of national or international mathematical organizations. A complete list of meetings of the Society can be found on the last page of each issue.
An announcement will be published in the *Notices* if it contains a call for papers and specifies the place, date, subject (when applicable), and the speakers; a second announcement will be published only if there are changes or necessary additional information. Once an announcement has appeared, the event will be briefly noted in every third issue until it has been held and a reference will be given in parentheses to the month, year, and page of the issue in which the complete information appeared. Asterisks (*) mark those announcements containing new or revised information.
In general, announcements of meetings and conferences carry only the date, title of meeting, place of meeting, names of speakers (or sometimes a general statement on the program), deadlines for abstracts or contributed papers, and source of further information. If there is any application deadline with respect to participation in the meeting, this fact should be noted. All communications on meetings and conferences in the mathematical sciences should be sent to the Editor of the *Notices* in care of the American Mathematical Society in Providence or electronically to `notices@ams.org` or `mathcal@ams.org`.
In order to allow participants to arrange their travel plans, organizers of meetings are urged to submit information for these listings early enough to allow them to appear in more than one issue of the *Notices* prior to the meeting in question. To achieve this, listings should be received in Providence **eight months** prior to the scheduled date of the meeting.
The complete listing of the Mathematics Calendar will be published only in the September issue of the *Notices*. The March, June/July, and December issues will include, along with new announcements, references to any previously announced meetings and conferences occurring within the twelve-month period following the month of those issues. New information about meetings and conferences that will occur later than the twelve-month period will be announced once in full and will not be repeated until the date of the conference or meeting falls within the twelve-month period.
The Mathematics Calendar, as well as Meetings and Conferences of the AMS, is now available electronically through the AMS website on the World Wide Web. To access the AMS website, use the URL: `http://www.ams.org/`.

language for quantum field theory, just in the same way as standard calculus is for classical physics.
Information: http://www.levi-civita.org/Activities/DiffietySchools/XIIWDS.

February 2012

* 20–24 **Emerging Developments in Real Algebraic Geometry: Positivity, Convexity, NC-Geometry, Optimization**, Otto-von-Guericke University, Magdeburg, Germany.
Description: The main objectives of this workshop is to bring together senior leading and promising young researchers actively involved in the recent emerging developments in Real Algebraic Geometry with a particular focus on: Positivity and sums of squares; convex algebraic geometry; noncommutative, real algebraic geometry; polynomial optimization.
Information: http://www.uni-magdeburg.de/ragc/index.html.

March 2012

* 9–10 **International Conference on Advances in Computing and Emerging E-Learning Technologies (ICAC2ET 2012)**, Hotel Marina, Singapore, Singapore.
Description: ICAC2ET 2012 will discover some new technologies that will assist the attendees to fulfill their dreams. It will have discussion on educational structures over crossing country borders—international recognition of qualifications and comparability of qualifications, Sharing best practices on intercultural education and lots more.
Information: http://www.icac2et.com.

* 11–31 **Branching Laws**, Institute for Mathematical Sciences, National University of Singapore, Singapore.
Description: The current program aims to examine important recent progress on branching problems, with special attention to the following topics: (1) Invariant theory and toric deformation; (2) Unitary representations and branching laws; (3) Gross-Prasad conjectures. The activity will consist of a series of seminars by the overseas and local participants every day.
Information: http://www2.ims.nus.edu.sg/Programs/012law/index.php.

* 13–14 **International Conference on Internet & Cloud Computing Technology (ICICCT 2012)**, Hotel Marina, Singapore, Singapore.
Description: The objectives of the ICICCT'12 are to bridge the knowledge gap between academia and industry, promote research esteem in secured Internet transactions and the importance of information technology evolution to secured transactions. The ICICCT-2012 invites research papers that encompass conceptual analysis, design implementation and performance evaluation.
Information: http://www.icicct.com.

* 19–21 **Topology: Quantitative and Applied**, Tulane University, New Orleans, Louisiana.
Description: The Mathematics Department at Tulane University will host Professor Shmuel Weinberger from the University of Chicago who will deliver a series of talks at the annual Clifford Lecture on the topic surrounding the title "Topology: Quantitative and Applied".
Talks: Supporting talks will be given by the following participants: Yuliy Baryshnikov (UIUC), John Etnyre (Georgia Tech), Steve Ferry (Rutgers), Robert Kusner (UMass), Sanjeevi Krishnan (Penn), Erik Guentner (Univ. Hawaii), Jerry Kaminker (UC Davis), Stefan Wenger (UIC), Vivian Ferry (Berkeley), Monica Nicolau (Stanford), Eric Rawdon (St. Thomas), Yevgeniy Liokumovich (Toronto).
General abstract: Although topology is traditionally a qualitative field, for many reasons, both pure and applied, it has become important to reconsider basic ideas of connectedness, homotopy, and homeomorphism through a quantitative lens. These four lectures will be devoted to various sides of this idea, and will focus on the new problems pressed upon topology.
Information: http://www.math.tulane.edu/~clifford.

* 25–26 **International Conference on Information Technology, System & Management (ICITSM 2012)**, Abu Dubai, United Arab Emirates
Description: The ICITSM'2012 aims to bring together researchers and scientists from academia, industry, and government laboratories to present new results and identify future research directions in data, information, and knowledge engineering. It continues to focus on the newly scientific discovery and implementation in all relevant aspects of information technologies, and information systems and management, which enables an enterprise to improve the management and efficiency of its resources, including capital, people, and information systems, to support the achievement of its business vision.
Information: http://www.icitsm.com.

* 30–31 **International Conference on Human Computer Interaction & Learning Technologies (HCILT 2012)**, Abu Dubai, United Arab Emirates.
Description: The theme of this conference is Educational Technology for Societal Benefit. This theme is a reflection of the technological development occurring in the region and indeed worldwide reflecting the role of innovation in the ever-increasing sustainable applications of technology in education.
Information: http://www.ichciit.com.

April 2012

* 8–9 **International Conference on Information Systems, Engineering & Management Science (ICISEMS 2012)**, Hong Kong, Japan.
Description: ICISEMS 2012 focuses on the newly scientific discovery and implementation in all relevant aspects of information technologies, and information systems and management, which enables an enterprise to improve the management and efficiency of its resources, including capital, people, and information systems, to support the achievement of its business vision.
Information: http://www.icisems.com.

* 13–15 **Underrepresented Students in Topology and Algebra Research Symposium (USTARS)**, University of Iowa, Iowa City, Iowa.
Description: The Underrepresented Students in Topology and Algebra Research Symposium (USTARS) is a project proposed by a group of underrepresented students and is largely run and organized by graduate students. After a successful first meeting in April 2011, the committee is planning the second meeting for April 13-15, 2012, at the University of Iowa, an institution known for its commitment to underrepresented student issues. In its second year the conference will be structured so that underrepresented speakers give 30-minute parallel research talks, and one distinguished graduate student and one invited faculty member will give 1-hour presentations. This year's meeting will also include a research poster session featuring undergraduate topology and algebra students from the VIGRE/ALLIANCE Summer REU held at the University of Iowa during the Summer of 2011 and those graduate students who do not give a 30-minute talk.
Information: http://www.mathalliance.org/ustars.asp.

* 22–28 **Variational Analysis and Its Applications**, Paseky nad Jizerou, Czech Republic.
Invited speakers and titles: Rene Henrion, Structure and stability of optimization problems with probabilistic constraints; Alexander Ioffe, Variational analysis of semi-algebraic mappings; Alejandro Jofre, Variational analysis and economic equilibrium; Boris Mordukhovich, Various topics of variational analysis.
Organizers: Marian Fabian, Jaroslav Lukes, and Jiri Outrata.
Deadline: For a reduced fee or support: January 15, 2012.
Information: email: pasejune@karlin.mff.cuni.cz; http://www.karlin.mff.cuni.cz/katedry/kma/ss/apr12/.

May 2012

* 10–12 **25th Cumberland Conference on Combinatorics, Graph Theory, and Computing**, East Tennessee State University, Johnson City, Tennessee.
Description: This will be the 25th anniversary of this popular spring conference.
Invited talks: Will be given by Jozsef Balogh, Fan Chung, Michael Henning, and Curt Lindner. An after dinner talk will be given by Ron Gould and Ralph Faudree. There will be no registration fee.
Information: http://www.etsu.edu/cas/math/cumberland/.

* 14–25 **School and Workshop on Random Polymers and Related Topics**, Institute for Mathematical Sciences, National University of Singapore, Singapore.
Description: The topics to be covered in the school and workshop include, but are not restricted to: random pinning models, charged polymers, copolymer models, directed polymers with bulk disorder, Kardar-Parisi-Zhang (KPZ) universality class, and dynamics of polymers. The first week of the program, May 14–18, will be a school with three mini-courses. The first mini-course will be given by Frank den Hollander on some background material on probability theory and statistical physics. Two mini-courses then follow. Francesco Caravenna will give an overview of some classic random polymer models, such as the random pinning model, the copolymer model and the directed polymer model with bulk disorder. Timo Seppalainen will give an introduction to the KPZ universality class and its connection to the directed polymer model with bulk disorder, and to last passage percolation. The second week of the program, May 21–25, will be a workshop on random polymer models and related problems.
Information: http://www2.ims.nus.edu.sg/Programs/012randompoly/index.php.

* 21–25 **CANT 2012—School and Conference on Combinatorics, Automata and Number Theory**, CIRM–Centre International de Rencontres Mathématiques: International center of Mathematical Meetings, Marseille, France.
Description: This meeting is meant to be both an international summer school and conference. To reach these complementary goals, high quality lecturers of international recognition have been selected. Due to their scientific and pedagogical capabilities, we hope that they will attract a wide audience including Ph.D. students, young researchers, as well as more mature researchers.
Invited speakers: Marie-Pierre Béal, Université Paris-Est Marne-la-Vallée; Maxime Crochemore, King's College London; Mike Hochman, Hebrew University of Jerusalem; Jarkko Kari, University of Turku; Narad Rampersad, University of Winnipeg; Christophe Reutenauer, UQAM Montréal.
Grants: To cover living expenses are available (see details on the web pages).
Information: http://www.cant.ulg.ac.be/cant2012/index.html.

* 28–June 1 **Workshop on Nonlinear Partial Differential Equations on the occasion of the sixtieth birthday of Patrizia Pucci**, Perugia, Italy.
Description: The aim of the conference is to bring together leading experts and researchers in nonlinear partial differential equations, to promote research and to stimulate interactions among the participants. The conference will continue the tradition of the previous meetings on PDEs methods and their applications held in Perugia in the last decades. The conference will honor Professor Patrizia Pucci on the occasion of her 60th birthday.
Speakers: The panel of speakers includes, in particular, numerous collaborators of Patrizia Pucci. Besides elliptic and parabolic issues, the topics of the conference include geometry, free boundary problems, fluid mechanics, evolution problems in general, calculus of variations, and numerical analysis.
Information: email: pucci2012@dmi.unipg.it; http://www.dmi.unipg.it/pucci2012.

* 28–June 2 **BALWOIS 2012 Conference (Fifth International Scientific Conference on Water, Climate and Environment**, Ohrid, Macedonia.
Description: To send one or more abstracts you have to: 1. Register yourself at: http://ocs.balwois.com. 2. Use your username and password every time when you want to access your account, to send an abstract and to follow the process on your paper. If you have already submitted an abstract and you want to make changes (to add more authors, to change the title or the text of abstract, etc.) you should: 1. Use your username and password to access your account; 2. Click on the title of the abstract that you want to change; 3. Click on the button EDIT METADATA; 4. After making corrections, click on the button SEND.
Deadline: All changes can be done until: November 20, 2011. Abstract Submission Deadline: November 20, 2011.
Information: For any question please contact: secretariat@balwois.com; http://www.balwois.com/2012.

June 2012

* 1–22 **Financial Time Series Analysis: High-dimensionality, Non-stationarity and the Financial Crisis**, Institute for Mathematical Sciences, National University of Singapore, Singapore.
Description: The program will invite world-leading experts in the areas of stationary and non-stationary modelling of low- and high-dimensional financial time series, and encourage them to use data covering the period of the recent financial crisis to discuss the impact of the crisis on their proposed models, methods and theories. Activities include 1. Workshop: June 4–7, 2012; 2. Public Lectures and Graduate Student Poster Presentation: June 11–15, 2012; 3. Public lectures by 4 speakers and poster presentations by graduate students; 4. Workshop: June 19–22, 2012.
Information: http://www2.ims.nus.edu.sg/Programs/012hidim/index.php.

* 3–30 **Clay Mathematics Institute 2012 Summer School "The Resolution of Singular Algebraic Varieties"**, Obergurgl, Tyrolean Alps, Austria.
Description: The resolution of singularities is one of the major topics in algebraic geometry. Due to its difficulty and complexity, as well as certain historical reasons, research to date in the field has been pursued by a relatively small group of mathematicians. However, the field has begun a renaissance over the last twenty years. This school will consist of three weeks of foundational courses supplemented by exercise and problem sessions, designed to provide graduate students and young mathematicians with a comprehensive framework for research in this field. The fourth week will consist of mini-courses with selected experts, aimed at providing participants with state of the art techniques, as well as a survey of some of the main open problems and the most promising approaches now under investigation. Facilities will be provided for lectures, meals and lodging at the Obergurgl Center.
Deadline: For applications is February 1, 2012.
Information: http://www.claymath.org/summerschool.

* 4–8 **BIOCOMP2012 - Mathematical Modeling and Computational Topics in Biosciences**, Hotel Lloyd's Baia, Vietri sul Mare, Italy.
Description: A program of invited lectures, selected contributed papers and roundtable discussions. Topics are centered on mathematical models, stochastic approaches and computational tools in information processing and neuronal coding, in ecology and population dynamics. Some invited talks will also focus on current problems in various other areas of applications of mathematics, probability and statistics to biosciences, and on related computational problems.
Dedication: To the Memory of Professor Luigi M. Ricciardi (1942–2011).

Information: http://biocomp.unina.it; email: biocomp@unina.it.

* 4–8 **Probability, Control and Finance**, Columbia University, New York, New York.
Description: A conference on Probability, Control and Finance is in the works, to honor Prof. Ioannis Karatzas' 60th birthday and his immense contribution to these fields. This is a preliminary announcement. Registration will open later this academic year.
Organizers: Peter Bank, Adrian Banner, Jaksa Cvitanic, Panagiota Daskalopoulos, Kostas Kardaras, Marcel Nutz, Johannes Ruf, Gordan Zitkovic.
Information: We will ensure that you receive any essential updates. As time evolves, further details will be made available at: http://math.columbia.edu/procofin/.

* 8–13 **38th International Conference "Applications of Mathematics in Engineering and Economics" AMEE'12**, Leisure House of the Technical University of Sofia, Sozopol, Bulgaria.
Description: The aim of the conference is to provide an overview of the "hot topics" in Applied Mathematics and to bring together young researchers and senior scientists to discuss the modern trends in various applications of Mathematics in Engineering, Physics, Economics, Biology, etc. The working program of the conference consists of invited talks, contributed papers and discussions concerning present-day scientific and educational problems. The peer-reviewed contributions will be published in the Conference Proceedings Series of the American Institute of Physics (AIP).
Organizing Committee: Ketty Peeva (Bulgaria), Vesela Pasheva (Bulgaria), Igor Ananievski (Russia), Michail Konstantinov (Bulgaria), Bernadette Miara (France), Vladimir Georgiev (Italy), Ralitza Kovacheva (Bulgaria), Alexander Ovseevich (Russia), Lubomir Dechevsky (Norway), Svetozar Margenov (Bulgaria), Stefanka Chukova (New Zealand), George Venkov (Bulgaria).
Information: http://www.tu-sofia.bg/ENG/fpmi/amee/.

* 11–22 **Mathematical Modeling on Ecology and Epidemiology**, University of Wyoming, Laramie, Wyoming.
Description: The purpose of the summer program is to provide effective training for collaborative research in ecology and epidemiology based on mathematical modeling and qualitative analysis. Our goal is to expose mathematics and statistics participants how to address issues of great importance in ecology and epidemiology, and to expose biology graduate students and researchers why and how mathematical and statistical techniques and tools are useful. We hope that the summer program will prepare participants who might wish to work as modelers in ecology or epidemiology, and to help participants in life sciences and mathematical sciences to learn a language in which they can communicate with one another. By bringing them together, we also hope it also provides opportunities for them to develop future collaborations.
Speakers: Fred Adler, Carlos Castillo-Chavez, Zhilan Feng, Libin Rong, Sebastian Schreiber, Glenn Webb.
Contact: Rongsong Liu; email: rongsong.liu@uwyo.edu.
Information: http://math.uwyo.edu/rmmc/2012.

* 18–August 15 **Random Matrix Theory and its Applications II**, Institute for Mathematical Sciences, National University of Singapore, Singapore.
Description: The two-month program will provide the mathematicians and engineers a unique platform to discuss interesting fundamental problems, results, and explore possible solutions related to RMT and its applications in wireless communications and statistics. Activities: Informal seminars, ad hoc talks and discussions: June 18–July 6, 2012; Tutorial 1: July 9–13, 2012. Workshop 1—RMT Applications in Wireless Communications: July 16–20, 2012. Informal seminars, ad hoc talks and discussions: July 23–27, 2012; Tutorial 2: July 30–August 3, 2012. Workshop 2—RMT Applications in Statistics: August 8–15, 2012.
Information: http://www2.ims.nus.edu.sg/Programs/012random/index.php.

* 25–30 **IVth Workshop on Coverings, Selections, and Games in Topology**, Department of Mathematics, Seconda Università di Napoli, Caserta, Italy.
Description: Organized on the occasion of Ljubiša Kočinac turning 65, this workshop covers the study of selective properties in mathematics (SPM), with particular emphasis on applications in general topology, topological algebra, and real analysis. A list of confirmed invited speakers and a call for contributed lectures are provided at the conference webpage.
Organizing Committee: Agata Caserta, Giuseppe Di Maio (chair), Dragan Djurčić, Boaz Tsaban.
Scientific Committee: Alexander V. Arhangel'skii, Giuseppe Di Maio, Cosimo Guido, Ljubiša D. R. Kočinac, Roberto Lucchetti, Masami Sakai, Marion Scheepers, Boaz Tsaban.
Information: http://u.cs.biu.ac.il/~tsaban/spmc12.

July 2012

* 2–6 **Model Theory in Algebra, Analysis and Arithmetic**, Cetraro, Italy.
Description: A course on "Model Theory in Algebra, Analysis and Arithmetic" will be within the 2012 program of CIME (International Mathematical Summer Center). There will be 4 courses - Theories without the independence property, Anand Pillay (Leeds) - Model theory of valued fields, Lou Van den Dries (Urbana-Champaign) - On the model theory of real and complex exponentiation, Alex Wilkie (Manchester) - Undecidability in number theory, Jochen Koenigsmann (Oxford). Additional talks by Angus Macintyre and Sergei Starchenko are also planned, as well as a poster session.
Applications: Are open from December 1, 2011– April 15, 2012. The course directors are: Dugald MacPherson (Leeds), Carlo Toffalori (Camerino).
Information: http://php.math.unifi.it/users/cime/; or ask Carlo Toffalori, carlo.toffalori_at_unicam.it.

* 4–6 **The 2012 International Conference of Applied and Engineering Mathematics**, Imperial College London, London, United Kingdom.
Description: The conference ICAEM'12 is held under the World Congress on Engineering 2012. The WCE 2012 is organized by the International Association of Engineers (IAENG), and serves as a good platform for the engineering community members to meet with each other and to exchange ideas. The last IAENG conferences attracted more than one thousand participants from over 30 countries. All submitted papers will be under peer review and accepted papers will be published in the conference proceeding (ISBN: 978-988-19251-3-8). The abstracts will be indexed and available at major academic databases. The accepted papers will also be considered for publication in the special issues of the journal *Engineering Letters*, in IAENG journals, and in edited books.
Draft Paper Submission Deadline: March 6, 2012.
Information: http://www.iaeng.org/WCE2012/ICAEM2012.html

* 4–6 **Workshop: Statistical Inference in Complex/High-Dimensional Problems**, University of Vienna, Vienna, Austria.
Description: The workshop will consist of a series of invited and contributed talks on the general topic of inference in complex/high-dimensional problems, with a special focus on methods that are based on model-selection, shrinkage, and regularization.
Invited speakers: Rudy Beran (UC Davis), Lawrence Brown (The Wharton School), Tianxi Cai (Harvard School of Public Health), Xu Cheng (University of Pennsylvania), Bruce E. Hansen (University of Wisconsin), Susan Murphy (University of Michigan), Richard Nickl (University of Cambridge), Cun-Hui Zhang (Rutgers University). Contributed presentations are welcome!

Deadline: Please submit your extended abstract or paper to: benedikt.poetscher@univie.ac.at before March 15, 2012.
Information: http://www.univie.ac.at/inference2012/.

* 8–15 **International Conference on Wavelets and Applications**, Euler International Mathematical Institute, St. Petersburg, Russia.
Main topics: Wavelet bases and frames; multiresolution and wavelet methods; greedy algorithms; subdivision schemes; signal analysis and processing.
Related topics: Approximation theory; functional analysis.
Tentative list of Plenary Speakers: A. Averbuch (Israel), M. Bownik (USA), N. Chernych (Russia), R. DeVore (USA), N. Dyn (Israel), K. Jeter (Germany), B. Han (Canada), A. Olevskij (Israel), J. Prestin (Germany), Z. Shen (Singapore), Yu. Subbotin (Russia), V. Temlyakov (USA).
Organizing committee: I. Novikov and M. Skopina (co-chairmen), A. Krivoshein and P. Severov (secretaries), N. Zalesskaya (accommodation support), T. Vinigradova (visa support).
Program committee: I. Novikov (Russia), M. Skopina (Russia), B. Han (Canada), A. Petukhov (USA), V. Protasov (Russia), V. Temlyakov (USA), I. Krishtal (USA).
Information: email: conference.wla.2012@gmail.com; http://www.pdmi.ras.ru/EIMI/2012/WLA/index.html. Registration is open. Deadline for registration: January 31, 2012.

* 9–11 **Third Workshop on Mathematical Cryptology**, International Centre for Mathematical Meetings (CIEM), Castro Urdiales (Cantabria), Spain.
Description: The third Workshop on Mathematical Cryptology (WMC2012) is co-located with third international conference on Symbolic Computation and Cryptography (SCC 2012), an event also organized by the research group Algorithmic Mathematics and Cryptography (AMAC), of the University of Cantabria, which will be held on July 11–13, 2012. WMC 2012 is the third edition of a new series of conferences, which have been established in response to the growing interest among mathematicians and cryptographers in cryptosystem based on algebraic problems and its related cryptanalysis. The main purpose is to learn and discuss recent developments and emerging open problems derived from cryptology and having mathematical interest.
Information: http://wmc2012.unican.es.

* 9–13 **Additive Combinatorics in Paris 2012 — Combinatoire Additive à Paris 2012**, Institut Henri Poincaré, Paris, France.
Description: The conference will be dedicated to the memory of Yahya ould Hamidoune, who passed away earlier this year. As such, the scope of the conference encompasses topics in additive and combinatorial number theory, additive group theory, graph theory and probabilistic combinatorics as well as adjacent fields. There will be a special talk on Yahya's mathematical achievements, a movie documenting his battle against environmental destruction in his native Mauritania as well as a themed conference dinner.
Information: http://caparis2012.wordpress.com/.

* 9–13 **EVEQ 2012: International Summer School on Evolution Equations**, Prague, Czech Republic.
Description: Continuing a long-established tradition, we would like to invite you to EVEQ 2012: A Summer school on evolution equations, organized by the Charles University, the Faculty of Mathematics and Physics and Institute of Mathematics of Czech Academy of Sciences as the activity of the Jindrich Necas Center for Mathematical Modeling. EVEQ 2012 is also a satellite meeting of the 6th European Congress of Mathematics which will be held in Krakw, July 2-7, 2012.
Lectures: Helmut Abels (Universität Regensburg), Adrian Constantin (Universität Wien), David Gérard-Varet (Université Denis Diderot Paris 7), Igor Rodnianski (Princeton University), Sylvia Serfaty (Laboratoire Jacques-Louis Lions, Université Pierre et Marie Curie), Ulisse Stefanelli (Istituto di Matematica Applicata e Tecnologie Informatiche, Pavia).
Organizers: Miroslav Bulicek (executive organizer), Eduard Feireisl, Pavel Krejci, Josef Malek, Vit Prusa, Lenka Bauerova (secretary), Jana Peskova (secretary).
Deadlines: For details (deadlines, conference fee, poster session) see the above web-page, or do not hesitate to contact us directly.
Information: http://tinyurl.com/eveq-2012-prague.

* 11–13 **Third International Conference on Symbolic Computation and Cryptography**, International Centre for Mathematical Meetings (CIEM), Castro Urdiales (Cantabria), Spain.
Description: The third international conference on Symbolic Computation and Cryptography (SCC 2012) is the third edition of a new series of conferences, which have been established in response to the growing interest in applying and developing methods, techniques, and software tools of symbolic computation for cryptography. The first conference (SCC 2008) was held in Beijing, China, in April 2008, and the second one (SCC 2010) was held in Egham, UK, in June 2010. SCC 2012 aims at providing an interactive forum for researchers to present recent results, exchange ideas, and learn and discuss the latest developments and problems in the area of symbolic computation and cryptography.
Information: http://scc2012.unican.es.

* 17–27 **The 5th Mathematical Society of Japan Seasonal Institute, 2012 International Summer School and Conference on Schubert Calculus**, Osaka City University, Osaka, Japan.
Description: The focus of this conference is on Schubert calculus and its many connections and applications to related areas of mathematics, such as geometric representation theory, combinatorial aspects of algebraic varieties arising in Lie theory, and equivariant topology. One of our primary aims is to inspire cross-disciplinary discussion and to invite mathematicians to explore the field of Schubert calculus. The first week of the meeting is an introductory summer school aimed at a broad mathematical audience, including graduate students and recent Ph.D.s. The second week is an international research conference on Schubert calculus and related areas. Summer school: July 17- 20, 2012. Research conference: July 23-27, 2012.
Information: http://mathsoc.jp/meeting/msjsi12/.

* 30–August 11 **Workshop and Conference on Holomorphic Curves and Low-Dimensional Topology**, Stanford University, Palo Alto, California.
Focus: The main focus of this workshop will be on holomorphic curve techniques in low-dimensional topology and symplectic geometry. The workshop is a part of the FRG: Collaborative Research: Topology and Invariants of Smooth 4-Manifolds. It is funded by NSF Focused Research Grant DMS-1065955. Additional funds come from the Stanford University Mathematics Research Center. There will be one week of mini-courses, primarily for graduate students, followed by a conference during the second week.
Mini-course speakers: Selman Akbulut, Yasha Eliashberg, Sergei Gukov, Ko Honda, Robert Lipshitz, Katrin Wehrheim.
Information: http://www.math.umn.edu/~akhmedov/Stanford2012.

August 2012

* 13–26 **Meeting the Challenges of High Dimension: Statistical Methodology, Theory, and Applications**, Institute for Mathematical Sciences, National University of Singapore, Singapore.
Description: The topic of high-dimensional data analysis has many aspects, motivated by many applications, sometimes relying heavily on dimension reduction and variable selection, and sometimes co-habiting happily with more conventional multivariate methods. The August workshop, the first of two in the IMS Singapore program titled "Meeting the Challenges of High Dimension — Statistical Methodology, Theory and Applications," will address all of these aspects. They lie at the frontiers along which statistical methodology, the applications that motivate it, the questions that it answers, and the

theory that underpins it, are advancing today. The October workshop continues to address challenges of high-dimensional data analysis with more focuses on the methods and applications where sparsity is present. Activities include Workshop 1: August 13–24, 2012; 2. Tutorials; 3. Workshop 2: October 1–12, 2012.
Information: http://www2.ims.nus.edu.sg/Programs/012statheory/index.php.

September 2012

* 5–7 **ICERM Semester Program: Computational Challenges in Probability**, ICERM, Providence, Rhode Island.
Description: Modern explorations in science, technology and medicine increasingly demand complex stochastic models. Computational and theoretical advances are needed in order to formulate, analyze, apply, and interpret these models. Recent years have witnessed a remarkable interplay between computation and probability. On the one hand, probabilistic techniques have led to powerful computational methods such as Markov chain Monte Carlo algorithms, while on the other hand, the calculation of probabilistic quantities such as modes and marginals of high-dimensional distributions and the analysis of data from random samples has posed several computational challenges. The fall 2012 semester on "Computational Challenges in Probability" aims to bring together leading experts and young researchers who are advancing the use of probabilistic and computational methods to study complex models in a variety of fields. The goal is to identify common challenges, exchange existing tools, reveal new application areas.
Information: http://icerm.brown.edu/sp-f12.

* 17–21 **ICERM Workshop: Bayesian Nonparametrics**, ICERM, Providence, Rhode Island.
Description: Data-rich investigations need advanced tools for allowing data to inform and interact with models. Bayesian Nonparametrics is a rapidly growing subfield of statistics and machine learning that provides a framework for creating complex statistical models that are both expressive and tractable. Recent successful applications of nonparametric Bayesian models across a variety of domains suggests that these models have the potential for wide use. The challenge of constructing and using models on very high-dimensional or even infinite-dimensional spaces creates many opportunities for fruitful interactions between mathematicians, statisticians, and computer scientists. Areas of interest include prior construction, posterior inference, posterior asymptotics, algorithmic development, and practical applications.
Information: http://icerm.brown.edu/sp-f12-w1.

October 2012

* 8–12 **ICERM Workshop: Uncertainty Quantification**, ICERM, Providence, Rhode Island.
Description: Rapid growth in computational resources has heightened the expectation that scientific knowledge can indeed be a driver for societal well-being and betterment. At the same time, our ability to measure the natural and social world around has significantly increased, aided by technological development in sensors, the Internet, and other modalities of communication. Science is thus faced, simultaneously, with a complex description of reality at an unprecedented resolution, and the possibility to describe this reality with mathematical models of increasing complexity. Probabilistic formulations of physical problems can be viewed as attempts to adapt rational procedures to this complexity, while tackling the conceptual challenges they inevitably present. As a testament to the significance of this confluence of mathematics, science, and technology, Uncertainty Quantification is arguably one of the fastest growing sub-disciplines in mechanics.
Information: http://icerm.brown.edu/sp-f12-w2.

* 29–November 2 **ICERM Workshop: Monte Carlo Methods in the Physical and Biological Sciences**, ICERM, Providence, Rhode Island.
Description: Monte Carlo methods are one of the main tools used to study the properties of complex physical, chemical, and biological systems. Since their introduction in the late 1940s, these methods have undergone a remarkable expansion and are now used in many other fields, including statistical inference, engineering, and computer science. However, the design and theoretical understanding of Monte Carlo methods is still a challenging topic, especially for those problems where rare events play the key role in determining algorithm performance. The aim of the workshop is to bring together specialists in the application areas who understand the specific challenges posed by realistic problems and have developed sophisticated tools to tackle these problems, and mathematicians developing methods for algorithm analysis, abstraction, and optimization.
Information: http://icerm.brown.edu/sp-f12-w3.

The following new announcements will not be repeated until the criteria in the next to the last paragraph at the bottom of the first page of this section are met.

January 2013

* 7–12 **Iwasawa Theory, Representations, and the p-adic Langlands program**, University of Münster, Münster, Germany.
Description: A conference in honour of Peter Schneider's 60th birthday.
Information: http://wwwmath.uni-muenster.de/sfb878/activities/.

* 28–May 3 **ICERM Semester Program: Automorphic Forms, Combinatorial Representation Theory and Multiple Dirichlet Series**, ICERM, Providence, Rhode Island.
Description: This program will explore this interface between automorphic forms and combinatorial representation theory, and will develop computational tools for facilitating investigations. On the automorphic side, Whittaker functions on p-adic groups and their covers are the fundamental objects. Whittaker functions and their relatives are expressible in terms of combinatorial structures on the associated L-group, its flag variety, or Schubert varieties. In the combinatorial theory crystal graphs, Demazure characters, the Schubert calculus and Kazhdan-Lusztig theory all enter.
Information: http://icerm.brown.edu/sp-s13.

July 2013

* 1–5 **International conference on Sampling Theory and Applications 2013**, Jacobs University, Bremen, Germany.
Description: SampTA 2013 is the 10th International Conference on Sampling Theory and Applications. SampTA takes place every two years, the previous locations were Riga (Latvia), Aveiro (Portugal), Loen (Norway), Orlando (USA), Strobl (Austria), Samsun (Turkey), Thessaloniki (Greece), Marseille (France), and, most recently, in Singapore. SampTA conferences bring together mathematicians and engineers interested in sampling theory and its applications to related fields (such as signal and image processing, coding theory, control theory, complex analysis, harmonic analysis, differential equations) to exchange recent advances and to discuss open problems. SampTA 2013 will feature plenary lectures, special sessions on selected topics such as frame theory, compressed sensing, sampling and communications, quantization, super resolution imaging, and general sessions on sampling and its applications. Paper submissions on any aspect of sampling theory and applications are welcome.
Information: http://www.jacobs-university.de/sampta.

Classified Advertisements

Positions available, items for sale, services available, and more

ALABAMA

UNIVERSITY OF ALABAMA IN HUNTSVILLE
Department of Mathematical Sciences
Faculty Position

The Department of Mathematical Sciences at the University of Alabama in Huntsville invites applications for a tenure-track position at the rank of Assistant Professor, beginning August 2012. A Ph.D. degree in mathematics or applied mathematics is required. Applicants must show evidence of excellent research potential in an area that matches the interests of the department. Applicants must also have a strong commitment to teaching and show evidence of excellent teaching ability. The research areas we are seeking are differential equations, and probability and stochastic processes. The priority is partial differential equations. Applicants should send a curriculum vita with the AMS standard cover sheet and a list of three references (include name, mailing address, telephone number, and email address) to Chairman, Department of Mathematical Sciences, University of Alabama in Huntsville, Huntsville, AL 35899. For more information about the department, visit our website at: `http://www.math.uah.edu`. Review of applicants will begin February 1, 2012, and will continue until the position is filled. Women and minorities are encouraged to apply. The University of Alabama in Huntsville is an Affirmative Action, Equal Opportunity Institution.

000003

CONNECTICUT

UNIVERSITY OF CONNECTICUT
Professor Stuart and Joan Sidney Professorship of Mathematics
Department of Mathematics

The Department of Mathematics at the University of Connecticut seeks a distinguished senior mathematician to hold the Stuart and Joan Sidney Professorship of Mathematics to start in Fall 2012. This is a tenured position at the Professor level. Highly qualified candidates in all mathematical disciplines are encouraged to apply. The search is pending budgetary approval.

Minimum Qualifications: A Ph.D. in Mathematics or a related area and an exceptional record of published research in high-quality mathematical journals.

Preferred Qualifications: An internationally recognized research program with international stature, a commitment to effective teaching at the undergraduate and graduate levels, a strong record of mentoring Ph.D. students, and demonstrated ability to attract external funding.

Review of applications will begin on November 15, 2011, and continue until the position is filled. Applications, questions, or requests for further information should be sent to the Hiring Committee at `mathhiring@uconn.edu`.

The University of Connecticut is an Equal Opportunity and Affirmative Action Employer. We enthusiastically encourage applications from underrepresented groups, including minorities, women, and people with disabilities.

000011

UNIVERSITY OF CONNECTICUT
Assistant Professor
Department of Mathematics

The Department of Mathematics at the University of Connecticut invites applications for a tenure-track position at the Assistant Professor level starting in Fall 2012. Highly qualified candidates in all mathematical disciplines are encouraged to apply; analysis and differential geometry are areas of particular, but not exclusive, focus of the search. The position is at the Storrs campus and is pending budgetary approval.

Minimum Qualifications: A completed Ph.D. in Mathematics by August 22, 2012; and demonstrated evidence of excellent teaching ability and outstanding research potential.

Preferred Qualifications: Research focus in analysis or in differential geometry and the ability to contribute through research, teaching and/or public engagement to the diversity and excellence of the learning experience at UConn.

Review of applications will begin on November 15, 2011, and continue until the position is filled. Applications and at least 4 letters of reference, one of which addresses the applicant's teaching abilities, should be submitted online at `http://www.mathjobs.org/jobs`. Questions or requests for further information should be sent to the Hiring Committee at `mathhiring@uconn.edu`.

The University of Connecticut is an Equal Opportunity and Affirmative Action Employer. We enthusiastically encourage applications from underrepresented groups, including minorities, women, and people with disabilities.

000012

Suggested uses for classified advertising are positions available, books or lecture notes for sale, books being sought, exchange or rental of houses, and typing services.

The 2011 rate is $3.25 per word. No discounts for multiple ads or the same ad in consecutive issues. For an additional $10 charge, announcements can be placed anonymously. Correspondence will be forwarded.

Advertisements in the "Positions Available" classified section will be set with a minimum one-line headline, consisting of the institution name above body copy, unless additional headline copy is specified by the advertiser. Headlines will be centered in boldface at no extra charge. Ads will appear in the language in which they are submitted.

There are no member discounts for classified ads. Dictation over the telephone will not be accepted for classified ads.

Upcoming deadlines for classified advertising are as follows: February 2012 issue–November 28, 2011; March 2012 issue–December 28, 2011; April 2012 issue–January 30, 2012; May 2012 issue–February 28, 2012; June/July 2012 issue–April 30, 2012; August 2012 issue–May 29, 2012.

U.S. laws prohibit discrimination in employment on the basis of color, age, sex, race, religion, or national origin. "Positions Available" advertisements from institutions outside the U.S. cannot be published unless they are accompanied by a statement that the institution does not discriminate on these grounds whether or not it is subject to U.S. laws. Details and specific wording may be found on page 667 (vol. 56).

Situations wanted advertisements from involuntarily unemployed mathematicians are accepted under certain conditions for free publication. Call toll-free 800-321-4AMS (321-4267) in the U.S. and Canada or 401-455-4084 worldwide for further information.

Submission: Promotions Department, AMS, P.O. Box 6248, Providence, Rhode Island 02940; or via fax: 401-331-3842; or send email to `classads@ams.org`. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 20904. Advertisers will be billed upon publication.

ILLINOIS

UNIVERSITY OF ILLINOIS AT CHICAGO
Department of Mathematics, Statistics, and Computer Science

The Department has active research programs in a broad spectrum of centrally important areas of pure mathematics, computational and applied mathematics, combinatorics, mathematical computer science and scientific computing, probability and statistics, and mathematics education. See http://www.math.uic.edu for more information.

Applications are invited for the following position, effective August 16, 2012. Final authorization of the position is subject to the availability of state funding.

Research Assistant Professorship. This is a non-tenure-track position, normally renewable annually to a maximum of three years. This position carries a teaching responsibility of three courses per year, and the expectation that the incumbent play a significant role in the research life of the department. The salary for AY 2011-2012 for this position is $55,000. Applicants must show evidence of outstanding research potential in mathematics, computer science, statistics, mathematics education or related field, and should expect to have a Ph.D. or equivalent degree by the start date.

Applicants should provide a vita, research and teaching statements, and at least three (3) letters of recommendation. Applications should be submitted through mathjobs.org. No applications will be accepted by surface mail or email. To ensure full consideration, application materials must be received by December 31, 2011, but applications will be accepted through January 31, 2012. Minorities, persons with disabilities, and women are particularly encouraged to apply. UIC is an AA/EOE.

000009

UNIVERSITY OF ILLINOIS AT CHICAGO
Department of Mathematics, Statistics, and Computer Science
Tenure-Track Assistant Professor

The Department of Mathematics, Statistics, and Computer Science has active research programs in a broad spectrum of centrally important areas of pure mathematics, computational and applied mathematics, mathematical computer science, probability and statistics, and mathematics education. See http://www.math.uic.edu for more information.

Applications are invited for tenure-track assistant professor positions. The positions are effective August 16, 2012, and the salary is negotiable. Applicants must have a Ph.D. or equivalent degree in mathematics, computer science, statistics, mathematics education or related field; an outstanding research record; and evidence of strong teaching ability. Final authorization of the position is subject to the availability of state funding.

Applicants should provide a vita, research and teaching statements, and at least three (3) letters of recommendation. Applications should be submitted through mathjobs.org. No applications will be accepted by surface mail or email. To ensure full consideration, application materials must be received by November 15, 2011, but applications will be accepted through December 31, 2011. Minorities, persons with disabilities, and women are particularly encouraged to apply. UIC is an AA/EOE.

000010

MASSACHUSETTS

BOSTON UNIVERSITY
Tenure-Track Position
Stochastic Processes and Stochastic Analysis

The Department of Mathematics and Statistics at Boston University invites applications at the tenure-track Assistant Professor level in Stochastic Processes and Stochastic Analysis. Ph.D. required, salary commensurate with experience. The position will begin Fall 2012, subject to final budgetary approval. Strong commitment to research and teaching is essential. Please submit the AMS Application Cover Sheet, CV, research statement, teaching statement, and at least four letters of recommendation, one of which addresses teaching, to http://mathjobs.org. Alternatively, send all material to Stochastic Processes Search, Department of Mathematics and Statistics, Boston University, 111 Cummington St., Boston, MA 02215. Application deadline January 9, 2012. Boston University is an Affirmative Action, Equal Opportunity Employer.

000004

ST. MARK'S SCHOOL
Institute of Mathematics (SMIM)

St. Mark's School, an independent secondary school located in the greater Boston area, seeks a dynamic mathematics educator to lead the St. Mark's Institute of Mathematics (SMIM) beginning in the fall of 2012. This enthusiastic leader has the opportunity to shape the SMIM to meet his or her personal interests and strengths, all while serving the greater educational community through outreach efforts and the promotion of mathematics. The director has the opportunity to collaborate with other colleagues in the Mathematics Department to develop curricular materials for the benefit of St. Mark's School and the greater mathematics community.

For more information, see: http://www.stmarksschool.org.

000002

MISSOURI

UNIVERSITY OF MISSOURI
Kansas City
Department of Mathematics and Statistics

The Department of Mathematics and Statistics at the University of Missouri-Kansas City seeks applicants for two nine-month tenure-track assistant professor positions, one in Applied Mathematics (37003) and one in Statistics (54406), to start on August 15, 2012. For the Applied Mathematics position, candidates must have a Ph.D. in Mathematics with specialization in Applied Mathematics by August 2012. For the Statistics position, candidates must have a Ph. D. in Statistics or in Mathematics with specialization in Statistics by August 2012. Please visit: http://www.umkc.edu/jobs for detailed information regarding these positions. UMKC accepts online applications only. It is the fundamental policy of UMKC to provide equal opportunity regardless of race, creed, color, sex, sexual orientation, national origin, age, veteran status, or disability status in all education, employment and contracted activities. All final candidates will be required to successfully pass a criminal background check prior to beginning employment.

000001

NEW YORK

CLARKSON UNIVERSITY
Department of Mathematics

The Department of Mathematics (http://www.clarkson.edu/math) invites applications for a tenure-track Assistant Professor position in applied mathematics starting in August 2012.

We are especially interested in candidates with expertise in computational areas of applied mathematics, including statistics or dynamical systems, but all areas of applied mathematics will be considered. Responsibilities will include teaching undergraduate and graduate level mathematics courses, and directing graduate students. Minimum requirements are a Ph.D. in mathematics by the date of appointment, demonstrated excellence in both research potential and teaching ability, and fluency in English. In addition, the candidate should be able to interact with other faculty in the department and the university.

Applications including vita and three reference letters should be submitted to https://clarkson.peopleadmin.com/. Completed applications will be reviewed starting immediately. Women and minorities are urged to apply. Clarkson University is an AA/EOE Employer. (Pos. #270)

000013

SUNY-ALBANY
Department of Mathematics and Statistics
Tenure-track Position in Mathematics

The Department of Mathematics and Statistics at SUNY-Albany invites applications for a tenure-track position at the level of assistant professor to start in fall 2012. The targeted areas for the search are Algebra, Analysis, and Topology, with an emphasis on Analysis. For a full job description, and to apply online, please visit: http://albany.interviewexchange.com/joboffердetails.jsp?JOBID=28201. Email inquiries should be directed to: kzhu@math.albany.edu.

000006

RHODE ISLAND

UNIVERSITY OF RHODE ISLAND
Assistant Professor, Mathematics

This is a tenure-track position in the Mathematics Department with appointment to begin Fall 2012. Visit our website at http://jobs.uri.edu to apply and view complete details for job posting #(6000590). Applications will close January 14, 2012. A complete application must include: (1) a letter of application, which addresses the position description, qualifications, and shared research interests with current members of the faculty (one document in PDF format), (2) a CV to include a description of the teaching philosophy, a description of research of the applicant, and additional supporting materials (one document in PDF format), and (3) a minimum of three academic reference letters, at least one of which should address the teaching qualifications and at least two of which should address the research of the candidate. Reference letters should be sent by the letter writers either electronically to mathsearch@etal.uri.edu, or by regular mail to: Orlando Merino, Search Committee Chair, Department of Mathematics, 5 Lippitt Hall, URI, Kingston, RI 02881. Visit http://www.math.uri.edu for more information about the Mathematics Department. The University of Rhode Island is an AA/EEOD employer and values diversity.

000007

VIRGINIA

UNIVERSITY OF VIRGINIA
Department of Mathematics

The Department of Mathematics at the University of Virginia invites applications for two Whyburn Instructorships beginning August 25, 2012. These positions carry a three-year appointment. Preference will be given to candidates who have received their Ph.D. within the last three years. Candidates must have a Ph.D. by the date of hire, an outstanding research record, and demonstrated teaching success.

Preference will be given to researchers working in an area of algebra, analysis, or topology currently represented by the department. In the application cover letter, it will be very helpful to indicate which members of our department are closest to the applicant's research interests. See http://artsandsciences.virginia.edu/mathematics/research/researchguide/index.html.

To apply, please submit the following required documents electronically through http://www.MathJobs.org. An AMS Standard Cover Sheet, a curriculum vitae, a publication list, a description of research, and a statement about teaching interests and experience. The applicant must also have four letters of recommendation submitted, of which one letter must support the applicant's effectiveness as a teacher.

In addition, all candidates are required to complete the Candidate Profile through the University of Virginia's employment system, which is Jobs@UVA (https://jobs.virginia.edu); posting number 0608644. Your application process will not be complete until all required documents are available on MathJobs, and you receive a confirmation number for your Candidate Profile from Jobs@UVA.

Priority consideration will be given to applications received by December 1, 2011; however, the positions remain open to applications until filled.

Additional information about this position and our department is available on our website: http://artsandsciences.virginia.edu/mathematics/. The University of Virginia is an Equal Opportunity/Affirmative Action Employer. Women, Minorities, Veterans and Persons with Disabilities are encouraged to apply. For more information about the position or institution: http://artsandsciences.virginia.edu/mathematics/aboutus/employment/index.html.

000014

TAIWAN

ACADEMIA SINICA
Institute of Mathematics
Taiwan, R.O.C.

The Institute of Mathematics, Academia Sinica is entrusted to promote mathematical research. The institute strives to become a national center of mathematical sciences in Taiwan, as well as an international mathematical institute. Mathematical researchers are welcome to apply for regular positions as well as 2012-2013 postdoctoral positions. There is also the Institute of Mathematics Research Scholar position for young Ph.D. with exceptional research potential. This recently established position has the duration of 4-5 years. Application for regular (resp. postdoctoral and Research Scholar) positions completed by Jan. 15, 2012 (resp. May 31, 2012), will be given full consideration. Interested applicants should have the following materials: 1. curriculum vitae, 2. doctoral degree certificate, 3. description of research, 4. copies of representative publications, 5. three letters of reference. Either upload the materials to the site: http://www.math.sinica.edu.tw/applicant or send to The Chairman, The Hiring Committee, Institute of Mathematics, Academia Sinica 6F, Astronomy-Mathematics Building No. 1, Sec. 4, Roosevelt Rd., Taipei 10617, Taiwan. For any questions on applications, please contact personnel@math.sinica.edu.tw. For general information about the institute please see http://www.math.sinica.edu.tw.

000008

PUBLICATIONS FOR SALE

CONSTRAINT RESOLUTION THEORIES
by Professor Denis Berthier

Professor Berthier introduces a pure logic perspective of the finite Constraint Satisfaction Problem (CSP), with emphasis on finding the "simplest" solution. Based on constructive logic, the resolution paradigm involves resolution rules: logical formulae in the condition-action form, where the condition pattern implies (in the "action" part) the negation of a candidate (a possible value for a CSP variable). Defining a resolution theory as a set of resolution rules, it introduces several families of such theories. Each of them carries its own notion of simplicity, defines a rating of CSP instances, and satisfies two main theorems: the confluence property (guaranteeing that the associated rating has good computational properties) and a correspondence with a form of structured search procedure without guessing.

The book includes a detailed case study of Sudoku with: counter-examples to questions about rules subsumption; unbiased statistics and classification results; scope comparisons for various resolution theories. Examples from n-Queens show that the same abstract pattern can appear in various guises in different CSPs.

For more information, see: http://www.carva.org/denis.berthier/CRT.

000005

About the Cover

Numbers: A very, very short history

The cover was suggested by Rafe Jones' review of Peter Higgins' book, *Numbers: A Very Short Introduction*. It attempts to give a very rough idea of the history of numbers, at least insofar as they have come down more or less directly to modern Western civilization. Its dates are very approximate, and it incorporates a few mythological elements. This outline is in fact ridiculously short; every one of the topics mentioned could probably fill (and in some cases, has filled) much of a book all by itself and still retain interest.

For most mathematicians, the least familiar part will presumably be what one might call the earliest years of their subject. In about 8,000 BCE the people of what is now northern Iraq started moving down into the plains further south, likely because of climatic changes making them more inhabitable. Along with this movement came major economic changes, enabling occupational specialization and with it the necessity for less primitive quantitative techniques. They introduced *tokens* to count objects traded and exchanged. Different objects corresponded to different kinds of tokens. A multiplicity of objects were often represented by a multiplicity of tokens, but sometimes by larger tokens of the same shape. As time went on the variety of tokens grew, along with the development of more sophisticated urban life, but it still happened that different objects were represented by different kinds of tokens.

However, at some point quantity was separated from quality—numbers were generally now thought of abstractly, with certain symbols standing for quantities of different objects, paired independently with other symbols specifying the type of object. This transition is quite evident in the record of clay tablets that are extant. *It took roughly five thousand years for this invention of abstract numbers to take place—essentially the same length of time as from that moment to the current era.* The thesis has been advanced, most notably by Denise Schmandt-Besserat and not without controversy, that this separation of number and object also enabled the development of writing, at least in Mesopotamia. There is little tangible evidence for the claim that this civilization had an enormous influence on the beginnings of Greek mathematics, but it was plausibly so. Somewhat less evidence exists for an accurate estimate of its influence on Indian mathematics, which in turn passed crucially through Islam to Europe.

The interaction between mathematics and the rest of Mesopotamian culture is discussed in the first two books mentioned below. Others on the list are books also probably not well known to mathematicians, but which offer unusual insight into the history of mathematics as a natural human endeavor that only perspective can provide.

• Denise Schmandt-Besserat, *How Writing Came About,* University of Texas Press, 1996.

• Hans Jörg Nissen, Peter Damerow, and Robert K. Englund, *Archaic Bookkeeping: Early Writing and Techniques of Economic Administration in the Ancient Near East*, University of Chicago Press, 1993. The earlier German edition of 1991 exhibits a spectacular collection of images, many in color.

• Alexander Jones, *Astronomical Papyri from Oxyrhynchus*, American Philosophical Society, 1999. Some discussion and examples of the use of a kind of zero found in astronomical tables of the Hellenistic era.

• Kim Plofker, *Mathematics in India*, Princeton University Press, 2008.

• Takao Hayashi, *The Bakhshali Manuscript: An Ancient Indian Mathematical Treatise*, Groningen, 1995.

• Len Berggren, *Episodes in the Mathematics of Medieval Islam*, Springer-Verlag, 1986.

Implicit in the timeline on the cover is the claim that the representation of numbers is intricately entangled with the concepts behind the representation. The Babylonian scribes dealt reasonably well with numbers expressed in base 60, even floating point numbers without either a symbol for '0' or a 'decimal' point. But it wasn't until our current decimal place value notation was introduced in India that numbers became a part of popular culture, and it wasn't until the decimal point was adopted much later that computation became accessible to the common man. Surely familiarity fed back to expand the concepts involved.

What is most striking about the cover is that so much of the timeline is blank. The very short blue segment signals approximately the period in which, as far as we know, the foundations of mathematics as modern mathematicians think of it were essentially laid down. It is hard to understand why it took 9,000 years to develop current decimal notation, which is so important in everyday economic life, when it took only 300 years to invent axiomatic mathematics, not at first sight of any use at all to human development, or even within the reach of human capablity.

—Bill Casselman
Graphics Editor
(notices-covers@ams.org)

General Information Regarding Meetings & Conferences of the AMS

Speakers and Organizers: The Council has decreed that no paper, whether invited or contributed, may be listed in the program of a meeting of the Society unless an abstract of the paper has been received in Providence prior to the deadline.

Special Sessions: The number of Special Sessions at an Annual Meeting is limited. Special Sessions at annual meetings are held under the supervision of the Program Committee for National Meetings and, for sectional meetings, under the supervision of each Section Program Committee. They are administered by the associate secretary in charge of that meeting with staff assistance from the Meetings and Conferences Department in Providence. (See the list of associate secretaries on page 255 of this issue.)

Each person selected to give an Invited Address is also invited to generate a Special Session, either by personally organizing one or by having it organized by others. Proposals to organize a Special Session are sometimes solicited either by a program committee or by the associate secretary. Other proposals should be submitted to the associate secretary in charge of that meeting (who is an ex officio member of the program committee) at the address listed on page 255. These proposals must be in the hands of the associate secretary at least seven months (for sectional meetings) or nine months (for national meetings) prior to the meeting at which the Special Session is to be held in order that the committee may consider all the proposals for Special Sessions simultaneously. Special Sessions must be announced in the *Notices* in a timely fashion so that any Society member who so wishes may submit an abstract for consideration for presentation in the Special Session.

Talks in Special Sessions are usually limited to twenty minutes; however, organizers who wish to allocate more time to individual speakers may do so within certain limits. A great many of the papers presented in Special Sessions at meetings of the Society are invited papers, but any member of the Society who wishes to do so may submit an abstract for consideration for presentation in a Special Session, provided it is submitted to the AMS prior to the special early deadline for consideration. Contributors should know that there is a limit to the size of a single Special Session, so sometimes all places are filled by invitation. An author *may* speak by invitation in more than one Special Session at the same meeting. Papers submitted for consideration for inclusion in Special Sessions but not accepted will receive consideration for a contributed paper session, unless specific instructions to the contrary are given.

The Society reserves the right of first refusal for the publication of proceedings of any Special Session. If published by the AMS, these proceedings appear in the book series *Contemporary Mathematics*. For more detailed information on organizing a Special Session, see `www.ams.org/meetings/specialsessionmanual.html`.

Contributed Papers: The Society also accepts abstracts for ten-minute contributed papers. These abstracts will be grouped by related *Mathematical Reviews* subject classifications into sessions to the extent possible. The title and author of each paper accepted and the time of presentation will be listed in the program of the meeting. Although an individual may present only one ten-minute contributed paper at a meeting, any combination of joint authorship may be accepted, provided no individual speaks more than once.

Other Sessions: In accordance with policy established by the AMS Committee on Meetings and Conferences, mathematicians interested in organizing a session (for either an annual or a sectional meeting) on employment opportunities inside or outside academia for young mathematicians should contact the associate secretary for the meeting with a proposal by the stated deadline. Also, potential organizers for poster sessions on a topic of choice should contact the associate secretary before the deadline.

Abstracts: Abstracts for all papers must be received by the meeting coordinator in Providence by the stated deadline. Unfortunately, late papers cannot be accommodated.

Submission Procedures: Visit the Meetings and Conferences homepage on the Web at `http://www.ams.org/meetings` and select "Submit an abstract".

Site Selection for Sectional Meetings

Sectional meeting sites are recommended by the associate secretary for the section and approved by the Secretariat. Recommendations are usually made eighteen to twenty-four months in advance. Host departments supply local information, ten to fifteen rooms with overhead projectors and a laptop projector for contributed paper sessions and Special Sessions, an auditorium with twin overhead projectors and a laptop projector for Invited Addresses, space for registration activities and an AMS book exhibit, and registration clerks. The Society partially reimburses for the rental of facilities and equipment and for staffing the registration desk. Most host departments volunteer; to do so, or for more information, contact the associate secretary for the section.

Meetings & Conferences of the AMS

IMPORTANT INFORMATION REGARDING MEETINGS PROGRAMS: AMS Sectional Meeting programs do not appear in the print version of the *Notices.* However, comprehensive and continually updated meeting and program information with links to the abstract for each talk can be found on the AMS website. See `http://www.ams.org/meetings/`. Final programs for Sectional Meetings will be archived on the AMS website accessible from the stated URL and in an electronic issue of the *Notices* as noted below for each meeting.

Boston, Massachusetts

John B. Hynes Veterans Memorial Convention Center, Boston Marriott Hotel, and Boston Sheraton Hotel

January 4–7, 2012

Wednesday – Saturday

Meeting #1077

Joint Mathematics Meetings, including the 118th Annual Meeting of the AMS, 95th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2011
Program first available on AMS website: November 1, 2011
Program issue of electronic *Notices*: January 2012
Issue of *Abstracts*: Volume 33, Issue 1

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

Honolulu, Hawaii

University of Hawaii at Manoa

March 3–4, 2012

Saturday – Sunday

Meeting #1078

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: December 2011
Program first available on AMS website: January 26, 2012
Program issue of electronic *Notices*: March 2012
Issue of *Abstracts*: Volume 33, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Zhiqin Lu, University of California Irvine, *Geometry of Calabi-Yau moduli*.

Peter Schroder, California Institute of Technology, *Title to be announced*.

Pham Tiep, University of Arizona, Tucson, *Representations of finite groups: Conjectures, reductions, and applications*.

Lauren Williams, University of California Berkeley, *Title to be announced*.

Special Sessions

Algebraic Combinatorics, **Federico Ardila**, San Francisco State University, **Sara Billey**, University of Washington, and **Kelli Talaska** and **Lauren Williams**, University of California Berkeley.

Algebraic Geometry: Singularities and Moduli, **Jim Bryan**, University of British Columbia, and **Jonathan Wise**, Stanford University.

Algebraic Number Theory, Diophantine Equations and Related Topics, **Claude Levesque**, Université de Laval, Quebec, Canada.

Applications of Nonstandard Analysis, **Tom Lindstrom**, University of Oslo, Norway, **Peter Loeb**, University of Illinois at Urbana-Champaign, and **David Ross**, University of Hawaii at Honolulu.

Arithmetic Geometry, **Xander Faber**, **Michelle Manes**, and **Gretel Sia**, University of Hawaii.

Asymptotic Group Theory, **Tara Davis**, Hawaii Pacific University, **Erik Guentner**, University of Hawaii, and **Michael Hull** and **Mark Sapir**, Vanderbilt University.

Automorphic and Modular Forms, **Pavel Guerzhoy**, University of Hawaii, and **Zachary A. Kent**, Emory University.

C-algebras and Index Theory*, **Erik Guentner**, University of Hawaii at Manoa, **Efren Ruiz**, University of Hawaii at Hilo, and **Erik Van Erp** and **Rufus Willett**, University of Hawaii at Manoa.

Computability and Complexity, **Cameron E. Freer**, Massachusetts Institute of Technology, and **Bjorn Kjos-Hanssen**, University of Hawaii at Manoa.

Geometry and Analysis on Fractal Spaces, **Michel Lapidus**, University of California, Riverside, **Hung Lu**, Hawaii Pacific University, **John A. Rock**, California State Polytechnic University, Pomona, and **Machiel van Frankenhuijsen**, Utah Valley University.

Holomorphic Spaces, **Hyungwoon Koo**, Korea University, and **Wayne Smith**, University of Hawaii.

Kaehler Geometry and Its Applications, **Zhiqin Lu**, University of California Irvine, **Jeff Streets**, Princeton University, **Li-Sheng Tseng**, Harvard University, and **Ben Weinkove**, University of California San Diego.

Kernel Methods for Applications on the Sphere and Other Manifolds, **Thomas Hangelbroek**, University of Hawaii at Manoa.

Knotting in Linear and Ring Polymer Models, **Tetsuo Deguchi**, Ochanomizu University, **Kenneth Millett**, University of California, Santa Barbara, **Eric Rawdon**, University of St. Thomas, and **Mariel Vazquez**, San Francisco State University.

Linear and Permutation Representations, **Robert Guralnick**, University of Southern California, and **Pham Huu Tiep**, University of Arizona.

Mathematical Coding Theory and its Industrial Applications, **J. B. Nation**, University of Hawaii, and **Manabu Hagiwara**, National Institute of Advanced Industrial Science and Technology, Japan.

Mathematical Teacher Preparation, **Diane Barrett** and **Roberto Pelayo**, University of Hawaii at Hilo.

Model Theory, **Isaac Goldbring**, University of California Los Angeles, and **Alice Medvedev**, University of California Berkeley.

New Techniques and Results in Integrable and Near-Integrable Nonlinear Waves, **Jeffrey DiFranco**, Seattle University, and **Peter Miller**, University of Michigan.

Noncommutative Algebra and Geometry, **Jason Bell**, Simon Fraser University, and **James Zhang**, University of Washington.

Nonlinear Partial Differential Equations at the Common Interface of Waves and Fluids, **Ioan Bejenaru** and **Vlad Vicol**, University of Chicago.

Nonlinear Partial Differential Equations of Fluid and Gas Dynamics, **Elaine Cozzi**, Oregon State University, and **Juhi Jang** and **Jim Kelliher**, University of California Riverside.

Singularities, Stratifications and Their Applications, **Terence Gaffney**, Northeastern University, **David Trotman**, Université de Provence, and **Leslie Charles Wilson**, University of Hawaii at Manoa.

Transformation Groups in Topology, **Karl Heinz Dovermann**, University of Hawaii at Manoa, and **Daniel Ramras**, New Mexico State University.

Universal Algebra and Lattice Theory, **Ralph Freese**, **William Lampe**, and **J. B. Nation**, University of Hawaii.

Tampa, Florida

University of South Florida

March 10–11, 2012

Saturday – Sunday

Meeting #1079

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: January 2012
Program first available on AMS website: February 2, 2012
Program issue of electronic *Notices*: March 2012
Issue of *Abstracts*: Volume 33, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: January 18, 2012

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Anne Condon, University of British Columbia, *Some why's and how's of programming DNA molecules*.

Mark Ellingham, Vanderbilt University, *Beyond the Map Color Theorem*.

Mauro Maggioni, Duke University, *Digital data sets: Geometry, random walks, multiscale analysis, and applications*.

Weiqiang Wang, University of Virginia, *What is super in representation theory of Lie superalgebras?*

Special Sessions

Algebraic and Combinatorial Structures in Knot Theory (Code: SS 2A), **J. Scott Carter**, University of South Alabama, and **Mohamed Elhamdadi** and **Masahico Saito**, University of South Florida.

Analysis in Metric Spaces (Code: SS 3A), **Thomas Bieske**, University of South Florida, and **Jason Gong**, University of Pittsburgh.

Applications of Complex Analysis in Mathematical Physics (Code: SS 9A), **Razvan Teodorescu**, University of South Florida, **Mihai Putinar**, University of California, Santa Barbara, and **Pavel Bleher**, Indiana University-Purdue University Indianapolis.

Asymptotic Properties of Groups (Code: SS 20A), **Alexander Dranishnikov**, University of Florida, and **Mark Sapir**, Vanderbilt University.

Combinatorics: Algebraic and Geometric (Code: SS 23A), **Drew Armstrong**, University of Miami, and **Benjamin Braun**, University of Kentucky.

Complex Analysis and Operator Theory (Code: SS 8A), **Sherwin Kouchekian**, University of South Florida, and **William Ross**, University of Richmond.

Computational Algebraic Geometry and Applications (Code: SS 25A), **Tony Shaska**, Oakland University, and **Artur Elezi**, American University.

Dirac Analysis (Code: SS 18A), **Craig Nolder**, Florida State University, and **John Ryan**, University of Arkansas.

Discrete Mathematics and Geometry (Code: SS 17A), **Eunjeong Yi** and **Cong X. Kang**, Texas A&M University Galveston.

Discrete Models in Molecular Biology (Code: SS 1A), **Alessandra Carbone**, Université Pierre et Marie Curie and Laboratory of Microorganisms Genomics, **Natasha Jonoska**, University of South Florida, and **Reidun Twarock**, University of York.

Extremal Combinatorics (Code: SS 13A), **Linyuan Yu**, University of South Carolina, and **Yi Zhao**, Georgia State University.

Finite Fields and Their Applications (Code: SS 15A), **Xiang-dong Hou**, University of South Florida, and **Gary Mullen**, Pennsylvania State University.

Graph Theory (Code: SS 14A), **Mark Ellingham**, Vanderbilt University, and **Xiaoya Zha**, Middle Tennessee State University.

Hopf Algebras and Galois Module Theory (Code: SS 7A), **James Carter**, College of Charleston, and **Robert Underwood**, Auburn University Montgomery.

Interaction between Algebraic Combinatorics and Representation Theory (Code: SS 4A), **Mahir Can**, Tulane University, and **Weiqiang Wang**, University of Virginia.

Inverse Problems in Partial Differential Equations (Code: SS 24A), **Xiaosheng Li**, Florida International University, and **Alexandru Tamasan**, University of Central Florida.

Low-Dimensional Topology (Code: SS 22A), **Peter Horn**, Columbia University, and **Constance Leidy**, Wesleyan University.

Modeling Crystalline and Quasi-Crystalline Materials (Code: SS 5A), **Mile Krajcevski** and **Gregory McColm**, University of South Florida.

Nonlinear Partial Differential Equations and Applications (Code: SS 19A), **Netra Khanal**, University of Tampa.

Recent Developments of Finite Element Methods for Partial Differential Equations (Code: SS 21A), **Bo Dong**, Drexel University, and **Wei Wang**, Florida International University.

Representations of Algebraic Groups and Related Structures (Code: SS 12A), **Joerg Feldvoss** and **Cornelius Pillen**, University of South Alabama.

Solvability and Integrability of Nonlinear Evolution Equations (Code: SS 6A), **Wen-Xiu Ma**, University of South Florida, and **Ahmet Yildirim**, Ege University and University of South Florida.

Spectral Theory (Code: SS 11A), **Anna Skripka** and **Maxim Zinchenko**, University of Central Florida.

Stochastic Analysis and Applications (Code: SS 16A), **Sivapragasam Sathananthan**, Tennessee State University, and **Gangaram Ladde**, University of South Florida.

Stochastic Partial Differential Equations and Random Global Dynamics (Code: SS 10A), **Yuncheng You**, University of South Florida, and **Shanjian Tang**, Fudan University.

Session for Contributed Talks

There also will be a session for 10-minute contributed talks. Please see the abstracts submission form at `http://www.ams.org/cgi-bin/abstracts/abstract.pl`. The deadline for all submissions is January 18, 2012.

Accommodations

Participants should make their own arrangements directly with the properties listed below. Special rates for the meeting have been negotiated and are available at the properties shown below for the period of March 9–11, 2012. When making reservations **participants should state that they are with the American Mathematical Society and cite the reservation code AMSUSF**. Room blocks in the following hotels may sell out, so please book early. Hotels have varying cancellation or early checkout penalties; be sure to ask for details when making your reservation. **The room rates listed do not include applicable taxes; the current tax rate on hotel rooms is 12%.**

Embassy Suites-USF/Busch Gardens, 3705 Spectrum Blvd. (on the USF campus) Tampa, FL 33612; phone: 813-977-7066 ext. 2099 or 800-362-2779; fax: 813-903-6600. `http://www.embassysuitesusf.com`. US$139 for single/double/triple. Rooms are equipped with a microwave, coffee maker, and refrigerator. Rates include free wireless Internet access (public areas; charge for sleeping room), complimentary full breakfast, manager's reception,

fitness center, outdoor swimming pool, and complimentary shuttle service within five miles of the hotel. The Oak Tree Lounge (cocktails) and Mangrove's Grill are located on premises. A variety of restaurants (including Vietnamese, contemporary American, Indian, Italian, etc.) are within walking distance, or you are welcome to take the free shuttle service to over 50 restaurants within five miles. Distance to the meeting site is .8 mile. Hotels have varying cancellation or early checkout penalties; be sure to ask for details when making your reservation. **The deadline for reservations is February 8, 2012**.

Wingate Inn-Busch Gardens Area, 3751 East Fowler Ave. (across from USF campus) Tampa, Florida 33612; phone: 813-979-2828 or 800-228-1000; fax: 813-977-1818. http://www.wingatetampa.com. US$108 for single/double. Rooms are equipped with a coffee maker, microwave, and small refrigerator. Rates include complimentary hot breakfast buffet, free wired/wireless Internet access, fitness center, outdoor swimming pool, indoor hot tub, and complimentary shuttle service within three miles of the hotel. A wine/beer lounge and a business center is located in the hotel. A variety of restaurants (including Vietnamese, contemporary American, Indian, Italian, etc.) are within walking distance, or you are welcome to take the free shuttle service to over 50 restaurants within three miles. Distance to the meeting site is .7 mile. Hotels have varying cancellation or early checkout penalties; be sure to ask for details when making your reservation. **The deadline for reservations is February 15, 2012**.

Clarion Hotel and Conference Center 2701 East Fowler Ave., (near USF campus and Busch Gardens) Tampa, Florida 33612; phone: 813-971-4710; fax: 813-910-8038. US$69 for single/double. Rooms are equipped with refrigerators, microwaves, and coffee makers. Rates include complimentary full American breakfast buffet, free wireless access, heated outdoor pool, and on-site fitness room. University Mall is across the street; a variety of restaurants and cocktail lounges are within easy walking distance (Friday's is next door). Distance to the meeting site is 1.5 mi.; complimentary shuttle to the campus is based on availability. Hotels have varying cancellation or early checkout penalties; be sure to ask for details when making your reservation. **The deadline for reservations is February 15, 2012**.

La Quinta Inn & Suites USF (near Busch Gardens), 9202 North 30th Street Tampa, Florida 33612; phone: 813-930-6900; fax: 813-930-0563. US$79 for single/double. Rates include complimentary breakfast including hot and cold items, free high-speed Internet access, and outdoor swimming pool. Rooms are equipped with coffee makers. Busch's Family Sports Bar & Grill is adjacent to the hotel. The distance to the meeting site is 2.8 mi. Hotels have varying cancellation or early checkout penalties; be sure to ask for details when making your reservation. **The deadline for reservations is February 9, 2012**.

Additional hotels near campus:

La Quinta Inn & Suites USF, 3701 East Fowler Ave. (across from USF campus) Tampa, Florida 33612; phone: 813-910-7500 or 800-531-5900; fax: 813-910-7600.

Hyatt Place Busch Gardens (near USF and Busch Gardens), 11408 North 30th St., Tampa, FL 33612; phone 813-979-1922.

Grand Suites Tampa Bay (near Busch Gardens), 11310 North 30th St., Tampa, FL 33612; phone: 813-971-7690.

Wingate Inn-Tampa North 17301 Dona Michelle Dr., Tampa, FL 33647; phone: 813-971-7676.

Dining near Campus

There are a number of restaurants adjacent to campus and nearby. A handy list will be available at the meeting registration desk.

Local Information and Maps

The USF Department of Mathematics and Statistics website is found at http://math.usf.edu. Our hosts also plan to post a website with more meeting details at http://math.usf.edu/research/conferences. A campus map is found at http://usfweb2.usf.edu/parking_services/maps/Visitor_Map.pdf.

Other Activities

AMS Book Sale: Stop by the on-site AMS bookstore and review the newest titles from the AMS, enjoy up to 25% off all AMS publications, or take home an AMS t-shirt! Complimentary coffee will be served courtesy of AMS Membership Services.

AMS Editorial Activity: An acquisitions editor from the AMS book program will be present to speak with prospective authors. If you have a book project that you would like to discuss with the AMS, please stop by the book exhibit.

Parking

Free parking on Saturday and Sunday is across the street from the College of Business Administration (COBA) Building where the meeting will be held.

Registration and Meeting Information

The meeting will take place on the main campus of the University of Southern Florida, Tampa, FL. Registration and sessions will be held in the College of Business Administration (COBA) . The registration desk will be open Saturday, 7:30 a.m.–4:00 p.m., and Sunday, 8:00 a.m.–noon. Fees are US$52 for AMS members, US$72 for nonmembers; and US$5 for students, unemployed mathematicians, and emeritus members. Fees are payable on-site by cash, check, or credit card.

Travel Information

The nearest airport is Tampa International Airport (**TPA**), http://www.tampaairport.com, 5507 W. Spruce St., Tampa, FL 33607. The airport is about 14 miles from the campus, a 25-minute drive under optimal conditions. A few hotels offer a free shuttle service from TPA; participants should ask about this service when making a hotel reservation. **Bay Shuttle, Inc**., 1-813-259-9998 offers transportation services between the airport (TPA) and the meeting hotels for US$25 each way. **Reservations are required** by phone or through the website at http://www.tampabayshuttle.com.

Alternative shuttle services, airport limos, and taxis are also available (See http://www.tampaairport.com/ground_transportation.)

The second nearest airport is Saint Petersburg-Clearwater International Airport (**PIE**), 14700 Terminal Blvd # 221, Clearwater, FL 33762. PIE is about 26 miles away and you will need to rent a car to get to campus and the hotels.

Getting to the campus by car:

From the east: Take I-4 west to exit 9/I-75 north. Travel north on I-75 for 3.8 miles to Exit 265/Fowler Avenue. Head west on Fowler Avenue 4.4 miles to the university's main entrance at Leroy Collins Boulevard.

From the west/Tampa International Airport: Take I-275 North to Exit 45B/I-4 East. Travel east on I-4 for 8.1 miles to Exit 9/I-75 North. Travel north on I-75 for 3.8 miles to Exit 265/Fowler Avenue. Head west on Fowler Avenue 4.4 miles to the university's main entrance at Leroy Collins Boulevard.

Car Rental

Hertz is the official car rental company for the meeting. To make a reservation accessing our special meeting rates online at www.hertz.com, click on the box "I have a discount", and type in our convention number (CV): **04N30002**. You can also call Hertz directly at 800-654-2240 (U.S. and Canada) or 405-749-4434 (other countries). At the time of reservation, the meeting rates will be automatically compared to other Hertz rates and you will be quoted the best comparable rate available.

Weather

Spring is definitely in the air in March and the weather is sunny, dry, and wonderful. Temperatures vary from 76° F to 56° F and the water temperature for the Gulf of Mexico (West Coast) and the Atlantic Ocean (East Coast) range from the low 60s to middle 70s.

Information for International Participants

Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at http://sites.nationalacademies.org/pga/biso/visas and http://travel.state.gov/visa/visa_1750.html. If you need a preliminary conference invitation in order to secure a visa, please send your request to dls@ams.org.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

* Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of "binding" or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:

- family ties in home country or country of legal permanent residence
- property ownership
- bank accounts
- employment contract or statement from employer stating that the position will continue when the employee returns;

* Visa applications are more likely to be successful if done in a visitor's home country than in a third country;

* Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;

* Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location and dates of the activity, and how travel and local expenses will be covered;

* If travel plans will depend on early approval of the visa application, specify this at the time of the application;

* Provide proof of professional scientific and/or educational status (students should provide a university transcript).

This list is not to be considered complete. Please visit the websites above for the most up-to-date information.

Washington, District of Columbia

George Washington University

March 17–18, 2012

Saturday – Sunday

Meeting #1080

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: January 2012
Program first available on AMS website: February 9, 2012
Program issue of electronic *Notices*: March 2012
Issue of *Abstracts*: Volume 33, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: Expired
For abstracts: January 31, 2012

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Jim Geelen, University of Waterloo, *Matroid minors*.

Boris Solomyak, University of Washington, *Some recent advances in tiling dynamical systems*.

Gunther Uhlmann, University of Washington, *Cloaking: Science meets science-fiction* (Einstein Public Lecture in Mathematics).

Anna Wienhard, Princeton University, *Deformation spaces of geometric structures*.

Special Sessions

Analysis of Wavelets, Frames, and Fractals (Code: SS 11A), **Keri Kornelson**, University of Oklahoma, and **Judy Packer**, University of Colorado Boulder.

Computable Mathematics (in honor of Alan Turing) (Code: SS 8A), **Douglas Cenzer**, University of Florida, **Valentina Harizanov**, George Washington University, and **Russell Miller**, Queens College and Graduate Center–CUNY.

Convex and Discrete Geometry (Code: SS 9A), **Jim Lawrence** and **Valeriu Soltan**, George Mason University.

Difference Equations and Applications (Code: SS 18A), **Michael Radin**, Rochester Institute of Technology.

Dynamics of Complex Networks (Code: SS 7A), **Yongwu Rong**, **Guanyu Wang**, and **Chen Zeng**, George Washington University.

Homology Theories Motivated by Knot Theory (Code: SS 3A), **Jozef H. Przytycki**, George Washington University, **Radmila Sazdanovic**, University of Pennsylvania, and **Alexander N. Shumakovitch** and **Hao Wu**, George Washington University.

Mathematical Methods in Disease Modeling (Code: SS 15A), **Shweta Bansal**, Georgetown University and National Institutes of Health, and **Sivan Leviyang**, Georgetown University.

Mathematics Applied in the Sciences: From Statistics to Topology (Code: SS 12A), **James Carroll** and **Hanna Makaruk**, Los Alamos National Laboratory, and **Robert Owczarek**, Enfitek, Inc. and University of New Mexico.

Matroid Theory (Code: SS 1A), **Joseph E. Bonin**, George Washington University, and **Sandra Kingan**, Brooklyn College.

Nonlinear Dispersive Equations (Code: SS 10A), **Manoussos Grillakis**, University of Maryland, **Justin Holmer**, Brown University, and **Svetlana Roudenko**, George Washington University.

Optimization: Theory and Applications (Code: SS 2A), **Roman Sznajder**, Bowie State University.

Relations between the History and Pedagogy of Mathematics (Code: SS 14A), **David L. Roberts**, Prince George's Community College, and **Kathleen M. Clark**, Florida State University.

Self-organization Phenomena in Reaction Diffusion Equations (Code: SS 5A), **Xiaofeng Ren**, George Washington University, and **Junping Shi**, College of William and Mary.

Structural and Extremal Problems in Graph Theory (Code: SS 4A), **Daniel Cranston**, Virginia Commonwealth University, and **Gexin Yu**, College of William & Mary.

Symmetric Functions, Quasisymmetric Functions, and the Associated Combinatorics (Code: SS 16A), **Nicholas Loehr**, Virginia Tech, and **Elizabeth Niese**, Marshall University.

The Legacy of Goedel's Second Incompleteness Theorem for the Foundations of Mathematics (Code: SS 17A), **Karim J. Mourad**, Georgetown University.

Tilings, Substitutions, and Bratteli-Vershik Transformations (Code: SS 6A), **E. Arthur Robinson**, George Washington University, and **Boris Solomyak**, University of Washington.

Topics in Geometric Analysis and Complex Analysis (Code: SS 13A), **Zheng Huang** and **Marcello Lucia**, City University of New York, Staten Island.

Accommodations

Participants should make their own arrangements directly with the hotel of their choice. Special discounted rates were negotiated with the hotels listed below. Rates quoted do not include the District of Columbia hotel tax (14.5%). Participants must state that they are with the **American Mathematical Society (AMS) Meeting at George Washington University** to receive the discounted rate. The AMS is not responsible for rate changes or for the quality of the accommodations. **Hotels have varying cancellation and early checkout penalties; be sure to ask for details.**

Washington Suites Georgetown/Avenue Suites,* 2500 Pennsylvania Avenue NW, Washington, DC 20037; 202-333-8060; 877-736-2500 (toll free); `http://www.washingtonsuitesgeorgetown.com`. Rates are US$149 per night for single/double occupancy. This is an all suite property. Amenities include complimentary continental breakfast each morning; fully equipped kitchen with full sized appliances; limited valet parking available for US$34 + tax per night; and free wired and wireless Internet in guest rooms. This hotel is pet friendly. This property is located approximately .55 miles from the campus. Cancellation and early check-out policies vary; be sure to check when you make your reservation. **Please note that this property has been renovated and will be renamed Avenue Suites in January 2012.* The deadline for reservations at this rate is **February 7, 2012**.

George Washington University Inn, 824 New Hampshire Ave. NW, Washington, D.C. 20037; 800-426-4455 (toll free); 202-337-6620 (reservations department); `http://www.gwuinn.com`. Rates are US$149 per night for a standard king, single occupancy, and US$20 for each additional guest. Amenities include complimentary access to Bally's Total Fitness; complimentary shoeshine service; most rooms have kitchenettes (please request this feature if desired); secure underground valet parking available for US$30 + tax per day; five-minute walk to Foggy Bottom Metro stop; "Notti Bianchi Restaurant" located on property; and free in-room wired and wireless Internet. This property is located approximately .34 miles from the campus. Cancellation and early check-out policies vary; be sure to check when you make your reservation. The deadline for reservations at this rate is **February 7, 2012**.

One Washington Circle Hotel, One Washington Circle NW, Washington DC, 20037; 202-872-1680; 800-424-9671 (toll free); `http://www.thecirclehotel.com`. Rates are US$149 per night for single/double occupancy. Amenities include fitness center, "Circle Bistro and Lounge" restaurant on property, and free wired and wireless Internet in guest rooms. This property is located approximately one mile from the campus. Cancellation and early check-out policies vary; be sure to check when you make your reservation. The deadline for reservations at this rate is **February 7, 2012**.

Residence Inn by Marriott Arlington Courthouse, 1401 N. Adams St, Arlington, VA 22201; 703-312-2100;

http://www.marriott.com/wasca. Rates are US$129 per night for single occupancy. This is an all suite property. Amenities include complimentary hot "Home Touch" breakfast each morning; fully equipped kitchen; indoor pool; on-site fitness room; limited on-site parking for US$14 + tax per night; and free wired and wireless Internet in guest rooms. This hotel is pet friendly. This property is located approximately 3.4 miles from the campus or two metro stops away. The Courthouse metro stop is less than a block away. Cancellation and early check-out policies vary; be sure to check when you make your reservation. The deadline for reservations at this rate is **February 7, 2012**.

The River Inn, 924 Twenty-Fifth street NW, Washington, DC 20037; 202-337-7600; 888-874-0100 (toll free); http://www.theriverinn.com. Rates are US$149 per night for single/double occupancy for a corporate suite with a queen bed. There is a US$20 per person charge for additional guests and there is an upgrade to a one bedroom suite available for an additional US$35 per night. This is an all suite property. Amenities include a fully equipped kitchen; excercise facility; on-site restaurant "DISH + drinks"; limited valet parking is available for US$34 + tax per night; complimentary two-hour bike rentals; and free wired and wireless Internet in guest rooms. This property is located approximately one mile from the campus. Cancellation and early check-out policies vary; be sure to check when you make your reservation. The deadline for reservations at this rate is **February 7, 2012**.

Food Services

On Campus: Campus facilities will be closed during the weekend of the meeting for Spring Break.

Off Campus: There are many dining choices for casual dining and "grab and go" options convenient to campus. The Shops at 2000 Penn afford several choices just a short distance from the meeting:

Au Bon Pain, 202-887-9215; offering sandwiches, soups, salads, and entrees.

Bertucci"s, 202-296-2600; offering Italian cuisine.

Con-E-Island, 202-822-8460; offering ice cream, frozen yogurt, and fresh baked goods.

Johnny Rockets, 202-822-1260; offering hamburgers, sandwiches, and shakes.

Kinkeads, 202-296-7700; not open for lunch on the weekends, dinner only; an American brasserie.

The Perfect Pita, 202-293-7482; closed on Sunday; offering soups, salads, and sandwiches with a Mediterranean American flair.

Wasabi to Go, 202-822-0648; closed on Sunday; offering sushi and Japanese cuisine.

Please visit http://www.gwu.edu/explore/visitingcampus/lodgingdining#fbd, for more casual and fine dining options in the Foggy Bottom neighborhood.

Registration and Meeting Information

Registration and the AMS book exhibit will be located in Monroe Hall, on the second floor. Special Sessions will be held in Monroe Hall, Funger Hall, Duques Hall, and the Hall of Government. The Einstein Lecture will be held in Funger 108 (McCrea Auditorium) with additional seating available in Funger 103 (Dworetzky Auditorium). Please refer to the campus map at http://www.gwu.edu/staticfile/GW/Campus%20Information/Campus%20Maps/gw_campus-map_2011.pdf for specific locations. The registration desk will be open on Saturday, March 17, 7:30 a.m.-4:00 p.m., and Sunday, March 18, 8:00 a.m.–12:00 p.m. Fees are US$52 for AMS members, US$72 for nonmembers; and US$5 for students, unemployed mathematicians, and emeritus members. Fees are payable on-site via cash, check, or credit card; advance registration is not available.

AMS Einstein Public Lecture in Mathematics

The Einstein Public Lecture will be given by **Gunther Uhlmann,** University of California, Irvine, and University of Washington. The title of his talk is *Cloaking: Science meets science-fiction*. The lecture will be given on Saturday, March 17, at 5:00 p.m., in Funger Hall in the McCrea Auditorium (Funger 108).

A reception hosted by the Department of Mathematics and the AMS will take place between 6:00 p.m. - 7:00 p.m. in the lobby of Funger Hall outside the auditoriums. The AMS thanks our hosts for their gracious hospitality.

Other Activities

Book Sales: Stop by the on-site AMS bookstore and review the newest titles from the AMS, enjoy up to 25% off all AMS publications, or take home an AMS t-shirt! Complimentary coffee will be served courtesy of AMS Membership Services.

AMS Editorial Activity: An acquisitions editor from the AMS book program will be present to speak with prospective authors. If you have a book project that you would like to discuss with the AMS, please stop by the book exhibit.

Local Information and Maps

This meeting will take place on the Foggy Bottom Campus of George Washington University. A campus map can be found at http://www.gwu.edu/staticfile/GW/Campus%20Information/Campus%20Maps/gw_campus-map_2011.pdf Information about the GWU Department of Mathematics may be found at http://www.gwu.edu/~math/. Please watch the website available at http://www.ams.org/meetings/sectional/sectional.html for additional information on this meeting. Please visit the George Washington University website at www.gwu.edu for additional information on the campus.

Parking

Both the Academic Center Garage (marked 30 on the campus map) and the Marvin Center (marked 22 on the campus map) offer parking for meeting participants. The rates at the time of publication were weekdays US$9 for up to one hour and US$15 for up to two hours, with a daily maximum rate of US$19. There is an evening maximum rate of US$9 and a weekend daily maximum rate of US$11.

Travel

GWU is approximately a nine-minute drive from Ronald Regan Washington National Airport (DCA), approximately a 35-minute drive from Washington Dulles International Airport (IAD), and 60-minute drive from Baltimore-Washington International Thurgood Marshall Airport (BWI). To view several other airport options please reference the George Washington University website at http://www.gwu.edu/explore/visitingcampus/gettingtoarounddc

By Air: Reagan Washington National Airport (DCA) in suburban Virginia is the closest and most convenient airport to the university. From the airport, you can use the Metrorail train to the Foggy Bottom GWU Metro Stop or take a taxi directly to the Foggy Bottom Campus. To access the Metrorail Station from Terminal B and C use the pedestrian bridges that lead directly to the station; to access the station from Terminal A board any "Airport Shuttle" bus from outside the terminal and travel to the station. Metrorail passes may be purchased in machines located at the station and fares range between US$1.60 and US$2.55 one way. Taxicab stands are located near the Arrivals (Baggage Claim) exits of each terminal and no advanced reservations are required. Taxi fares can be estimated at between US$11–US$15one way. There is also a US$2.50 airport fee payable in addition to the taxi fare.

Dulles International Airport (IAD) is more distant in the Virginia suburbs. You may use a taxi or use the Washington Flyer shuttles to get into the city. Washington Flyer Coach Service will take you non-stop to Metrorail's West Falls Church Station for US$10 one-way or US$18 round-trip. Tickets for the Flyer Coach can be purchased at the ticket counter located inside the vestibule of Door 4 on the arrivals level of the main terminal. The Metrorail ride from West Falls Church Station to the Foggy Bottom GWU Metro stop takes approximately 18 minutes and the fare ranges between US$2.15 and US$3.60. The exclusive taxicab service serving the airport is Washington Flyer Taxi. No reservations are necessary for leaving the airport, follow the signs for ground transportation to the lower level of the main terminal. To arrange for a reservation to return to the airport call 703-572-8294 at least 8 hours prior to the desired pick-up time to place a reservation. Approximate cab fare could range between US$50 to US$65. There is not yet direct rail transport from Dulles to Washington, D.C.

Baltimore-Washington International Airport (BWI), in Maryland, is the most distant area airport from the campus. To get to the campus, ground transportation options include the Super Shuttle, and the Amtrak train into Washington, D.C. Super Shuttle reservations can be made via the Web at http://www.supershuttle.com/en/BWIAirport. Super Shuttle counters are located at the lower level baggage claims 1 through 10. To utilize Amtrak service into Washington D.C. from the airport, take a complimentary shuttle from the terminal to BWI Marshall Rail Station. Board the Amtrak train from BWI to Washington's Union Station. The estimated fare is US$11 one way. To contact Amtrak Passenger Services at Union Station, please call 202-906-3260. To contact the Union Station ticket office, call 202-906-3104.

By Train: The Washington region is served by Amtrak. Reservations can be made at http://www.amtrak.com. If traveling by rail, you will arrive at Union Station, not far from the Capitol. Inside Union Station, you can board Metrorail for a short subway ride to the Foggy Bottom-GWU Metro stop.

By Bus: The Washington region is served by Greyhound Lines, reservations can be made at http://www.greyhound.com. Megabus also travels to the DC area; reservations can be made at http://us.megabus.com/. Boltbus also provides service to the DC area; reservations can be made at https://www.boltbus.com/. you will arrive at Union Station, not far from the Capitol. Inside Union Station, you can board Metrorail for a short subway ride to the Foggy Bottom-GWU Metro stop.

By Car: From the north, travel on Interstate 95 south to Interstate 495 (Capital Beltway) toward Silver Spring/Northern Virginia. Take exit 33, heading south on Connecticut Avenue for about 9 miles. Turn right onto Florida Avenue (just past the Washington Hilton) and turn left immediately onto 21st Street. Turn right on I Street. The visitor entrance to the parking garage is on the left between 21st and 22nd Streets.

From the northwest, travel on Interstate 270 to Interstate 495 (Capital Beltway) toward Silver Spring. Take exit 33, heading south on Connecticut Avenue for about 9 miles. Follow directions as given in From North.

From the west, Interstate 66 and Route 50 both connect with the Theodore Roosevelt (TR) Bridge. Cross the bridge and exit left at E Street, then again at Virginia Avenue. Bear left, following signs for 23rd Street. Turn right on 23rd Street and continue a few blocks to campus. Turn right on I Street. The visitor entrance to the parking garage is on your right between 22nd and 21st Streets.

From the south, Interstate 95 to Interstate 395 Arlington Memorial Bridge exit. Cross the bridge and bear left at the Lincoln Memorial. Turn left onto 23rd Street, NW, and follow directions as given in From West.

Car Rental: Hertz is the official car rental company for the meeting. To make a reservation accessing our special meeting rates online at www.hertz.com, click on the box "I have a discount", and type in our convention number (CV): 04N30002. You can also call Hertz directly at 800-654-2240 (U.S. and Canada) or 1-405-749-4434 (other countries). At the time of reservation, the meeting rates will be automatically compared to other Hertz rates and you will be quoted the best comparable rate available.

Local Transportation

Taxi Service: Licensed, metered taxis are available throughout Washington, D.C., close-in suburbs, and the airports.

Bus and Subway Service: The Metro bus and rail system serves Washington D.C. and surrounding areas. Metrobus fare for regular routes can range from US$1.50 to US$3.85 using cash. Senior/Disabled fare can range from US.75¢ to US$1.80 on express routes. You must have exact change, drivers do not carry cash.

Metrorail regular fares are in effect on weekdays from opening to 9:30 a.m., 3:00 p.m.–7:00 p.m., and on weekends from midnight to closing. A peak-of-the-peak fee of US.20¢ is added to regular fares weekdays 7:30-9 a.m. and 4:30-6 p.m. Each rider needs his or her own farecard or pass to ride Metrorail. A pass or farecard cannot be shared with another person. Farecards hold between US$1.60 and US$45 and are available at fare vending machines in Metrorail stations, retail outlets and commuter stores. Farecards valued at US$10–US$20 can be purchased online in advance. Additional information can be found at http://www.wmata.com/fares/.

If travelling to GWU by the Metro: The Blue and Orange lines stop at Foggy Bottom/GWU Metro station which is located on the GWU campus. Foggy Bottom/GWU Metro station is at the corner of 23rd and I streets, and is marked with a big M on the campus map.

Weather:

The average high temperature for March is approximately 56 degrees Fahrenheit and the average low is approximately 38 degrees Fahrenheit. Rain is common for this time of year. Visitors should be prepared for inclement weather and check weather forecasts in advance of their arrival.

Information for International Participants

Visa regulations are continually changing for travel to the United States. Visa applications may take from three to four months to process and require a personal interview, as well as specific personal information. International participants should view the important information about traveling to the U.S. found at http://sites.nationalacademies.org/pga/biso/visas/ and http://travel.state.gov/visa/visa_1750.html. If you need a preliminary conference invitation in order to secure a visa, please send your request to mac@ams.org.

If you discover you do need a visa, the National Academies website (see above) provides these tips for successful visa applications:

* Visa applicants are expected to provide evidence that they are intending to return to their country of residence. Therefore, applicants should provide proof of "binding" or sufficient ties to their home country or permanent residence abroad. This may include documentation of the following:

- family ties in home country or country of legal permanent residence
- property ownership
- bank accounts
- employment contract or statement from employer stating that the position will continue when the employee returns;

* Visa applications are more likely to be successful if done in a visitor's home country than in a third country;

* Applicants should present their entire trip itinerary, including travel to any countries other than the United States, at the time of their visa application;

* Include a letter of invitation from the meeting organizer or the U.S. host, specifying the subject, location and dates of the activity, and how travel and local expenses will be covered;

* If travel plans will depend on early approval of the visa application, specify this at the time of the application;

* Provide proof of professional scientific and/or educational status (students should provide a university transcript).

This list is not to be considered complete. Please visit the websites above for the most up-to-date

Lawrence, Kansas

University of Kansas

March 30 – April 1, 2012

Friday – Sunday

Meeting #1081

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: February 2012
Program first available on AMS website: March 8, 2012
Program issue of electronic *Notices*: March 2012
Issue of *Abstracts*: Volume 33, Issue 2

Deadlines

For organizers: Expired
For consideration of contributed papers in Special Sessions: December 20, 2011
For abstracts: February 14, 2012

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Frank Calegari, Northwestern University, *Title to be announced.*

Christopher Leininger, University of Illinois at Urbana-Champaign, *Title to be announced.*

Alina Marian, University of Illinois at Chicago, *Title to be announced.*

Catherine Yan, Texas A&M University, *Title to be announced.*

Special Sessions

Algebraic Geometry and its Applications (Code: SS 9A), **Yasuyuki Kachi**, **B. P. Purnaprajna**, and **Sarang Sane**, University of Kansas.

Combinatorial Commutative Algebra (Code: SS 1A), **Christopher Francisco** and **Jeffrey Mermin**, Oklahoma State University, and **Jay Schweig**, University of Kansas.

Complex Analysis, Geometry and Probability (Code: SS 20A), **Pietro Poggi-Corrandini** and **Hrant Hakobyan**, Kansas State University.

Dynamics and Stability of Nonlinear Waves (Code: SS 12A), **Mat Johnson** and **Myunghyun Oh**, University of Kansas.

Enumerative and Geometric Combinatorics (Code: SS 5A), **Margaret Bayer**, University of Kansas, **Joseph P. King**, University of North Texas, **Svetlana Poznanovik**, Georgia Institute of Technology, and **Catherine Yan**, Texas A&M University.

Geometric Representation Theory (Code: SS 4A), **Zongzhu Lin**, Kansas State University, and **Zhiwei Yun**, Massachusetts Institute of Technology.

Geometric Topology and Group Theory (Code: SS 16A), **Richard P. Kent IV**, University of Wisconsin-Madison, **Christopher J. Leininger**, University of Illinois Urbana-Champaign, and **Kasra Rafi**, University of Oklahoma.

Geometry of Moduli Spaces of Sheaves (Code: SS 17A), **Alina Marian**, University of Illinois at Chicago, and **Dragos Oprea**, University of California San Diego.

Harmonic Analysis and Applications (Code: SS 6A), **Arpad Benyi**, Western Washington University, **David Cruz-Uribe**, Trinity College, and **Rodolfo Torres**, University of Kansas.

Interplay between Geometry and Partial Differential Equations in Several Complex Variables (Code: SS 13A), **Jennifer Halfpap**, University of Montana, and **Phil Harrington**, University of Arkansas.

Invariants of Knots (Code: SS 3A), **Heather A. Dye**, McKendree University, and **Aaron Kaestner** and **Louis H. Kauffman**, University of Illinois at Chicago.

Mathematical Statistics (Code: SS 14A), **Zsolt Talata**, University of Kansas.

Mathematics of Ion Channels: Life's Transistors (Code: SS 15A), **Bob Eisenberg**, Rush Medical Center at Chicago, **Chun Liu**, Penn State University, and **Weishi Liu**, University of Kansas.

Mirror Symmetry (Code: SS 19A), **Ricardo Castano-Bernard**, Kansas State University, **Paul Horja**, Oklahoma State University, and **Zheng Hua** and **Yan Soibelman**, Kansas State University.

Nonlinear Dynamical Systems and Applications (Code: SS 11A), **Weishi Liu** and **Erik Van Vleck**, University of Kansas.

Numerical Analysis and Scientific Computing (Code: SS 10A), **Weizhang Huang**, **Xuemin Tu**, **Erik Van Vleck**, and **Honggou Xu**, University of Kansas.

Partial Differential Equations (Code: SS 2A), **Milena Stanislavova** and **Atanas Stefanov**, University of Kansas.

Singularities in Commutative Algebra and Algebraic Geometry (Code: SS 7A), **Hailong Dao**, University of Kansas, **Lance E. Miller**, University of Utah, and **Karl Schwede**, Pennsylvania State University.

Stochastic Analysis (Code: SS 18A), **Jin Feng**, **Yaozhong Hu**, and **David Hualart**, University of Kansas.

Topics in Commutative Algebra (Code: SS 8A), **Hailong Dao**, **Craig Huneke**, and **Daniel Katz**, University of Kansas.

Undergraduate Research (Code: SS 22A), **Marianne Korten** and **David Yetter**, Kansas State University.

University Mathematics Education in an Online World (Code: SS 21A), **Andrew G. Bennett** and **Carlos Castillo-Garsow**, Kansas State University.

Rochester, New York

Rochester Institute of Technology

September 22–23, 2012

Saturday – Sunday

Meeting #1082

Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: May 2012
Program first available on AMS website: July 19, 2012
Program issue of electronic *Notices*: September 2012
Issue of *Abstracts*: Volume 33, Issue 3

Deadlines

For organizers: February 22, 2012
For consideration of contributed papers in Special Sessions: May 15, 2012
For abstracts: July 10, 2012

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Invited Addresses

Steve Gonek, University of Rochester, *Title to be announced.*

James Keener, University of Utah, *Title to be announced.*

Dusa McDuff, Barnard College, *Title to be announced.*

Peter Winkler, Dartmouth College, *Title to be announced.*

Special Sessions

Continuum Theory (Code: SS 3A), **Likin C. Simon Romero**, Rochester Institute of Technology.

Financial Mathematics (Code: SS 1A), **Tim Siu-Tang Leung**, Columbia University.

Microlocal Analysis and Nonlinear Evolution Equations (Code: SS 2A), **Raluca Felea**, Rochester Institute of Technology, and **Dan-Andrei Geba**, University of Rochester.

Special Session on Operator Theory and Function Spaces (Code: SS 4A), **Gabriel T. Prajitura** and **Ruhan Zhao**, State University of New York at Brockport.

New Orleans, Louisiana

Tulane University

October 13–14, 2012

Saturday – Sunday

Meeting #1083

Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: June 2012
Program first available on AMS website: September 6, 2012
Program issue of electronic *Notices*: October 2012
Issue of *Abstracts*: Volume 33, Issue 3

Deadlines

For organizers: March 13, 2012
For consideration of contributed papers in Special Sessions: July 3, 2012
For abstracts: August 28, 2012

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Anita Layton, Duke University, *Title to be announced.*

Lenhard Ng, Duke University, *Title to be announced.*

Henry K. Schenck, University of Illinois at Urbana-Champaign, *From approximation theory to algebraic geometry: The ubiquity of splines.*

Milen Yakimov, Louisiana State University, *Title to be announced.*

Akron, Ohio

University of Akron

October 20–21, 2012

Saturday – Sunday

Meeting #1084

Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: August 2012
Program first available on AMS website: September 27, 2012
Program issue of electronic *Notices*: October 2012
Issue of *Abstracts*: Volume 33, Issue 4

Deadlines

For organizers: March 22, 2012
For consideration of contributed papers in Special Sessions: July 10, 2012
For abstracts: September 4, 2012

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Tanya Christiansen, University of Missouri, *Title to be announced.*

Tim Cochran, Rice University, *Title to be announced.*

Ronald Solomon, Ohio State University, *Title to be announced.*

Ben Weinkove, University of California San Diego, *Title to be announced.*

Special Sessions

Groups, Representations, and Characters (Code: SS 1A), **Mark Lewis**, Kent State University, **Adriana Nenciu**, Otterbein University, and **Ronald Solomon**, Ohio State University.

Tucson, Arizona

University of Arizona, Tucson

October 27–28, 2012

Saturday – Sunday

Meeting #1085

Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: August 2012
Program first available on AMS website: October 4, 2012
Program issue of electronic *Notices*: October 2012
Issue of *Abstracts*: Volume 33, Issue 4

Deadlines

For organizers: March 27, 2012
For consideration of contributed papers in Special Sessions: July 17, 2012
For abstracts: September 11, 2012

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Michael Hutchings, University of California Berkeley, *Title to be announced.*

Kenneth McLaughlin, University of Arizona, Tucson, *Title to be announced.*

Ken Ono, Emory University, *Title to be announced* (Erdős Memorial Lecture).

Jacob Sterbenz, University of California San Diego, *Title to be announced.*

Goufang Wei, University of California, Santa Barbara, *Title to be announced.*

Special Sessions

Dispersion in Heterogeneous and/or Random Environments (Code: SS 2A), **Rabi Bhattacharya**, Oregon State University, Corvallis, and **Edward Waymire**, University of Arizona, Tucson.

Harmonic Maass Forms and q-Series (Code: SS 1A), **Ken Ono**, Emory University, **Amanda Folsom**, Yale University, and **Zachary Kent**, Emory University.

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 9–12, 2013

Wednesday – Saturday

Meeting #1086

Joint Mathematics Meetings, including the 119th Annual Meeting of the AMS, 96th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2012
Program first available on AMS website: November 1, 2012
Program issue of electronic *Notices*: January 2012
Issue of *Abstracts*: Volume 34, Issue 1

Deadlines

For organizers: April 1, 2012
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Oxford, Mississippi

University of Mississippi

March 1–3, 2013

Friday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: August 1, 2012
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Chestnut Hill, Massachusetts

Boston College

April 6–7, 2013

Saturday – Sunday
Eastern Section
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 6, 2012
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Ames, Iowa

Iowa State University

April 27–28, 2013

Saturday – Sunday
Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: April 2013
Issue of *Abstracts*: To be announced

Deadlines

For organizers: September 27, 2012
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see `www.ams.org/amsmtgs/sectional.html`.

Special Sessions

Operator Algebras and Topological Dynamics (Code: SS 1A), **Ken Ono**, Emory University, **Amanda Folsom**, Yale University, and **Zachary Kent**, Emory University.

Alba Iulia, Romania

June 27–30, 2013

Thursday – Sunday

First Joint International Meeting of the AMS and the Romanian Mathematical Society, in partnership with the "Simion Stoilow" Institute of Mathematics of the Romanian Academy.

Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: To be announced
Program first available on AMS website: Not applicable
Program issue of electronic *Notices*: Not applicable
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Louisville, Kentucky

University of Louisville

October 5–6, 2013

Saturday – Sunday
Southeastern Section
Associate secretary: Matthew Miller
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 5, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

St. Louis, Missouri

Washington University

October 18–20, 2013

Friday – Sunday
Central Section
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 20, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Riverside, California

University of California Riverside

November 2–3, 2013

Saturday – Sunday
Western Section
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 2, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Baltimore, Maryland

Baltimore Convention Center, Baltimore Hilton, and Marriott Inner Harbor

January 15–18, 2014

Wednesday – Saturday

Joint Mathematics Meetings, including the 120th Annual Meeting of the AMS, 97th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association for Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2013
Program first available on AMS website: November 1, 2013
Program issue of electronic *Notices*: January 2013
Issue of *Abstracts*: Volume 35, Issue 1

Deadlines

For organizers: April 1, 2013
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Tel Aviv, Israel

Bar-Ilan University, Ramat-Gan and Tel-Aviv University, Ramat-Aviv

June 16–19, 2014

Monday – Thursday
The 2nd Joint International Meeting between the AMS and the Israel Mathematical Union.
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Antonio, Texas

Henry B. Gonzalez Convention Center and Grand Hyatt San Antonio

January 10–13, 2015

Saturday – Tuesday
Joint Mathematics Meetings, including the 121st Annual Meeting of the AMS, 98th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Steven H. Weintraub
Announcement issue of *Notices*: October 2014
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2015
Issue of *Abstracts*: Volume 36, Issue 1

Deadlines

For organizers: April 1, 2014
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Porto, Portugal

University of Porto

June 11–14, 2015

Thursday – Sunday
Associate secretary: Georgia Benkart
Announcement issue of *Notices*: To be announced
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: Not applicable

Deadlines

For organizers: To be announced
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Seattle, Washington

Washington State Convention Center and the Sheraton Seattle Hotel

January 6–9, 2016

Wednesday – Saturday
Joint Mathematics Meetings, including the 122nd Annual Meeting of the AMS, 99th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).
Associate secretary: Michel L. Lapidus
Announcement issue of *Notices*: October 2015
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2016
Issue of *Abstracts*: Volume 37, Issue 1

Deadlines

For organizers: April 1, 2015
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Atlanta, Georgia

Hyatt Regency Atlanta and Marriott Atlanta Marquis

January 4–7, 2017

Wednesday – Saturday

Joint Mathematics Meetings, including the 123rd Annual Meeting of the AMS, 100th Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Georgia Benkart
Announcement issue of *Notices*: October 2016
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: January 2017
Issue of *Abstracts*: Volume 38, Issue 1

Deadlines

For organizers: April 1, 2016
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

San Diego, California

San Diego Convention Center and San Diego Marriott Hotel and Marina

January 10–13, 2018

Wednesday – Saturday

Joint Mathematics Meetings, including the 124th Annual Meeting of the AMS, 101st Annual Meeting of the Mathematical Association of America, annual meetings of the Association for Women in Mathematics (AWM) and the National Association of Mathematicians (NAM), and the winter meeting of the Association of Symbolic Logic, with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Matthew Miller
Announcement issue of *Notices*: October 2017
Program first available on AMS website: To be announced
Program issue of electronic *Notices*: To be announced
Issue of *Abstracts*: To be announced

Deadlines

For organizers: April 1, 2017
For consideration of contributed papers in Special Sessions: To be announced
For abstracts: To be announced

Presenters of Papers

Boston, Massachusetts; January 4–7, 2012

Numbers following the name indicate the speaker's position on the program.
∗ Special Session Speaker, ■ NAM Invited Lecturer, ▲ SIAM Invited Lecturer, • AMS Invited Lecturer, ◦ MAA Invited Lecturer, ◇ Joint Invited Lecturer, ♢ ASL Invited Lecturer, ✠ AMS Retiring Presidential Address, □ AWM Emmy Noether Lecturer, ► Graduate Student, ◄ Undergraduate Student

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◦ Abbott, S. 1630
∗► Abdeljabbar, A. M. 2445
► Abdullayev, F. 814
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∗ Abokhodair, A. A. 2421
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∗ Abramov, R. V. 1038
∗ Accardi, L. 436
∗ Achter, J. D. 2093
∗ Ackleh, A. S. 2162
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∗► Adams, H. 717
∗► Adamu, M. Y. 2448
∗ Adeboye, I. 808
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∗ Adler, M. A. 1376
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► Adrovic, D. 1476
► Aghasi, A. 2711
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∗ Ahmed, N. U. 2382
∗ Aiden, E. L. 735
► Akhavin, M. 1495
∗ Akkermans, E. 2413
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∗ Ali, J. 2526
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∗ Allen, L. J. 399
∗◄ Allen, S. 1344
◄ Allen-Prince, M. N. 2663
◄ Allison, T. F. 822
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► Almomani, A. R. 810
∗ Alpay, D. A. 1756
∗► Alpert, H. 2070
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► Alshawarbeh, E. 847
∗ Alvarado, A. 38
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∗ Anastassiou, G. A. 1725
∗ Anastassiou, G. A. 2433
∗ Anco, S. C. 2449
∗ Andersen, N. 2519
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∗ Anderson, M. 1709
∗ Andrade, R. 2113
✠ Andrews, G. E. 1339
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◄ Arbesfeld, N. 1823
∗ Archdeacon, D. 443
∗ Arciniega, A. 2172
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∗ Armstrong, D. 1714
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∗◄ Asai, N. 437
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∗► Augustin, M. 2109
◄ Auld, E. B. 2670
∗► Aulicino, D. 1458
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∗ Avalos, G. 1054
∗ Avdonin, S. 1699
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∗ Averbuch, A. 2417
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∗ Axvig, N. 340
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∗ Ayala, D. H. 2116
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∗ Babai, L. 374
► Badawy, M. 1902
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Baggett, P. 2266
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∗ Bahls, P. 1786
► Bahmanian, A. 1821
► Bailey, B. L. 2006
► Baker, B. 1816
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∗ Bal, G. 82
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► Balasubramanian, K. 2585
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∗ Banerjee, R. 2115
∗ Bani-Yaghoub, M. 2502
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► Bannish, B. E. 2003
∗ Bao, G. 1694
∗ Barbasch, D. M. 119
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∗ Barchini, L. I. 2517
Barfield, W. S. 889
∗ Barker, A. T. 681
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Barnes, J. 1250
∗ Barrett, W. 2126
► Barry, A. M. 2020
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∗► Barthelmé, T. 1801
► Basu, K. 1202
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∗ Bauer, C. 1022
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∗ Baum, P. F. 1743
∗ Baum, P. F. 2442
∗ Bayer, M. M. 1046
∗ Bazlov, Y. 2496
► Beagley, J. E. 2208
Beauregard, M. A. 1896
◄ Beck, E. S. 1207
Becker, P. E. 556
◄ Becker, T. G. 929
∗ Beckmann, S. 1350
◄ Beckwith, O. 1591
∗ Becnel, J. J. 438
Beecher, B. 2258
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∗ Behrens, M. J. 1693
∗ Behrstock, J. 387
∗ Beier, J. 1128
Beier, J. 1942
∗ Beilock, S. L. 2073
Beisiegel, M. 588
Belanger, J. P. 2755
∗ Belcastro, S.-M. 1783
Belcastro, S.-M. 1993

Belding, J. V. ... 2700
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∗ Bendich, P. L. ... 1047
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∗► Bickel, K. ... 104
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∗ Bisztriczky, T. ... 1042
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∗ Bleiler, S. A. ... 778
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∗ Bober, J. W. ... 770
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∗ Bociu, L. ... 1055
∗ Bodine, E. N. ... 2097
Bodner, B. L. ... 209
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Boggess, M. ... 1288
∗ Bogomolov, F. A. ... 794
Bohman, T. ... 261
∗ Bohmann, A. ... 1419
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∗ Bolotnikov, V. ... 1757
∗ Boman, J. ... 1441
∗ Bona, J. L. ... 971
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Hanes, J. 827
►Hanson, E. D. 2721
◄Harman, N. R. 201
Harnish, S. H. 2017
∗►Harpaz, Y. 1772
∗Harper, J. E. 2435
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∗►Harris, P. E. 1127
◄Harrison, Z. M. 2045
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∗Harvey, D. 1354
►Hasenauer, R. E. 1177
Hass, J. 1463
►Hassani Monfared, K. . 816
Hathaway, D. K. 898
Haugh, J. M. 1999
∗Haution, O. 1751
◄Hawley, K. M. 468
∗Haynes, T. W. 2135
∗►He, Q. 409
∗►He, Y. 702
Heath, J. W. 223
►Heaton, R. J. 1883
∗Heck, P. 1739
∗Heckenberger, I. 2165
∗Hedden, M. 1075
∗Hedetniemi, S. T. 2133
◄Hedman, A. D. 1534
►Hegemann, R. A. 2010
►Hegg, M. 169
∗Heitsch, C. E. 2462
∗◄Held, R. 1642
∗►Helfand, I. 711
∗Helgason, S. 1443
◄Hellwig, E. 2662
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∗Helminck, A. G. 451
∗Helton, J. W. 1435
∗Henderson, J. 355
∗Henderson, J. 1723
Henderson, J. R. 1924
∗Henle, J. M. 356
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◊Henson, C. W. 2776
∗Henson, S. M. 1094
◄Herdan, J. D. 190
∗Herichi, H. 368
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∗◄Heroor, C. 1639
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►Hineman, J. L. 2737
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►Hird, J. T. 2190
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∗►Holden, M. H. 766
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∗Holmer, J. 979
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►Hong, S. 1184
∗Hoobler, R. T. 721
∗de Hoop, M. 1400
Hoover, K. R. 1980
Horn, P. 1490
∗Horn, P. D. 1734
►Horvath, A. K. 1234
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◄Hostetter, M. 2599
∗►Hough, B. 1277
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►Howe, S. P. 281
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∗Hritonenko, N. 760
∗Hritonenko, N. 780
∗Hrynkiv, V. 2399
►Hu, W. 1511
►Huang, H. 2015
►Huang, J.-J. 1526
∗Huang, X. 425
Huang, Y. 2032
Huber, T. 1889
∗►Hudecek, J. 1017
►Hughes, J. 2292
Hulett, H. 1941
Hull, T. C. 1248
Hulsebosch, K. L. 636
Hulsizer, H. N. 292
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∗Humphreys, J. E. 1748
∗Hunter, J. K. 1365
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∗Imrich, W. 2490
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∗►Jafari, N. 403
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∗Jafri, M. S. 782
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∗◄Jameson, N. J. 799
◄Jamieson, W. B. 1161
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►Janoski, J. E. 2187
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◄Jayasuriya, S. 537
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∗Jerrard, R. L. 294
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►Johnson, B. 1172
∗Johnson, B. 1692
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∗Johnson, J. 75
►Johnson, K. V. 818
∗Johnson, N. 2439
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►Johnson, V. 251
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∗◄Johnston, H. 1638
Johnston, W. 1966
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∗Jones, G. A. 116
∗Jones, J. W. 2084
∗Jones, K. M. 2319
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Jones, L. 2008
∗Jones, M. A. 460
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►Jones, M. E. 473
∗Jones, R. 55
∗Jordan, D. A. 2548
∗Jordan, K. E. 83
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∗Joshi, H. R. 2096
∗Joyal, A. 2434
Joyner, M. L. 1867
∗Juan, L. 1704
Judge, C. M. 1144
Judson, T. 1279
∗Jugnon, V. 1696
Jugnon, V. 2712
►Jung, J. 475
►Jung, J. 2369
∗►Junkins, C. 1752
►Junod, M. 1828
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∗Kamensky, M. 1708
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∗►Kang, S. 2108
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∗Kaplan, D. T. 1650
∗Karaali, G. 126
∗Karaali, G. 2446
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Karev, G. 1987
Karev, G. P. 158
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∗Katok, A. 2177
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∗Kauffman, L. H. 752
∗Kauffman, S. A. 30
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∗►Kealy, B. J. 29
∗►Kealy, B. J. 1106
∗►Kealy, B. J. 1669
∗►Kealy, B. J. 2405
∗►Kealy, B. J. 2501
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∗Keigher, W. F. 720
Kelly, A. R. 1948
Kelly, B. P. 1507
Kelly, B. P. 2743
Kelsey, G. A. 604
∗►Kemajou, E. 1119
►Kengwoung-Keumo, J.-J. 177
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∗Kent, C. M. 348
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►Keough, L. 891
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∗Kessel, C. 2078
□Keyfitz, B. L. 1013
∗Khan, A. A. 416
∗Khan, F. S. 2119
∗►Khan, I. F. 447
Khan, N. 619
Khan, N. 2571
Khan, S. M. 943
Khanal, N. P. 2223
Khazanov, L. 1936
►Khoshaim, H. B. 653
∗Khoshnevisan, D. 1408
Khoury, M. C. 2289
Kiihne, P. 2263
∗Kilgour, D. M. 459
►Kilpack, M. H. 2210
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∗Kim, C.-G. 2529
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►Kim, H. 2192
∗Kim, I.-J. 2130
►Kim, K.-W. 986
∗Kim, S.-h. 749
Kim, Y.-S. 2622
►King, S. 1913
Kinney, W. M. 2699
◄Kirby, A. 1998
Kirby, N. O. 167
∗Kirov, R. M. 36
►Kirshtein, J. 1848
Kirtland, J. 1859
Kiteck, D. 654
∗Klagsbrun, Z. 793
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∗Kleinbock, D. 2102
∗Kleiner, M. 1433
∗Kleitman, D. J. 2484
∗Klep, I. 783
∗Klepac, P. 767
►Kleski, C. 146
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Klyve, D. W. 2057
Knaust, H. 1982
∗Knese, G. 421
∗►Knevel, R. 1129
∗Knight, J. F. 687
◊Knight, J. F. 2047
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►Kohli, P. 945
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∗Koranyi, A. 1766
∗Korotkin, D. 2393
∗Korzeniowski, A. 1727
Kose, E. 1269
Kosick, P. 620
►Kosloff, L. 1916
◊◄Kossak, R. 2753
Kostelich, E. J. 506
∗Kotevska, E. 2420
∗Kotiuga, P. R. 373
∗Koukoulopoulos, D. 773
◄Kovacs, A. 540
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∗Kramar, M. 712
►Kramer, D. 2719
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∗Kremer, R. L. 22
∗Krinik, A. 109

∗Krishnan, S. 1051
∗Krishnan, V. P. 1700
Kronholm, B. 1891
Kronholm, W. 877
∗Kronholm, W. C. 1417
◄Krueger, S. A. 2664
∗◄Kruger, C. 1345
Kruse, G. W. 247
∗Krushkal, S. 1741
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∗Kudlak, Z. 54
Kuiper, S. 1327
Kuiper, S. 1945
∗Kuit, J. J. 1767
■Kuku, A. O. 2370
∗Kulenovic, M. R. 351
∗Kulenovic, M. R. 2429
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∗Kumar, A. 1101
Kumar, S. 1262
►Kupin, E. J. 2194
∗Kuratsubo, S. 346
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Kwessi, E. A. 1965
Kwon, H. 2621
►Labrum, M. J. 503
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∗►Ladas, G. 2425
∗Ladas, G. E. 49
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∗►Lahodny Jr., G. 1445
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∗Laison, J. D. 1785
►Lakeland, G. S. 1855
∗►Lal, N. 2409
∗Lam, T. 1719
LaMar, M. D. 1819
Lamar, T. H. 1915
►Lamb, C. L. 479
Lamb, M. R. 926
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∗Lamberson, R. H. 1091
∗Lambrechts, P. 1691
∗Lamzouri, Y. 772
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◄Larsen, A. 226
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∗Larson, C. E. 1452
∗Lasiecka, I. M. 2098
►Lassonde, R. M. 2364
►Lastrina, M. A. 2363
Latulippe, J. 1997
∗Lau, K.-S. 2105
Laursen, S. 1292
∗Lawler, G. F. 1410
∗Lawrence, C. E. 2464
Lawrence, E. D. 1860
∗Lawrence, J. 1043
∗Lawson, T. 2440
◄Lazarev, O. 1595
Le, P. 1881
►Le, T. D. 869
∗Le, T. L. 2144
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∗◄Lee, C. 2380
Lee, E. 1328
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∗►Lee, I. 754
►Lee, J. 285
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Lee, J. 1908
Lee, J.-J. 2630
∗Lee, K. 2140
Lee, P. Y. 2256
Lee, S. 1196
∗Lee, S. 1374
Lee, S. 1952
Lee, S.-G. 985
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∗Lee, Y.-J. 440
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∗Leininger, C. J. 382
∗Leite, M. C. 407
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∗►Leon Sanchez, O. 1707
∗Leslie, C. S. 2465
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∗Levine, A. S. 755
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∗Levy, A. 1061
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∗Lewis, W. J. 1348
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∗►Li, D. 728
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►Li, H. 2362
∗Li, J. 2325
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►Li, P. 1487
∗Li, T. 76
►Li, T. 1892
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∗Li, W. 1796
◄Liang, J. L. 2297
►Liang, Y. 1817
►Liao, X. 1155
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►Linowitz, B. 2212
∗Linusson, S. 963
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◄Lipat, B. R. 863
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Liu, B. 2002
◄Liu, G. 2188
∗Liu, H. 1698
Liu, J. 1895
►Liu, P. 1502
∗Liu, P. 2528
►Liu, X. 179
►Liu, X. 2586
►Liu, Y. 2249
Liu, Y. 2720
Lockard, S. R. 638
◄Lockhart, E. W. 1213
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Loeb, P. A. 1964
Loepp, S. 2049
∗Loftin, J. C. 1136
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∗Long, R. 2454
∗►Longla, M. 107
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∗van Luijk, R. 1098
∗Luke, N. S. 1680
∗►Lukyanenko, A. 805
∗Luo, L. 1798
►Luo, Q. 1910
∗Luo, T. 1364
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Luttman, A. 2709
Lynch, F. H. 1862
∗►Lynd, C. D. 353
►Lyzinski, V. 194
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∗MacCluer, B. D. 2141
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∗Maki, K. L. 87
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∗Malestein, J. 72
∗Malik, M. T. 2158
►Malik, S. 1960
∗Malisoff, M. 2537
∗Malmskog, B. 1378
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∗Mangahas, J. 750
Mann, A. L. 2204
►Mann, J. 1911
◄Manning, J. 2601
∗Manning, J. F. 384
►Manning, N. J. 2282
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∗Marchand, R. J. 1057
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∗►Maris, F. 80
∗Marker, D. 1705
∗►Maroun, M. A. 2414
Marsh, S. L. 1962
◄Marsh, V. 1530
Marshall, J. 2551
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∗Martcheva, M. 1448
Martin, C. D. 1956
∗◄Martin, E. R. 1635
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∗►Martin, K. 1342
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∗ McDevitt, T. ... 1702
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∗ McGovern, W. M. ... 449
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∗ McKelvey, S. C. ... 764
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∗ Mellor, B. ... 112
∗ Melville, D. J. ... 24
◄ Meng, D. ... 2013
∗ Mengesha, T. ... 397
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Merritt, R. L. ... 2226
∗ Mertz, J. E. ... 2074
Merz, S. K. ... 465
∗ Mesirov, J. P. ... 2467
Metcalf, R. C. ... 628
◄ Meyerhofer, M. ... 2191
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► Miakonkana, G.-v. M. ... 947
∗ Micciancio, D. ... 2081
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∗ Michel, V. ... 1414
∗ Mickens, R. E. ... 2531
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∗► Miki, H. ... 1687
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► Miller, J. K. ... 2562
► Miller, J. M. ... 161
∗ Miller, J. S. ... 689
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∗ Miller, P. D. ... 2392
◄ Miller, R. ... 156
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► Milonovich, B. ... 213
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∗ Mitrea, I. ... 1033
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∗ Mixer, M. ... 1390
∗ Mkrtchyan, S. ... 1459
► Mo, Y. ... 1863
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∗▸ Wanduku, D. T. 1729
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∗▸ Wang, X. 1794
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∗ Weir, R. J. 2145
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∗ Zelditch, S. 343
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∗ Zhang, H.-K. 1804
► Zhang, J. 948
∗► Zhang, J. 2099
◄ Zhang, L. 938
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∗ Zhang, P. 2132
∗► Zhang, T. 1671
► Zhang, W. 1199
► Zhang, X. 1904
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∗► Zhang, Y. 679
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► Zou, Y. 2016
► Zupan, A. M. 836
∗ Zureick-Brown, D. 2094
∗ Zureick-Brown, D. M. 1776
∗ Zwicker, W. S. 128
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∗ Zyskin, M. 2085

Program of the Sessions

Boston, Massachusetts, January 4–7, 2012

Monday, January 2

AMS Short Course on Computing with Elliptic Curves Using Sage, Part I

8:00 AM – 5:00 PM

Organizer: **William Stein**, University of Washington

8:00AM Registration, Back Bay Ballroom D, Sheraton.

9:00AM ► (1) *Introduction to Python and Sage.*
Kiran Kedlaya, University of California San Diego

10:30AM Break.

11:00AM Question and answer session: How do I do XXX in Sage?

2:00PM (2) *Computing with elliptic curves over finite fields using Sage.*
Ken Ribet, University of California, Berkeley

3:30PM Break.

4:00PM Problem session: Try to solve a problem yourself using Sage.

AMS Short Course on Random Fields and Random Geometry, Part I

8:00 AM – 5:00 PM

Organizers: **Robert Adler**, Technion - Israel Institute of Technology
Jonathan Taylor, Stanford University

8:00AM Registration, Back Bay Ballroom D, Sheraton.

9:00AM (3) *Gaussian fields and Kac-Rice formulae.*
Robert Adler, Technion

10:15AM Break.

10:45AM (4) *The Gaussian kinematic fomula.*
Jonathan Taylor, Stanford University

2:00PM (5) *Gaussian models in fMRI image analysis.*
Jonathan Taylor, Stanford University

3:15PM Break.

3:45PM Tutorial session.

MAA Short Course on Discrete and Computational Geometry, Part I

8:00 AM – 5:00 PM

Organizers: **Satyan L. Devadoss**, Williams College
Joseph O'Rourke, Smith College

8:00AM Registration, Back Bay Ballroom D, Sheraton.

9:00AM (6) *Polygons: Building blocks of discrete and computational geometry.*
Satyan Devadoss*, Williams College, and **Joseph O'Rourke***, Smith College

10:15AM Break.

10:45AM (7) *Triangulations: Flip graphs and Delaunay triangulations.*
Satyan Devadoss, Williams College

2:00PM (8) *Convex hulls: Computing in 2D and 3D.*
Joseph O'Rourke, Smith College

2:15PM Break.

3:45PM (9) *Voronoi diagrams: Geometry, duality, and hulls revisited.*
Joseph O'Rourke, Smith College

Tuesday, January 3

AMS Department Chairs Workshop

8:00 AM – 6:30 PM

Presenters: **Timothy Hodges**, University of Cincinnati
John Meakin, University of Nebraska-Lincoln
Helen Roberts, Montclair State University
Alex Smith, University of Wisconsin-Eau Claire

The time limit for each AMS contributed paper in the sessions is ten minutes. The time limit for each MAA contributed paper varies. In the Special Sessions the time limit varies from session to session and within sessions. To maintain the schedule, time limits will be strictly enforced.
For papers with more than one author, an asterisk follows the name of the author who plans to present the paper at the meeting.

Papers flagged with a solid triangle (►) have been designated by the author as being of possible interest to undergraduate students.
Abstracts of papers presented in the sessions at this meeting will be found in Volume 33, Issue 1 of *Abstracts of papers presented to the American Mathematical Society*, ordered according to the numbers in parentheses following the listings.

MAA Ancillary Workshop on Statistics: Identifying and Addressing Difficult Concepts for Students in the Introductory Statistics Course

8:30 AM – 4:30 PM

Presenter: **Marjorie Bond**, Monmouth University

MAA Ancillary Workshop on Statistics: Facilitating Student Projects in Elementary Statistics

8:30 AM – 4:30 PM

Presenters: **Brad Bailey**, North Georgia College & State University
Sherry L. Hix, North Georgia College & State University
Dianna Spence, North Georgia College & State University

AMS Short Course on Computing with Elliptic Curves Using Sage, Part II

9:00 AM – 5:00 PM

Organizer: **William Stein**, University of Washington

9:00AM (10) *Computing with elliptic curves over the rational numbers using Sage.*
Jared Weinstein, Boston University

10:30AM Break

11:00AM (11) *Computing with the Birch and Swinnerton-Dyer conjecture using Sage.*
William Stein, University of Washington

2:00PM (12) *Computing with elliptic surfaces.*
Noam Elkies, Harvard University

3:30PM Break

4:00PM Question and answer session: How do I do XXX in Sage?

AMS Short Course on Random Fields and Random Geometry, Part II

9:00 AM – 5:00 PM

Organizers: **Robert Adler**, Technion - Israel Institute of Technology
Jonathan Taylor, Stanford University

9:00AM (13) *Random fields in Physics.*
Mark Dennis, University of Bristol

10:15AM Break.

10:45AM (14) *Random matrices and Gaussian analytic functions.*
Balint Virag, University of Toronto

2:00PM (15) *Random metrics.*
Dmitry Jakobson, McGill University

3:15PM Break.

3:45PM Discussion groups.

MAA Short Course on Discrete and Computational Geometry, Part II

9:00 AM – 5:00 PM

Organizers: **Satyan L. Devadoss**, Williams College
Joseph O'Rourke, Smith College

9:00AM (16) *Polyhedra from Euler to Gauss to Cauchy, I: Rigidity.*
Satyan Devadoss, Williams College

10:15AM Break.

10:45AM (17) *Polyhedra from Euler to Gauss to Cauchy, II: Unfolding.*
Joseph O'Rourke, Smith College

2:00PM (18) *Configuration spaces: Locked polygonal chains and particle collisions.*
Satyan Devadoss, Williams College

2:15PM Break.

3:45PM (19) *Pedagogy and research.*
Satyan Devadoss*, Williams College, and **Joseph O'Rourke***, Smith College

MAA Ancillary Workshop on Statistics: Teaching Modeling-Based Calculus

9:00 AM – 4:30 PM

Presenters: **Daniel Kaplan**, Macalester College
Daniel Flath, Macalester College
Randall Pruim, Calvin College
Eric Marland, Appalachian University

WeBWork Consulting Training Session

9:00 AM – 5:00 PM

Organizer: **Michael Gage**, University of Rochester

MAA Board of Governors

9:00 AM – 5:00 PM

AMS Council

1:30 PM – 10:00 PM

Joint Meetings Registration

3:00 PM – 8:00 PM

New registrations will be accepted until 7:00 p.m. Those who registered in advance may pick up materials until 8:00 p.m.

Wednesday, January 4

Joint Meetings Registration

7:30 AM – 6:00 PM

AMS-MAA Special Session on the History of Mathematics, I

8:00 AM – 10:50 AM

Organizers: **Sloan Despeaux**, Western Carolina University
Craig Fraser, University of Toronto
Deborah Kent, Hillsdale College

8:00AM ► (20) *Mathematical Schemes in Babylonian Astral Medicine.*
John Steele, Brown University (1077-01-455)

8:30AM ► (21) *Proportion Theory in Medieval Astronomical Works.*
Henry T. Zepeda, Dept. of the History of Science, University of Oklahoma (1077-01-2662)

9:00AM ► (22) *On Finding Times of True Syzygy in the Fifteenth Century: Melchion de Friquento's Eclipse Tables of 1437.* Preliminary report.
Richard L. Kremer, Dartmouth College (1077-01-556)

9:30AM ► (23) *The Evolution of Geometry in ancient China, from the newly discovered Shu and Suan shu shu bamboo texts to the Nine Chapters.* Preliminary report. **Joseph W. Dauben**, Herbert H. Lehman College, The CIty University of New York (1077-01-501)

10:00AM ► (24) *Who reads mathematics? A case study from Mesopotamia.* **Duncan J. Melville**, St. Lawrence University (1077-01-1669)

10:30AM ► (25) *Euclid's Elements in Spanish, during the XVII century.* Preliminary report. **Alejandro R. Garciadiego**, Universidad Nacional Autonoma de Mexico (1077-01-82)

AMS-ASL Special Session on the Life and Legacy of Alan Turing, I

8:00 AM – 10:40 AM

Organizers: **Damir Dzhafarov**, University of Chicago and University of Notre Dame
Jeff Hirst, Appalachian State University
Carl Mummert, Marshall University

8:00AM (26) *Algorithmic Randomness and Pathological Computable Measures.* Preliminary report. **Christopher P Porter**, University of Notre Dame (1077-03-2392)

8:30AM (27) *Computing the strength of some combinatorial theorems.* Preliminary report. **Stephen Flood**, University of Notre Dame (1077-03-1998)

9:00AM (28) Low_n *Boolean Subalgebras.* Preliminary report. **Rebecca M. Steiner**, Graduate Center, City University of New York (1077-03-476)

9:30AM ► (29) *Vegetative Turing Pattern Formation: A Historical Perspective.* **Bonni J Kealy*** and **David J Wollkind**, Washington State University (1077-92-84)

10:00AM ► (30) *Answering Descartes: Beyond Turing.* **Stuart A Kauffman**, University of Vermont (1077-68-384)

AMS Special Session on Advances in Coding Theory, I

8:00 AM – 10:50 AM

Organizers: **Sarah Spence Adams**, Olin College of Engineering
Gretchen L. Matthews, Clemson University
Judy L. Walker, University of Nebraska-Lincoln

8:00AM (31) *Symmetric Group Testing.* **Amin Emad***, **Jun Shen** and **Olgica Milenkovic**, University of Illinois at Urbana-Champaign (1077-94-1403)

8:30AM (32) *On Sums of Locally Testable Affine Invariant Properties.* **Eli Ben-Sasson**, Technion, Haifa, Israel, **Elena Grigorescu***, Georgia Institute of Technology, **Ghid Maatouk**, EPFL, Lausanne, Switzerland, **Amir Shpilka**, Technion, Haifa, Israel, and **Madhu Sudan**, Microsoft Research New England, Cambridge, MA (1077-68-1230)

9:00AM (33) *Flexible coding schemes with applications to emerging memory technologies.* **Lara Dolecek**, EE Department, UCLA (1077-94-1779)

9:30AM (34) *High-rate Codes with Sublinear-time Decoding.* **Swastik Kopparty**, Rutgers, **Shubhangi Saraf**, Institute for Advanced Study, and **Sergey Yekhanin***, Microsoft Research (1077-68-1057)

10:00AM (35) *Codes from separable linearized polynomials and associated Riemann-Roch spaces.* **Justin D. Peachey**, Clemson University (1077-14-1896)

10:30AM (36) *Asymmetric Quantum Codes from Two-Point Divisors on Algebraic Curves.* Preliminary report. **Martianus Frederic Ezerman**, Laboratoire d'Information Quantique, Université Libre de Bruxelles, and **Radoslav M Kirov***, San Francisco, CA (1077-94-1810)

AMS Special Session on Arithmetic Geometry, I

8:00 AM – 10:50 AM

Organizers: **Bo-Hae Im**, Chung-Ang University, South Korea
Jennifer Johnson-Leung, University of Idaho
Jennifer Paulhus, Grinnell College

8:00AM (37) *Infinite rank of elliptic curves over the maximal abelian extension of Q.* **Bo-Hae Im***, Chung-Ang University, Seoul, Korea, and **Michael Larsen**, Indiana University (1077-11-1759)

8:30AM ► (38) *Arithmetic Progressions in the x-coordinates on Mordell Curves.* **Alejandra Alvarado*** and **Edray Herbert Goins**, Purdue University (1077-11-1757)

9:00AM ► (39) *Rational linear spaces on hypersurfaces over quasi-algebraically closed fields.* **Todd Cochrane**, **Craig V. Spencer**, Kansas State University, and **Hee-Sung Yang***, Dartmouth College (1077-11-376)

9:30AM (40) *Mordell-Weil groups via Artin-Schreier extensions.* **Rachel Pries***, Colorado State University, and **Douglas Ulmer**, Georgia Institute for Technology (1077-11-1829)

10:00AM (41) *A variety with many points over a finite field.* **Jared S Weinstein**, Boston University (1077-11-1854)

10:30AM (42) *De Rham cohomology of Artin-Schreier curves in characteristic two.* **Arsen Elkin***, University of Warwick, and **Rachel Pries**, Colorado State University (1077-14-435)

AMS Special Session on Classical Fourier Analysis and Partial Differential Equations, I

8:00 AM – 10:50 AM

Organizers: **William O. Bray**, University of Maine
Mark A. Pinsky, Northwestern University

8:00AM (43) *The L^p-Operator Norm of a Perturbation of the Martingale Transform.* **Nicholas Boros**, Michigan State University (1077-42-1083)

8:30AM (44) *Variation and oscillation inequalities for convolution products.* **Anna Savvopoulou***, Indiana University South Bend, and **Karin Reinhold**, University at Albany (1077-28-79)

9:00AM (45) *An L^2 metric limit theorem for Wiener measure on manifolds with non-positive sectional curvature.* **Thomas Albert Laetsch**, UC San Diego (1077-60-2511)

9:30AM (46) *Decay of spherical means of Fourier transforms and distance sets of measures.*
Bassam H. Shayya, American University of Beirut (1077-42-115)

10:00AM (47) *Funk, Cosine, and Sine Transforms on Stiefel and Grassmann Manifolds. The Fourier Transform Approach.*
Boris Rubin, Louisiana State University (1077-42-726)

10:30AM (48) *Intrinsic square function and almost-orthogonality on homogeneous spaces.*
Caroline Sweezy, New Mexico State University, and **James Michael Wilson***, University of Vermont (1077-42-399)

AMS Special Session on Difference Equations and Applications, I

8:00 AM – 10:50 AM

Organizer: **Michael Radin**, Rochester Institute of Technology

8:00AM ► (49) *Open Problems and Conjectures in Difference Equations.* Preliminary report.
Gerasimos E. Ladas, University of Rhode Island (1077-39-490)

8:30AM ► (50) *Further Consequences of the m-M Theorem.* Preliminary report.
Gabriel Lugo* and **Frank Palladino**, University of Rhode Island (1077-39-1642)

9:00AM ► (51) *General Allee effect and semistability in planar difference equations.*
Saber N Elaydi*, Trinity University, and **George Livadiotis**, Soutwest Research Institute (1077-39-1259)

9:30AM (52) *Convergence of periodically forced rank-type equations.*
Tyrus Berry* and **Tim Sauer**, George Mason University (1077-39-669)

10:00AM (53) *On Periodic Trichotomies.*
Frank J. Palladino, University of Rhode Island (1077-39-470)

10:30AM ► (54) *On Rational Difference Equations with Nonnegative Periodic Coefficients.* Preliminary report.
Yevgeniy Kostrov, Xavier University, and **Zachary Kudlak***, Mount Saint Mary College (1077-39-1260)

AMS Special Session on Dynamical Systems in Algebraic and Arithmetic Geometry, I

8:00 AM – 10:50 AM

Organizers: **Patrick Ingram**, University of Waterloo, Canada

Michelle Manes, University of Hawaii, Honolulu

Clayton Petsche, Hunter College (CUNY)

8:00AM (55) *Fixed-point-free elements of iterated monodromy groups.* Preliminary report.
Rafe Jones, College of the Holy Cross (1077-37-2716)

8:30AM (56) *On the prime divisors in zero orbits of families of commuting polynomials.* Preliminary report.
Jason Bell and **Kevin Doerksen***, Simon Fraser University (1077-11-2109)

9:00AM (57) *Periods of rational maps modulo primes.*
Benjamin Hutz*, CUNY Graduate Center, **Robert L Benedetto**, Amherst College, **Dragos Ghioca**, University of British Columbia, **Par Kurlberg**, KTH, **Thomas Scanlon**, Univer of California Berkeley, and **Thomas J Tucker**, University of Rochester (1077-11-1703)

9:30AM (58) *A dynamical system for elliptic divisibility sequences.*
Joseph H. Silverman, Brown University, and **Katherine E. Stange***, Stanford University (1077-11-1267)

10:00AM (59) *Projective varieties covered by trivial families.*
Anupam Bhatnagar, New York University (1077-14-2726)

10:30AM (60) *Algebra, Geometry, and Dynamics of Pseudo-Real Maps.* Preliminary report.
Joseph H. Silverman*, Brown University, and **Michael Zieve**, University of MIchigan (1077-37-172)

AMS Special Session on Generalized Cohomology Theories in Engineering Practice, I

8:00 AM – 10:40 AM

Organizer: **P. Robert Kotiuga**, Boston University

8:00AM ► (61) *Cohomology in electromagnetic modelling.* Preliminary report.
Pawel Dlotko*, Institute of Computer Science, Jagiellonian University in Krakow, and **Ruben Specogna**, Unit of Electrical Engineering, Department DIEGM, University of Udine (1077-55-2353)

8:30AM (62) *Cohomology Ring: Algorithmic approach.*
Tomasz Kaczynski*, Université de Sherbrooke, and **Marian Mrozek**, Jagiellonian University Krakow (1077-55-1404)

9:00AM (63) *Hodge Theory and the Netflix Problem.*
Lek-Heng Lim, University of Chicago (1077-91-2946)

10:00AM (64) *Cohomology reveals when helicity is a diffeomorphism invariant.*
Jason Cantarella, University of Georgia, and **Jason Parsley***, Wake Forest University (1077-53-2888)

AMS Special Session on Groups, Algorithms, Complexity, and Theory of Security, I

8:00 AM – 10:50 AM

Organizers: **Maggie Habeeb**, City University of New York

Delaram Kahrobaei, City University of New York

8:00AM (65) *Automorphisms and isomorphism of finite p-groups.* Preliminary report.
James B Wilson, Colorado State University (1077-20-919)

8:30AM (66) *Polynomial-time isomorphism test for groups with abelian Sylow towers.* Preliminary report.
László Babai, the University of Chicago, and **Youming Qiao***, Institute for Theoretical Computer Science, Tsinghua University (1077-68-1157)

9:00AM (67) *On restricting free factors in relatively free groups.*
Lucas Sabalka* and **Dmytro Savchuk**, Binghamton University (1077-20-1122)

9:30AM (68) *Algorithms in* GAP *for permutability and Sylow permutability in finite groups.* Preliminary report. **Adolfo Ballester-Bolinches**, Universitat de València, and **Ramon Esteban-Romero***, Universitat Politècnica de València (1077-20-1079)

10:00AM ► (69) *Statistics about curves on surfaces.* **Moira Chas***, Stony Brook University, **Steven Lalley**, University of Chicago, **Keren Li** and **Bangrui Chen**, Stony Brook University (1077-57-357)

10:30AM (70) *Infinite primitive permutation groups whose set of subdegrees has a finite upper bound.* **Simon M. Smith**, Syracuse University (1077-20-716)

AMS Special Session on Hyperbolicity in Manifolds and Groups, I

8:00 AM – 10:50 AM

Organizers: **David Futer**, Temple University
Genevieve Walsh, Tufts University

8:00AM (71) *Exponential decay in the mapping class group.* **Joseph Maher**, College of Staten Island, CUNY (1077-57-311)

8:30AM (72) *On genericity of pseudo-Anosovs in the Torelli group.* **Justin Malestein***, Temple University, and **Juan Souto**, University of British Columbia (1077-51-1212)

9:00AM (73) *Mapping class groups and covers of surfaces.* **Thomas Koberda**, Harvard University (1077-20-1323)

9:30AM (74) *Triangulations of hyperbolic 3-manifolds admitting strict angle structures.* **Craig D. Hodgson**, **J. Hyam Rubinstein** and **Henry Segerman***, University of Melbourne (1077-57-588)

10:00AM (75) *Handlebody filling and the Heegaard tree.* Preliminary report. **Jesse Johnson**, Oklahoma State University (1077-57-571)

10:30AM (76) *Rank and genus of 3-manifolds.* **Tao Li**, Boston College (1077-57-589)

AMS Special Session on Local Field Properties, Microstructure, and Multiscale Modeling of Heterogeneous Media, I

8:00 AM – 10:50 AM

Organizers: **Silvia Jiménez**, Worcester Polytechnic Institute
Bogdan Vernescu, Worcester Polytechnic Institute

8:00AM (77) *Multiscale Modeling and Simulation of Fluid Flows in Deformable Porous Media.* **Yuliya Gorb**, University of Houston (1077-35-1840)

8:30AM ► (78) *Multiscale methods for high-contrast problems using local spectral basis functions.* **Juan Galvis***, IAMCS/ISC Texas A&M University, and **Efendiev**, Texas A&M University (1077-65-2268)

9:00AM (79) *A Numerical Boundary Eigenvalue Problem For Elastic Cracks in Free and Half Space.* **Darko Volkov**, WPI (1077-45-1023)

9:30AM (80) *Stochastic homogenization for permeable membranes.* **Florian Maris**, Worcester Polytechnic Institute (1077-49-2552)

10:00AM (81) *Acoustic Propagation in a Random Saturated Medium: The Biphasic Case.* **Robert P. Gilbert***, Univ. of Delaware, **Alexander Panchenko**, Washington State University, and **Ana Vasilic**, United Arab Emirates University (1077-35-579)

10:30AM (82) *Random fluctuations of solutions to partial differential equations.* **Guillaume Bal**, Columbia University (1077-35-534)

AMS Special Session on Mathematics in Industry, I

8:00 AM – 10:50 AM

Organizers: **Kirk E. Jordan**, IBM T. J. Watson Research
Donald Schwendeman, Renssalaer Polytechnic Institute
Burt S. Tilley, Worcester Polytechnic Institute
Suzanne L. Weekes, Worcester Polytechnic Institute

8:00AM ► (83) *The Importance of the Math Formulation for Modeling and Simulation of Industrial Strength Problems on Peta and Exascale Systems.* **Kirk E Jordan**, IBM Research (1077-65-1153)

8:30AM ► (84) *Constructions and Existence Results for Complementary Code Sets.* Preliminary report. **Gregory E Coxson**, Technology Service Corporation, Washington Office (1077-94-1183)

9:00AM (85) *Designing Scalable Algorithms for Complex Networks.* **Tuhin Sahai**, United Technologies Research Center (1077-37-1005)

9:30AM (86) *Real World Tracking.* **Rebecca D. Wasyk**, Metron, Inc (1077-00-843)

10:00AM (87) *Drying of spreading droplets of colloidal suspensions.* **Kara L Maki***, Rochester Institute of Technology, and **Satish Kumar**, University of Minnesota (1077-76-546)

10:30AM ► (88) *Some Applied Math Problems of Interest at Schlumberger.* **Lalitha Venkataramanan**, Schlumberger (1077-00-524)

AMS Special Session on Mathematics in Natural Resource Modeling, I

8:00 AM – 10:50 AM

Organizer: **Catherine Roberts**, College of the Holy Cross

8:00AM (89) *Non-Spatial and Spatial Models in Bioeconomics.* **Jon M. Conrad***, Cornell University, and **Martin D. Smith**, Duke University (1077-49-319)

9:00AM ► (90) *Modeling the Economics of Water: Progress and Challenges.* **James F. Booker***, Economics Department and Environmental Studies Department, Siena College, **Richard E. Howitt**, Department of Agricultural and Resource Economics, University of California, Davis, **Ari M. Michelsen**, Department of Agricultural Economics, Texas AgriLife Research and Extension Center, and **Robert A. Young**, Department of Agricultural and Resource Economics, Colorado State University (1077-91-2238)

9:30AM ► (91) *Accounting for Habitat Damage Increases the Economic Optimality of Marine Reserves.* Preliminary report.
Holly V. Moeller*, Department of Biology, Stanford University, and **Michael G. Neubert**, Department of Biology, Woods Hole Oceanographic Institution (1077-92-2201)

10:00AM ► (92) *Features of biologically realistic fishery models frequently used in fish stock assessment.*
Terrance J. Quinn II, Juneau Center, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks (1077-92-2194)

10:30AM ► (93) *Species Diversity, Fishing Induced Change In Carrying Capacity And Sustainable Fisheries Management.*
Worku T. Bitew* and **Wisdom Akpalu**, Farmingdale State College (1077-92-1320)

AMS Special Session on Set-Valued Optimization and Variational Problems, I

8:00 AM – 10:50 AM

Organizers: **Andreas H. Hamel**, Yeshiva University
Akhtar A. Khan, Rochester Institute of Technology
Miguel Sama, E.T.S.I. Industriales

8:00AM (94) *Global Metric Regularity.*
A. L. Dontchev, *Mathematical Reviews* (1077-49-1302)

8:30AM (95) *A new derivative concept for set-valued functions.*
Andreas H. Hamel, Yeshiva University New York (1077-49-1878)

9:00AM (96) *The Smallest Intersecting Ball Problem and the Smallest Enclosing Ball Problem: Theoretical Analysis.*
Mau Nam Nguyen* and **Cristina Villalobos**, University of Texas-Pan American (1077-90-1715)

9:30AM (97) *Coderivative Analysis of Quasi-Variational Inequalities in Asplund Spaces.*
Nhi Nguyen*, Carleton University, and **Boris Mordukhovich**, Wayne State University (1077-49-2776)

10:00AM (98) *KKT conditions for a nonconvex vector optimization problem.*
Miguel Sama*, **Bienvenido Jimenez** and **Vicente Novo**, Universidad Nacional de Educación a Distancia (UNED) (1077-90-1507)

10:30AM (99) *Some remarks on stochastic variational inequalities with applications to equilibrium problems.*
Baasansuren Jadamba*, **Akhtar A. Khan**, Rochester Institute of Technology, and **Fabio Raciti**, University of Catania, Italy (1077-49-2168)

AMS Special Session on Several Complex Variables and Multivariable Operator Theory, I

8:00 AM – 10:50 AM

Organizers: **Ronald Douglas**, Texas A&M University
John McCarthy, Washington University

8:00AM ► (100) *Regularity of Weighted Bergman Projections.*
Yunus E Zeytuncu, Texas A&M University (1077-32-656)

8:30AM (101) *H^1 and dyadic H^1 in multiparameter settings.*
Sergei Treil, Brown University (1077-42-2052)

9:00AM (102) *Compactness of Hankel operators on convex domains.* Preliminary report.
Zeljko Cuckovic* and **Sonmez Sahutoglu**, University of Toledo, Ohio (1077-47-467)

9:30AM (103) *The spectrum and essential spectrum of Toeplitz operators.*
Carl Sundberg, University of Tennessee, and **Dechao Zheng***, Vanderbilt University (1077-47-642)

10:00AM (104) *Fundamental Agler Decompositions.*
Kelly Bickel, Washington University in St. Louis (1077-46-677)

10:30AM (105) *Carleson Measures for Besov-Sobolev Spaces and Non-Homogeneous Harmonic Analysis.*
Brett D. Wick, Georgia Insitute of Technology (1077-32-798)

AMS Special Session on Stochastic Analysis (in honor of Hui-Hsiung Kuo), I

8:00 AM – 10:50 AM

Organizers: **Julius Esunge**, University of Mary Washington
Aurel Stan, Ohio State University

8:00AM (106) *Yang-Mills heat equation with $H_{1/2}$ initial data in three dimensions.* Preliminary report.
Leonard Gross, Cornell University (1077-35-2216)

9:00AM ► (107) *Some aspects of modelling dependence in copula based Markov Chains.*
Martial Longla* and **Magda Peligrad**, University of Cincinnati (1077-60-443)

9:30AM (108) *New Itô formula with application to linear SDEs with anticipating initial conditions.*
Hui-Hsiung Kuo, Louisiana State University, **Anuwat Sae-Tang**, King Mongkut's University of Technology Thonburi, and **Benedykt Szozda***, Louisiana State University, Baton Rouge (1077-60-1336)

10:00AM (109) *The Gambler's Ruin Problem for a Class of Non-stationary Markov Chains.*
Mark Burgin, UCLA, **Alan Krinik*** and **David Luu**, California State Polytechnic University, Pomona (1077-60-1307)

10:30AM ► (110) *Modeling Healthcare Data Using Markov Decision Process.* Preliminary report.
Kumer Pial Das, Lamar University (1077-60-1561)

AMS Special Session on Topological Graph Theory: Structure and Symmetry, I

8:00 AM – 10:50 AM

Organizers: **Jonathan L. Gross**, Columbia University
Thomas W. Tucker, Colgate University

8:00AM ► (111) *Applications of Discrete Morse Theory to Certain Complexes of Bounded Degree Graphs.* Preliminary report.
Luke P. Diaz, New Mexico State University (1077-55-1143)

8:30AM (112) *Topological Symmetry Groups of Complete Graphs.*
Erica Flapan, Pomona College, **Blake Mellor***, Loyola Marymount University, and **Ramin Naimi**, Occidental College (1077-57-93)

9:00AM (113) *Rotation systems for 2-complexes in orientable 3-manifolds.* Preliminary report.
Thomas Tucker*, Colgate University, **Ergun Akleman**, **Jianer Chen**, Texas A&M University, and **Jonathan Gross**, Columbia University (1077-05-1062)

9:30AM (114) *Chmutov's generalized duality and the gem representation of embedded graphs.* Preliminary report.
Mark Ellingham, Vanderbilt University (1077-05-1582)

10:00AM (115) *A recent progress in map enumeration.*
Roman Nedela, Matej Bel University, Banska Bystrica, Slovak rep. (1077-05-848)

10:30AM (116) *Abelian coverings of the platonic maps.* Preliminary report.
Gareth A. Jones, University of Southampton (1077-20-685)

AMS Special Session on Trends in Representation Theory, I

8:00 AM – 10:50 AM

Organizers: **Donald King**, Northeastern University
Alfred Noel, University of Massachusetts, Boston

8:00AM (117) *Kazhdan-Lusztig polynomials for disconnected groups.* Preliminary report.
David A. Vogan, MIT (1077-22-87)

8:30AM (118) *Generalized Harish-Chandra Modules for Mixed Subgroups.*
Annegret Paul, Western Michigan University, **Siddhartha Sahi**, Rutgers University, and **Wai Ling Yee***, University of Windsor (1077-22-1916)

9:00AM (119) *Unipotent representations for Sp(p,q) and O*(n).* Preliminary report.
Dan M Barbasch*, Cornell University, and **Peter A Trapa**, University of Utah (1077-22-1044)

9:30AM (120) *Unitary Representations of Double Covers of Linear Groups.* Preliminary report.
Annegret Paul, Western Michigan University (1077-22-1572)

10:00AM (121) *On the classification of some unitary representations.*
S. A. Salamanca-riba*, New Mexico State University, **A. Pantano**, University of California, Irvine, and **A. Paul**, Western Michigan University (1077-22-2107)

10:30AM (122) *Lefschetz Functors for the Metaplectic Group.*
Benjamin Trahan, University of Utah (1077-22-1415)

AMS Special Session on the Mathematics of Decisions, Elections, and Games, I

8:00 AM – 10:50 AM

Organizers: **Karl-Dieter Crisman**, Gordon College
Michael Jones, *Mathematical Reviews*
Michael Orrison, Harvey Mudd College

8:00AM ► (123) *The Separability Problem in Referendum Elections: Some Recent Developments.*
Jonathan K. Hodge, Grand Valley State University (1077-91-651)

8:30AM ► (124) *A Failure of Representative Democracy.*
Katherine A Baldiga, Harvard University (1077-91-75)

9:00AM (125) *Variable-population voting rules.*
Marcus J. Pivato, Trent University (1077-91-133)

9:30AM ► (126) *Coalitions and Cliques in the School Choice Problem.*
Sinan Aksoy, University of Chicago, **Adam Azzam**, University of Nebraska Lincoln, **Chaya Coppersmith**, Bryn Mawr College, **Julie Glass**, California State University East Bay, **Gizem Karaali***, Pomona College, **Xueying Zhao** and **Xinjing Zhu**, Mount Holyoke College (1077-91-126)

10:00AM (127) *Symmetry in Voting Theory: The Borda-Kemeny Spectrum and Beyond.* Preliminary report.
Karl-Dieter Crisman, Gordon College (1077-91-1410)

10:30AM (128) *The geometry of influence: weighted voting and hyper-ellipsoids.*
Nicolas Houy, Ecole Polytechnique, France, and **William S. Zwicker***, Union College (1077-91-580)

MAA Invited Paper Session on Algebraic Statistics

8:00 AM – 10:50 AM

Organizer: **Seth Sullivant**, North Carolina State University

8:00AM ► (129) *What is an algebraic statistical model?*
Luis David Garcia-Puente, Sam Houston State University (1077-AA-1821)

8:30AM (130) *Hypothesis testing on tensors.* Preliminary report.
Dustin Cartwright, Yale University (1077-AA-2393)

9:00AM (131) *Graphical models and monoidal categories.* Preliminary report.
Jason Morton, Penn State (1077-AA-2366)

9:30AM ► (132) *Binary Cumulant Varieties.*
Bernd Sturmfels*, UC Berkeley, and **Poitr Zwiernik**, IPAM UCLA (1077-AA-34)

10:00AM (133) *Betti numbers of ideals from graphs.*
Alexander Engström, Aalto University (1077-AA-2461)

10:30AM ► (134) *Species trees from gene trees.*
Elizabeth S. Allman*, University of Alaska Fairbanks, **James H. Degnan**, University of Canterbury, New Zealand, and **John A. Rhodes**, University of Alaska Fairbanks (1077-AA-291)

AMS Session on Combinatorics and Graph Theory, I

8:00 AM – 10:10 AM

8:00AM ► (135) *On Steinhaus Set of Four Points in $\mathbb{R}^2$.* Preliminary report.
Mingzhi Xuan, University of North Texas (1077-05-790)

8:15AM ► (136) *An alternate proof that any graph that is mn-colorable is decomposable into two graphs that are m-colorable and n-colorable, respectively.* Preliminary report.
Liam Rafferty, University of Montana (1077-05-2903)

8:30AM (137) *Jack Symmetric Functions and the Non-Orientability of Rooted Maps.*
Michael Andrew La Croix, Boston, MA (1077-05-2890)

8:45AM ► (138) *New Cameron-Liebler line classes relating to point sets of type (m, n) in odd order affine planes.* Preliminary report.
Morgan J Rodgers, University of Colorado Denver (1077-05-2862)

9:00AM (139) *Using Ehrhart theory for solving combinatorial problems.* Preliminary report.
Felix Breuer, San Francisco State University (1077-05-2874)

9:15AM (140) *A new clustering algorithm.*
Yezhou Wu* and **Cun-Qun Zhang**, West Virginia University (1077-05-2784)

9:30AM (141) *Quasi-residual and quasi-derived Hadamard designs.* Preliminary report.
Tariq A Alraqad*, Northern State University, and **Mohan Shrikhande**, Central Michigan University (1077-05-1235)

9:45AM (142) *Packing trees into complete bipartite graphs.* **Susan L Hollingsworth**, Edgewood College (1077-05-2842)

10:00AM ► (143) *An additive version of Ramsey's theorem.* **Andy Parrish**, University of California, San Diego (1077-05-2802)

AMS Session on Functional Analysis and Operator Theory, I

8:00 AM – 9:55 AM

8:00AM (144) *Picard group of dual operator algebras.* Preliminary report. **Upasana Kashyap**, The Citadel (1077-46-1917)

8:15AM (145) *Shrinking and Boundedly complete frames for Banach spaces.* **Kevin Beanland**, Virginia Commonwealth University, **Daniel Freeman***, University of Texas, Austin, and **Rui Liu**, Nankai University (1077-46-2645)

8:30AM (146) *Boundaries for operator systems.* **Craig Kleski**, University of Virginia (1077-46-2539)

8:45AM (147) *On locally JB*-algebras.* **Alexander A. Katz**, St. John's University, NY, USA (1077-46-2212)

9:00AM ► (148) *Research Experiences in Quantum Information Systems.* Preliminary report. **Manmohan Kaur**, Benedictine University (1077-97-2251)

9:15AM (149) *Prime E_0-semigroups.* **Christopher Jankowski***, University of Pennsylvania, **Daniel Markiewicz**, Ben-Gurion University of the Negev, and **Robert Powers**, University of Pennsylvania (1077-46-2193)

9:30AM (150) *A Browder topological degree theory for multi-valued pseudomonotone perturbation of maximal monotone operators.* Preliminary report. **Teffera M. Asfaw*** and **Athanassios G. Kartsatos**, University of South Florida (1077-46-494)

9:45AM (151) *On a version of dual space characterization of real Locally C*-algebras.* **Alexander A. Katz**, St. John's University, NY, and **Oleg Friedman***, Touro College/Lander College for Men, NY & UNISA, Pretoria, RSA (1077-46-1717)

AMS Session on History and Philosophy of Mathematics

8:00 AM – 9:25 AM

8:00AM (152) *Translating the Elements into Sanskrit: Jagannātha's Rekhaganita.* **Clemency Montelle**, University of Canterbury (1077-01-2865)

8:15AM ► (153) *Cryptanalysis vs Calvary.* Preliminary report. **Maryam Vulis**, Norwalk Community College, Fordham University (1077-01-2474)

8:30AM ► (154) *Khodjandi: A Tenth-Century Persian Mathematician.* **Mohammad Moazzam**, Salisbury University (1077-01-1938)

8:45AM ► (155) *Contributions of Rudjer Boscovich to civil engineering and architecture.* Preliminary report. **Radoslav Dimitric**, CUNY (1077-01-90)

9:00AM ► (156) *To Be Woman or Not To Be: The Struggles of Women Mathematicians and How They Have Impacted Mathematics.* Preliminary report. **Rebecca Miller**, University of Central Oklahoma (1077-01-1390)

9:15AM ► (157) *Mathematics at the Science Museum, London, England.* Preliminary report. **Agnes M. Kalemaris**, Farmingdale State College (1077-01-2253)

AMS Session on Mathematical Biology and Related Fields, I

8:00 AM – 10:10 AM

8:00AM (158) *On non-exponential models of prebiological evolution.* **Georgiy P Karev**, National Center for Biotechnological Information, NIH (1077-92-2494)

8:15AM (159) *A Data-Driven Approach to Modeling the Effect of Disease on the Immune System.* Preliminary report. **Anne Elizabeth Yust***, Birmingham-Southern College, and **Shlomo Ta'asan**, Carnegie Mellon University (1077-92-268)

8:30AM ► (160) *Health safety nets can break cycles of poverty and disease: a stochastic ecological model.* **Calistus Ngeh Ngonghala**, National Institute for Mathematical and Biological Synthesis (NIMBioS) (1077-92-2714)

8:45AM (161) *Measuring Information Storage and Transfer in Swarms.* **X Rosalind Wang**, CSIRO Information and Communications Technology Centre, **Jennifer M Miller***, University of Delaware, **Joseph T Lizier**, Max Planck Institute for Mathematics in the Sciences, **Mikhail Prokopenko**, CSIRO Information and Communications Technology Centre, and **Louis F Rossi**, University of Delaware (1077-92-2588)

9:00AM (162) *Discrete and Continuous Approaches to Modeling of Cell Movement in the Presence of a Foreign Stimulus.* **Alicia Prieto-Langarica***, **Hristo Kojouharov** and **Benito Chen-Charpentier**, University of Texas at Arlington (1077-92-2522)

9:15AM (163) *A numerical approximation and parameter estimation for modeling bee pollination: an application of the Shigesada-Kawasaki-Teramoto model.* Preliminary report. **Kamuela E Yong***, The University of Iowa, **Yi Li**, Wright State University, and **Stephen D Hendrix**, The University of Iowa (1077-92-2521)

9:30AM ► (164) *Invariant Based Quartet Puzzling for Phylogentic Reconstruciton.* Preliminary report. **Joseph Rusinko**, Winthrop University (1077-92-1009)

9:45AM ► (165) *A continuum model for the simultaneous growth and deformation of biofilms.* **Jared A. Hicks*** and **David L. Chopp**, Northwestern University (1077-92-2794)

10:00AM ► (166) *MicroRNA Target Modeling via Clustering of mRNA Microarray Data.* Preliminary report. **Frederick A Adkins**, Indiana University of Pennsylvania (1077-92-2778)

AMS Session on Mechanics and Mathematical Physics, I

8:00 AM – 10:10 AM

8:00AM ► (167) *Continuum equations from a model of step-flow.* **Nicholas O. Kirby**, University of Kentucky (1077-74-2807)

8:15AM (168) *The effect of a surface tension on the stress field near a curvilinear crack.* **Anna Zemlyanova**, Texas A&M University (1077-74-516)

8:30AM (169) *Exact Results for Effective Tensors of Fiber-Reinforced Elastic Composites.*
Meredith Hegg, Temple University (1077-74-250)

8:45AM (170) *Identifying jet noise source based on high-fidelity numerical simulations of round and chevron jet flows.*
Hyunsun Lee*, **Ali Uzun** and **M. Yousuff Hussaini**, Florida State University (1077-76-2481)

9:00AM (171) *Characteristics of Non-symmetric Edge Flames in Narrow Channels.*
Joanna A Bieri, University of Redlands (1077-76-2164)

9:15AM ► (172) *Hydrodynamic effects of spines: A different spin.*
Hoa V Nguyen, Center for Computational Science, Tulane University (1077-76-1470)

9:30AM (173) *Singularities in the complex plane for deep water waves.*
Gregory R Baker*, The Ohio State University, and **Chao Xie**, Austin, Texas (1077-76-1898)

9:45AM (174) *Analytic solution of the effect of slip condition on magnetohydrodynamic Stokes flow due to an oscillating wall.*
Sherif M Azeez, **Dawn A Lott*** and **Pablo Suarez**, Delaware State University (1077-76-1370)

10:00AM ► (175) *Mixed convection in viscoelastic flow due to a stretching sheet.* Preliminary report.
Antonio Mastroberardino, Penn State Erie, The Behrend College (1077-76-2077)

AMS Session on Ordinary Differential Equations and Special Functions

8:00 AM – 10:10 AM

8:00AM (176) *Bifurcation of Solutions to a Second Order Nonlinear Singular Differential Equation from Boundary Layer Theory.*
Chunqing Lu, Southern Illinois University Edwardsville (1077-34-783)

8:15AM ► (177) *Competition between two phytoplankton species under predation and allelopathic effects.*
Jean-Jacques Kengwoung-Keumo, New Mexico State University, Las Cruces (1077-34-2754)

8:30AM (178) *On the Solvability of Nonlinear Sturm-Liouville Problems.*
Zachary J. Abernathy*, Winthrop University, and **Jesus Rodriguez**, North Carolina State University (1077-34-1940)

8:45AM ► (179) *Existence of Positive Solutions of a Second Order Right Focal Boundary Value Problem.*
Douglas R. Anderson, Concordia College, **Richard I. Avery**, Dakota State University, **Johnny Henderson** and **Xueyan Liu***, Baylor University (1077-34-1857)

9:00AM (180) *Stability of solutions for fractional differential equations.*
Namjip Koo* and **Sung Kyu Choi**, Chungnam National University, Daejeon, South Korea (1077-34-1794)

9:15AM (181) *Role of $CD4^+$ T-cell proliferation in HIV infection under antiretroviral therapy.* Preliminary report.
Hongying Shu* and **Lin Wang**, University of New Brunswick (1077-34-1278)

9:30AM (182) *Topological Aspects of Stability of Trajectories.* Preliminary report.
Zhivko S. Athanassov, Bulgarian Academy of Sciences (1077-34-160)

9:45AM (183) *On the Approximation of the Lower Generalized Incomplete Gamma Function,Arising in Heat Conduction Problems.*
Mohamed T Boudjelkha, Rensselaer Polytechnic Institute (1077-33-81)

10:00AM (184) *On the asymptotic behavior of the solutions to the replicator equation.*
Faina Berezovskaya, Howard University (1077-34-2231)

AMS Session on Probability Theory, Stochastic Processes, and Statistics, I

8:00 AM – 10:25 AM

8:00AM (185) *Probability measures on the space of persistence diagrams.*
Yuriy Mileyko*, **Sayan Mukherjee** and **John Harer**, Duke University (1077-60-2532)

8:15AM (186) *Numerical methods for stochastic differential equations.*
Robert D Wooster, West Point (1077-60-2480)

8:30AM ► (187) *On the Volatility of Binomial Option Pricing Model.* Preliminary report.
Constantine Georgakis, DePaul University (1077-60-2327)

8:45AM (188) *How fed policy makes financial markets chaotic or not.*
James M. Haley, Point Park University (1077-60-2953)

9:00AM (189) *The rate of decay of the Wiener sausage in a local Dirichlet space.* Preliminary report.
Lee R Gibson, Indiana University - Southeast, and **Melanie A Pivarski***, Roosevelt University (1077-60-2751)

9:15AM ► (190) *Encoding and Counting Strings.*
Jennifer D Herdan* and **Melinda Lanius**, East Tennessee State University (1077-60-2749)

9:30AM (191) *Bistable systems with Stochastic Noise: Virtues and Limits of effective Langevin equations for the Thermohaline Circulation strength.*
Valerio Lucarini, Klimcampus, University of Hamburg (1077-60-2523)

9:45AM (192) *Numerical solutions of quantile hedging for guaranteed minimum death benefits under a regime-switching jump-diffusion formulation.*
Yumin Wang*, University of Misouri, St Louis, **Zuo Jin** and **George Yin**, Wayne State University (1077-60-2533)

10:00AM (193) *On the directions for which directional critical exponents are equal in inhomogeneous percolation models.* Preliminary report.
Matthew R. A. Sedlock* and **John C Wierman**, Johns Hopkins University (1077-60-2613)

10:15AM (194) *Random Additive Bases and Mixed Sidon Sets.*
Vince Lyzinski*, Johns Hopkins University, **Anant Godbole**, East Tennessee State University, **Chang Mou Lim**, University of Chicago, and **Nicholas George Triantafillou**, University of Michigan-Ann Arbor (1077-60-2208)

AMS Session on Undergraduate Research, I

8:00 AM – 10:10 AM

8:00AM ► (195) *Algebraic Tchoukaillon Representations.* Preliminary report.
Fanya Wyrick-Flax*, Bard College, and **Benjamin Warren**, Ramapo College of New Jersey (1077-00-1424)

8:15AM *Adinkra Phase Graphs.*
► (196) **Jasper O Weinrich-Burd**, Bard College (1077-00-2221)

8:30AM *Mathematics of Sowing Games.* Preliminary report.
► (197) **Spencer O Sims***, Oakwood University, **Amanda Fernandez**, **Qian Zhang**, **Tyesha Hall** and **Mikias Kidane**, James Madison University (1077-00-2282)

8:45AM *Periodicity and asymptotics of Tchoukaillon sequences.*
► (198) **David Creech***, Central Michigan University, and **Jeff Anway**, Longwood University (1077-00-2894)

9:00AM *The Magic Behind Franklin Magic Circles.*
► (199) **Maxsimino Aviles Montes***, **Katie Watkins** and **Tatiana Kovyrshina**, Sam Houston State University (1077-01-2224)

9:15AM *AN EPQ Model for Deterioration Items and Exponential Demand Rate Taking into Account the Time Value of Money.* Preliminary report.
► (200) **Vikram Jeet Singh**, Dehradun (1077-03-2928)

9:30AM *Families of Half-Transitive Graphs.*
► (201) **Nate R Harman**, University of Massachusetts Amherst (1077-05-1966)

9:45AM *Lower bounds on cliques of* $(2, m)$*-agreeable graphs.* Preliminary report.
► (202) **Benjamin J. Maguire*** and **Thierry Zell**, Lenoir-Rhyne University (1077-05-855)

10:00AM *A Turán-type Problem for Circular Arc Graphs.*
► (203) **Rosalie J. Carlson***, Harvey Mudd College, **Stephen Flood**, University of Notre Dame, **Kevin W. O'Neill** and **Francis Edward Su**, Harvey Mudd College (1077-05-136)

MAA Session on Arts and Mathematics, Together Again, I

8:00 AM – 10:55 AM

Organizer: **Douglas E. Norton**, Villanova University

8:00AM *Limits of Picture Sequences.*
► (204) **Craig M. Johnson**, Marywood University (1077-B1-1047)

8:20AM *Using Escher's Work to Demonstrate Symmetries of the Plane.*
► (205) **Jeffrey W Clark**, Elon University (1077-B1-92)

8:40AM *A family of butterfly patterns.* Preliminary report.
► (206) **Douglas Dunham**, University of Minnesota Duluth (1077-B1-2738)

9:00AM *Art First: How Artists Discovered the Projective Plane Before Mathematicians Knew It Was There.* Preliminary report.
► (207) **Meg Dillon**, Southern Polytechnic State University (1077-B1-1238)

9:20AM *Polyhedral Modularity in a Special Class of Decagram Based Interlocking Star Polygons.* Preliminary report.
► (208) **Reza Sarhangi**, Towson University, Maryland (1077-B1-451)

9:40AM *Recreating a 14th Century 14-Pointed Star Polygon Design Found on the Mimbar of the Mausoleum of Barquq in Egypt.*
► (209) **B Lynn Bodner**, Monmouth University (1077-B1-430)

10:00AM *Stigmmetry Prints.* Preliminary report.
► (210) **Gary R Greenfield**, University of Richmond (1077-B1-868)

10:20AM *Between pattern and chance.*
(211) **Andrzej K Brodzik**, The MITRE Corporation (1077-B1-290)

10:40AM *Variation of Parameters.* Preliminary report.
► (212) **Anne M. Burns**, Long Island University, C.W. Post Campus (1077-B1-355)

MAA Session on Effective Use of Dynamic Mathematical Software in the Classroom, I

8:00 AM – 10:55 AM

Organizers: **M. E. Waggoner**, Simpson College
Therese Shelton, Southwestern University

8:00AM *Exploring regressions through Geometer's Sketchpad and Microsoft Excel.* Preliminary report.
► (213) **Brandon Milonovich**, Syracuse University (1077-D5-1201)

8:20AM *Using Geometer's Sketch Pad to examine whether the SSA condition in Euclidean geometry is always ambiguous.*
► (214) **Jennifer Bergner**, Salisbury University (1077-D5-1700)

8:40AM *From Dilation to Similarity - an Exploration Using Geometer's Sketchpad.*
► (215) **Margaret L. Morrow**, SUNY Plattsburgh (1077-D5-2828)

9:00AM *Epsilons and Deltas with GeoGebra.*
► (216) **Jason McCullough**, University of California, Riverside (1077-D5-1499)

9:20AM *The Euler Line in GeoGebra.*
► (217) **Philip P. Mummert**, Taylor University (1077-D5-1769)

9:40AM *An iPad-based activity for learning to sketch the graph of the derivative of a given graph.*
(218) **Hillary Einziger**, Pennsyvania State University (1077-D5-700)

10:00AM *Rolling Wheels: Explore Curve Sketching via GeoGebra and Mathematica.*
► (219) **David A. Brown**, Ithaca College (1077-D5-468)

10:20AM *Motions and Rates: Using GeoGebra to Analyze Video Recordings.*
► (220) **Tibor Marcinek**, Central Michigan University (1077-D5-2854)

10:40AM *WeBWorK labs? A case study in differential equations.* Preliminary report.
► (221) **Dan Gries**, Hopkins School, **Barbara Margolius** and **Felipe Martins***, Cleveland State University (1077-D5-2542)

MAA Session on Mathematics and Sports, I

8:00 AM – 10:55 AM

Organizer: **R. Drew Pasteur**, College of Wooster

8:00AM *Streaking: Finding the probability for various batting streaks.*
► (222) **Stanley Rothman**, Quinnipiac University Hamden Connecticut (1077-G1-60)

8:20AM *What is the True Probability of Getting a Hit?*
► (223) **Jeffrey W. Heath*** and **Ian M. Powell**, Centre College (1077-G1-1114)

8:40AM *The Baseball Simulator: Accurately Simulating Major League Baseball Games with a Minimum Number of Statistics.* Preliminary report.
► (224) **Robert Franzosa**, University of Maine (1077-G1-618)

9:00AM *Individual player productivity in baseball and basketball can be measured in a Mathematically coherent fashion using play-by-play data.* Preliminary report.
► (225) **Charles T Zahn**, San Diego, California (1077-G1-1197)

9:20AM ► (226) *Beyond Regression: Using Learning Machines to Predict NBA Performance.*
Andrew Larsen* and **Kali Wickens**, Westminster College, Salt Lake City, UT (1077-G1-1417)

9:40AM ► (227) *Pursuing an optimal statistically-based model for NFL prediction.*
Andrew D. Blaikie*, **Gabriel J. Abud**, College of Wooster, **John A. David**, Virginia Military Institute, and **R. Drew Pasteur**, College of Wooster (1077-G1-1467)

10:00AM ► (228) *Boxing in Basketball: A Round-By-Round Analysis of the College Game.*
Paul P. Britton* and **Carl R. Yerger**, Davidson College (1077-G1-738)

10:20AM (229) *Seed Distributions for the NCAA Mens Basketball Tournament: Why it May Not Matter Who Plays Whom.*
Sheldon H. Jacobson*, University of Illinois at Urbana-Champaign, **Alexander G. Nikolaev**, University of Buffalo, **Douglas M. King**, University of Illinois at Urbana-Champaign, and **Adrian J. Lee**, CITERI (1077-G1-607)

10:40AM ► (230) *Using sports to inspire and teach math to the non-major.*
Chris M. Jones, Saint Mary's College of California (1077-G1-1194)

MAA Session on the Capstone Course: Innovations and Implementations, I

8:00 AM – 10:55 AM

Organizers: **Kathryn Weld**, Manhattan College
Agnes Rash, St. Joseph's College

8:00AM ► (231) *Capstone Course: Why it didn't work for us.*
Sandra Fillebrown, Saint Joseph's University (1077-C1-437)

8:20AM ► (232) *Problem Seminar: A Capstone Course.* Preliminary report.
Kathryn Weld, Manhattan College (1077-C1-1764)

8:40AM ► (233) *The Right Model Makes All The Difference!* Preliminary report.
Rachel Esselstein, California State University, Monterey Bay (1077-C1-668)

9:00AM ► (234) *A Course in Experimental Mathematics.*
Marc Chamberland, Grinnell College (1077-C1-2531)

9:20AM ► (235) *Assessing Mathematics and Mathematics-Secondary Education Majors through a Senior Seminar Capstone Experience.* Preliminary report.
Marcella Louise Wallowicz CSFN, Holy Family University (1077-C1-1383)

9:40AM ► (236) *Our capstone course - principles and tasks.* Preliminary report.
Greisy Winicki Landman, Cal Poly Pomona (1077-C1-213)

10:00AM (237) *A Capstone Course for Secondary Education Students.*
Rosemary C Farley, Manhattan College (1077-C1-1673)

10:20AM ► (238) *Showcasing students' mathematical understanding through portfolios: A capstone course for mathematics majors on a secondary teaching track.*
Pete Johnson* and **Hari P. Koirala**, Eastern Connecticut State University (1077-C1-181)

10:40AM ► (239) *Using Error-Eliciting Problems via a Classroom Voting System in a Capstone Course to Foster Conceptual Understanding and Mathematical Habits of Mind.*
Kien H Lim, University of Texas at El Paso (1077-C1-27)

MAA Session on the Scholarship of Teaching and Learning in Collegiate Mathematics, I

8:00 AM – 10:55 AM

Organizers: **Jacqueline Dewar**, Loyola Marymount University
Thomas Banchoff, Brown University
Pam Crawford, Jacksonville University
Edwin Herman, University of Wisconsin-Stevens Point
Nathan Wodarz, University of Wisconsin-Stevens Point

8:00AM ► (240) *From Fred Flintstone to Ferraris, Driving Mathematical Content through Questioning.*
Debbie Gochenaur, Shippensburg University (1077-N1-2866)

8:20AM (241) *They Can Do It: Applications of a Hybrid Classroom Model in a Traditional Classroom.*
Lee Evans*, **Heather Jackson**, **Christopher Weld** and **Gerald Kobylski**, United States Military Academy (USMA) (1077-N1-2490)

8:40AM ► (242) *Smartpen Technology as an Instructional Medium.* Preliminary report.
Jennifer A Czocher* and **Jenna Tague**, The Ohio State University (1077-N1-1899)

9:00AM (243) *Using and Analyzing Student Confidence in Classroom Voting.* Preliminary report.
Ann C. Stewart, Hood College (1077-N1-2058)

9:20AM ► (244) *Helping Algebra Students Succeed at Word Problems.* Preliminary report.
Ibrahim A. Saleh* and **Andrew G. Bennett**, Kansas State University (1077-N1-2040)

9:40AM ► (245) *Outside of Class Learning: Perspectives on Mathematics Tutoring Programs at a Community College.* Preliminary report.
C. Adam Feldhaus* and **David L. Reedy**, Columbus State Community College (1077-N1-1364)

10:00AM ► (246) *Role of Prerequisite Knowledge in Student Learning in Lower Level Mathematics Courses.*
Anne Albert, The University of Findlay (1077-N1-2660)

10:20AM ► (247) *Assessing and Improving Quantitative Reasoning Skills with CLA Performance Tasks.* Preliminary report.
Gerald W. Kruse* and **David Drews**, Juniata College (1077-N1-1020)

10:40AM ► (248) *Using Data to Develop an Adaptive Syllabus for PreCalculus Course at the College of Staten Island, City University of New York.*
Jane P Coffee*, College of Staten Island, City University of New York, and **Jesenko Vukadinovic**, College of Staten Island (1077-N1-612)

MAA General Contributed Paper Session: Interdisciplinary Topics in Mathematics

8:00 AM – 10:40 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:00AM (249) *On the intersection spectrum conjecture.* **C. A. Marx**, University of California, Irvine (UCI) (1077-VH-1396)

8:15AM ► (250) *A Study of Hudson Food Web and its Competition Graph.* Preliminary report. **Urmi Ghosh-Dastidar***, NYCCT, CUNY, **Margaret Cozzens**, DIMACS, Rutgers University, **Steven Lora** and **Alma Cabral-Reynoso**, NYCCT, CUNY (1077-VH-2851)

8:30AM (251) *Asymptotically normal distribution of some tree families relevant for phylogenetics.* **Eva Czabarka**, University of South Carolina, Columbia, **Peter Erdos**, Alfred Renyi Institute of Mathematics, Hungary, **Virginia Johnson***, University of South Carolina, Columbia, **Anne Kupczok**, Center for Integrative Bioinformatics, Vienna, and **Laszlo Szekely**, University of South Carolina, Columbia (1077-VH-1962)

8:45AM ► (252) *The mechanisms behind the evolution of cooperation.* **Candace Ohm**, Florida State University (1077-VH-1711)

9:00AM ► (253) *Mathematics in Computed Tomography.* Preliminary report. **Mohamed Allali**, Chapman University (1077-VH-2024)

9:15AM (254) *Model for self-polarization and motility of keratocyte fragments.* **Falko Ziebert**, Physikaisches Institut, **Sumanth Swaminathan***, Northwestern University, and **Igor Aronson**, Argonne National Laboratory (1077-VH-2882)

9:30AM ► (255) *Computing Stable Models of Logic Programs Using Metropolis Type Algorithms.* **Jeffrey Remmel** and **Alex Brik***, UC San Diego (1077-VH-1789)

9:45AM ► (256) *A course on pre-Hispanic Latin American mathematical ideas.* Preliminary report. **Colleen Duffy**, University of Wisconsin - Eau Claire (1077-VH-657)

10:00AM ► (257) *A course in spherical geometry and its applications for math majors.* Preliminary report. **Marshall A Whittlesey**, California State University San Marcos (1077-VH-1708)

10:15AM (258) *Creating an Institutional Interdisciplinary Culture with Mathematicians at the Lead.* **Gerald Kobylski*** and **Hilary DeRemigio Fletcher**, United States Military Academy (1077-VH-2319)

10:30AM ► (259) *Boston University Students' Interdisciplinary Activities.* **Emma Previato**, Boston University (1077-VH-2415)

SIAM Minisymposium on Probabilistic Combinatorics

8:00 AM – 10:55 AM

Organizers: **Jacob Fox**, Massachusetts Institute of Technology
Po-Shen Loh, Carnegie Mellon University

8:00AM ► (260) *From random graphs to graph limits and graphlets.* Preliminary report. **Fan Chung**, University of California, San Diego (1077-05-2756)

8:30AM (261) *A natural barrier for random greedy hypergraph matching.* **Patrick Bennett** and **Tom Bohman***, Carnegie Mellon University (1077-05-2399)

9:00AM ► (262) *Approximaing Minimum Linear Ordering Problems.* Preliminary report. **Prasad Tetali**, Georgia Institute of Technology (1077-68-2203)

9:30AM (263) *Chromatic number, clique subdivisions, and the conjectures of Hajós and Erdős-Fajtlowicz.* **Jacob Fox**, Massachusetts Institute of Technology (1077-05-2881)

10:00AM ► (264) *Bisections of graphs.* **Choongbum Lee**, UCLA, **Po-Shen Loh***, Carnegie Mellon University, and **Benjamin Sudakov**, UCLA (1077-05-2334)

10:30AM (265) *Analysis of a simple 2-matching algorithm on a random graph.* Preliminary report. **Alan Frieze**, Carnegie Mellon University (1077-05-1318)

Employment Center

8:00 AM – 6:00 PM

MAA General Contributed Paper Session: Mathematics and Technology, I

8:15 AM – 10:55 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:15AM ► (266) *An assessment of the use of an Interactive Electronic Text on student engagement and learning in Pre-Calculus and Calculus at Medgar Evers College, CUNY.* Preliminary report. **Terrence R Blackman**, Medgar Evers College, CUNY (1077-VI-2779)

8:30AM (267) *An Innovative Approach to Derivative Instruction Using Technology to Explore Local Straightness.* **Jason Samuels**, City University of New York-BMCC (1077-VI-2406)

8:45AM ► (268) *Using Dynamic Sketches to Help Calculus Students Develop and Integrate Coherent Mental Models of the Formal Definition of the Limit of a Sequence.* **Beth Cory*** and **Ken W. Smith**, Sam Houston State University (1077-VI-2847)

9:00AM ► (269) *Clickers in the Calculus II Classroom.* Preliminary report. **Ellen M Ziliak**, Benedictine University (1077-VI-199)

9:15AM ► (270) *Building Intuition and Computational Skills with Maplets for Calculus.* **Philip B. Yasskin***, Texas A&M University, and **Douglas B. Meade**, University of South Carolina (1077-VI-1127)

9:30AM (271) *Calculus Video Clips.* **Shay Fuchs**, University of Toronto Mississauga (1077-VI-1337)

9:45AM ► (272) *Motion Sensor Activities for Middle School Algebra.* **Kimberly Arp*** and **Ellen Panofsky**, Cabrini College (1077-VI-2932)

10:00AM ► (273) *Making proofs click: Classroom response systems in transition-to-proof courses.* **Robert Talbert**, Grand Valley State University (1077-VI-2059)

10:15AM ► (274) *Exploratory Activities for College Geometry.* Preliminary report. **Barbara E. Reynolds**, Cardinal Stritch University, and **William E. Fenton***, Bellarmine University (1077-VI-1043)

10:30AM ► (275) *Exploring Graph Theory Utilizing The OEIS, Wolfram Alpha, and Mathworld.* Preliminary report.
Jay Lawrence Schiffman, Rowan University (1077-VI-43)

10:45AM ► (276) *Using Octave (a freeware version of Matlab) to generate close calls for Fermat's last theorem.* Preliminary report.
Arthur J. Rosenthal, Salem State University (1077-VI-2817)

MAA General Contributed Paper Session: Research in Geometry and Linear Algebra

8:15 AM – 10:55 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:15AM (277) *New Results in Calibrated Geometry.*
Yongsheng Zhang, Stony Brook Univ. (1077-VJ-2632)

8:30AM ► (278) *Geometry of cubics.* Preliminary report.
Sam Northshield, SUNY-Plattsburgh (1077-VJ-2717)

8:45AM (279) *Minimum-size convex decompositions in d dimensions.*
Carlos M. Nicolas, UNC-Greensboro (1077-VJ-1737)

9:00AM ► (280) *A Characterization of Homeomorphisms on Cantor Sets by Orbit Structures.*
Casey L Sherman, Baylor University (1077-VJ-2191)

9:15AM (281) *The Log-Convex Density Conjecture and vertical surface area in warped products.*
Sean P Howe, Leiden University (1077-VJ-992)

9:30AM Break.

9:45AM (282) *Unitary Similarity To a Complex Symmetric Matrix And Its Extension to Orthogonal Symmetric Lie Algebra.*
Brice Merlin Nguelifack*, **Huhua Liu** and **Tin-Yau Tam**, Auburn University (1077-VJ-739)

10:00AM ► (283) *Moment Formulas for Ensembles of Classical Compact Groups.*
Steven J. Miller*, Williams College, and **Geoffrey S Iyer**, University of Michigan (1077-VJ-1903)

10:15AM ► (284) *Distribution of Eigenvalues of Weighted, Structured Matrix Ensembles.*
Karen Shen*, Stanford University, **Olivia Beckwith**, Harvey Mudd College, and **Steven J Miller**, Williams College (1077-VJ-601)

10:30AM (285) *A functional equation for a prehomogeneous vector space and unitary representations of $GL(2n, R)$.*
Juhyung Lee, Oklahoma State University (1077-VJ-2856)

10:45AM (286) *An inverse approach to the Littlewood-Richardson Rule for the K-theoretic coproducts.*
Huilan Li* and **Jennifer Morse**, Drexel University (1077-VJ-1961)

MAA Session on Touch It, Feel It, Learn It: Tactile learning Activities in the Undergraduate Mathematics Classroom, I

8:20 AM – 10:15 AM

Organizers: **Jessica Mikhaylov**, U.S. Military Academy
Julie Barnes, Western Carolina University

8:20AM ► (287) *Partition Numbers and Fractals: Insights Using Bulgarian Solitaire.*
Richard D Summers, Reinhardt University (1077-O1-565)

8:40AM ► (288) *A Photographic Assignment for Abstract Algebra.*
Gregory S. Warrington, University of Vermont (1077-O1-1543)

9:00AM (289) *The Parity Theorem Shuffle.*
Michael D Smith, Lycoming College (1077-O1-366)

9:20AM ► (290) *Active Learning in Discrete Mathematics.*
Ann N Trenk, Wellesley College (1077-O1-1479)

9:40AM ► (291) *Loaded Dreidels.* Preliminary report.
Allan Struthers, Michigan Technological University (1077-O1-1518)

10:00AM ► (292) *Rolling the Dice in Statistics.*
Heidi N Hulsizer, Hampden-Sydney College (1077-O1-1702)

AMS Special Session on Stability Analysis for Infinite Dimensional Hamiltonian Systems, I

8:30 AM – 10:20 AM

Organizers: **Wilhelm Schlag**, University of Chicago
Gene Wayne, Boston University

8:30AM (293) *Estimates and wellposedness for magnetic Schrödinger equations and related systems.* Preliminary report.
Magdalena Czubak, Binghamton University (SUNY) (1077-35-2478)

9:00AM ► (294) *On Schrödinger maps from T^1 to S^2.*
R. L. Jerrard*, University of Toronto, and **D. Smets**, Université Pierre et Marie Curie (1077-35-2332)

9:30AM (295) *Asymptotic stability of solitary waves in a water wave model with indefinite variational structure.* Preliminary report.
Robert L. Pego*, Carnegie Mellon University, **Tetsu Mizumachi**, Kyushu University, and **José Raúl Quintero**, Universidad del Valle (1077-35-1991)

10:00AM (296) *Birkhoff normal forms and scattering for the NLS on R^d.* Preliminary report.
Walter Craig, McMaster University (1077-35-1223)

MAA General Contributed Paper Session: Teaching Introductory Mathematics

8:30 AM – 10:55 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:30AM ► (297) *Money, That's What I Want!* Preliminary report.
Peter T. Olszewski, Penn State Erie, The Behrend College (1077-VB-1381)

8:45AM ► (298) *Pass with CARE (Clicking Algebra-Related Education).* Preliminary report.
Jerry J. Chen* and **Myung-Chul Kim**, Suffolk County Community College (1077-VB-1495)

9:00AM (299) *Teaching using the iPad and Air Sketch.*
Jason A Price, Nichols College (1077-VB-976)

9:15AM (300) *Minimum Academic Preparation and Performance in First Year Mathematics Courses.* Preliminary report.
Carrie Muir, University of Colorado, Boulder (1077-VB-1681)

9:30AM ► (301) *The origin of error: A study of the reasons behind common mistakes in introductory Mathematics.* Preliminary report.
Stefanos Orfanos, KFUPM (1077-VB-1541)

9:45AM (302) *Why Should Any Students Take Developmental Math?*
Sheldon P Gordon, Farmingdale State College (1077-VB-1910)

10:00AM (303) *Improving Student Success in Developmental Algebra and Its Impact on Subsequent Mathematics Courses.*
William O Bond* and **John C Mayer**, University of Alabama at Birmingham (1077-VB-2025)

10:15AM (304) *Refocusing Intermediate Algebra.*
Don Small, U.S. Military Academy (1077-VB-1391)

10:30AM (305) *Daily Quizzing as a Means of Motivating Review and Preview.*
Joshua Ducey, James Madison University (1077-VB-2876)

10:45AM (306) *Growing a Learning Center: From a small, underfunded closet to a popular learning space.*
Jim Sobota*, **Karoline Auby** and **Maighread McHugh**, University of Wisconsin - La Crosse (1077-VB-2048)

MAA Minicourse #6: Part A

9:00 AM – 11:00 AM

Getting students involved in undergraduate research.
Presenters: **Aparna Higgins**, University of Dayton
Joseph A. Gallian, University of Minnesota-Duluth

MAA Minicourse #8: Part A

9:00 AM – 11:00 AM

Preparing to serve as an outside consultant in the mathematical sciences.
Presenters: **Kyle Riley**, South Dakota School of Mines and Technology
Nancy Baxter Hastings, Dickinson College

MAA Minicourse #14: Part A

9:00 AM – 11:00 AM

Teaching introductory statistics.
Presenters: **Michael Posner**, Villanova University
Carolyn Cuff, Westminster College

MAA Panel Discussion

9:00 AM – 10:20 AM

National Science Foundation programs supporting learning and teaching in the mathematical sciences.
Organizers: **Richard Alo**, National Science Foundation
Ron Buckmire, National Science Foundation
Dean Evasius, National Science Foundation
Lee Zia, National Science Foundation

MAA Panel Discussion

9:00 AM – 10:20 AM

Quantitative support center: Common themes.
Organizer: **Michael E. Schuckers**, St. Lawrence University
Panelists: **Grace Coulombe**, Bates College
Cat McCune, Smith College
Tom Roby, University of Connecticut
Michael E. Schuckers

MAA/NCTM Mutual Concerns Committee Panel Discussion

9:00 AM – 10:20 AM

Why is transition from high school to college important? Issues and next steps.
Organizer: **Gail Burrill**, Michigan State University
Panelists: **Arthur Benjamin**, Harvey Mudd College
David Bressoud, Macalester College
William McCallum, University of Arizona
Daniel Teague, North Carolina School for Science and Mathematics
Paul Zorn, St. Olaf College
Gail Burrill

Student Hospitality/Information Center

9:00 AM – 5:00 PM

MAA Department Liaisons Meeting

9:30 AM – 11:00 AM

AMS Invited Address

10:05 AM – 10:55 AM

(307) *The polynomial method in combinatorial geometry.*
Larry Guth, University of Toronto (1077-05-8)

AMS-MAA Invited Address

11:10 AM – NOON

(308) *A stratification of the space of all k-planes in $\mathbb{C}^n$.*
Allen Knutson, Cornell University (1077-14-28)

Exhibits and Book Sales

12:15 PM – 5:30 PM

AMS Colloquium Lectures: Lecture I

1:00 PM – 1:50 PM

(309) *Langlands program, trace formulas, and their geometrization, I.*
Edward Frenkel, University of California Berkeley (1077-14-10)

MAA Invited Address

2:15 PM – 3:05 PM

(310) *Mathematics to DIE for: The battle between counting and matching.*
Jennifer Quinn, University of Washington, Tacoma (1077-A0-4)

AMS-MAA Special Session on the History of Mathematics, II

2:15 PM – 6:05 PM

Organizers: **Sloan Despeaux**, Western Carolina University

Craig Fraser, University of Toronto

Deborah Kent, Hillsdale College

2:15PM ► (311) *Toward Algebra as a General Problem-Solving Technique: Rafael Bombelli to Francois Viète.* **Karen V. H. Parshall**, University of Virginia (1077-01-1593)

2:45PM (312) *Newton and the Neo-Pythagorean Tradition.* **Niccolo' Guicciardini**, University of Bergamo, Italy (1077-01-422)

3:15PM ► (313) *Evolutes in the works of Huygens and Johann(I) Bernoulli.* **Robert E Bradley**, Adelphi University (1077-01-1416)

3:45PM ► (314) *We The Jury: The Mathematics of Group Decisions From Condorcet to Cournot.* **Jeff A Suzuki**, Brooklyn College (1077-01-73)

4:15PM ► (315) *Boscovich and the Line of Best Fit.* Preliminary report. **Lawrence A. D'Antonio**, Ramapo College of New Jersey (1077-01-743)

4:45PM ► (316) *C.H. Kummell and the Method of Least Squares.* **J. J. Tattersall*** and **Asta Shomberg**, Providence College (1077-01-425)

5:15PM ► (317) *Toward a history of the square-peg problem.* Preliminary report. **John McCleary**, Vassar College (1077-51-2102)

5:45PM (318) *Human collectives in mathematical practices: the example of the writing of a theorem, the kernel theorem of Laurent Schwartz (1915-2002).* **Anne-Sandrine Paumier**, Institut de Mathématiques de Jussieu, Paris (1077-01-1510)

AMS-SIAM Special Session on the Mathematics of Computation: Differential Equations, Linear Algebra, and Applications, I

2:15 PM – 6:05 PM

Organizers: **Susanne C. Brenner**, Louisiana State University

Chi-Wang Shu, Brown University

2:15PM (319) *Anderson Acceleration for Fixed-Point Iterations.* **Homer F. Walker**, Worcester Polytechnic Institute (1077-65-1285)

2:45PM (320) *A simple WENO limiter for Runge-Kutta Discontinuous Galerkin method.* **Xinghui Zhong*** and **Chi-Wang Shu**, Brown University (1077-65-460)

3:15PM (321) *WENO Scheme with Subcell Resolution for Computing Nonconservative Euler Equations.* **Tao Xiong***, University of Science and Technology of China, **Chi-Wang Shu**, Brown University, and **Mengping Zhang**, University of Science and Technology of China (1077-65-1218)

3:45PM (322) *Block Krylov Subspace Recycling: Theory and Application in a Newton Iteration.* **Michael Parks**, Sandia National Laboratories, and **Kirk M. Soodhalter***, Temple University (1077-65-1358)

4:15PM (323) *Local convergence analysis of several inexact Newton-type algorithms for general nonlinear eigenvalue problems.* Preliminary report. **Daniel B. Szyld** and **Fei Xue***, Temple University (1077-65-1347)

4:45PM (324) *The Reliability of Error Estimates for Multivariate Numerical Integration.* **Fred J. Hickernell**, Illinois Institute of Technology (1077-65-21)

5:15PM (325) *Inverse Lax-Wendroff procedure for numerical boundary conditions of hyperbolic equations.* **Sirui Tan*** and **Chi-Wang Shu**, Brown University (1077-65-1344)

5:45PM (326) *Approximation of Stochastic Partial Differential Equations by a Kernel-based Collocation Method.* **Qi Ye***, **Gregory Fasshauer** and **Igor Cialenco**, Illinois Institute of Technology (1077-35-327)

AMS-ASL Special Session on the Life and Legacy of Alan Turing, II

2:15 PM – 5:55 PM

Organizers: **Damir Dzhafarov**, University of Chicago and University of Notre Dame

Jeff Hirst, Appalachian State University

Carl Mummert, Marshall University

2:15PM ► (327) *A Survey of Alan Turing's Contributions to Logic, to the Invention of General Purpose Computers, and to Theoretical Computer Science.* **Martin D. Davis**, NYU/Courant and UC Berkeley (1077-01-389)

3:15PM ► (328) *Alan Turing: The creative power of mathematics.* Preliminary report. **Andrew P Hodges**, University of Oxford, UK (1077-01-423)

4:15PM ► (329) *The influence of Alan Turing.* **Marvin Minsky**, MIT (1077-01-2934)

5:15PM ► (330) *Alan Turing's Philosophy of Mind.* Preliminary report. **James H. Moor**, Dartmouth College (1077-01-1987)

AMS-AAAS Special Session on Science for Policy and Policy for Science: Career Opportunities at the Intersection of Science and Policy

2:15 PM – 4:35 PM

Organizers: **Cynthia Robinson**, AAAS Science & Technology Fellowships

Shar Steed, AAAS Science & Technology Fellowships

2:15PM ► (331) *Opportunities at the intersection of science and policy.* **Cynthia Robinson**, American Association for the Advancement of Science (1077-00-1074)

2:45PM ► (332) *Applying mathematical tools in public policy.* **Sonja Sandberg**, Framingham State University (1077-00-1614)

3:15PM ► (333) *Is there mathematical work to be done on Capitol Hill?* **Daniel H Ullman**, George Washington University (1077-00-1844)

3:45PM ► (334) *Careers in Math Policy.* **Katherine Socha**, Math for America (1077-00-1617)

4:15PM ► (335) *Radical Mathematicians: A (mostly) non-partisan call to arms.* **David Weinreich**, Washington, DC (1077-00-1883)

AMS Special Session on Advances in Coding Theory, II

2:15 PM – 6:05 PM

Organizers: **Gretchen L. Matthews**, Clemson University

Sarah Spence Adams, Olin College of Engineering

Judy L. Walker, University of Nebraska-Lincoln

2:15PM (336) *A Family of Codes with Two Homogeneous Weights.* **Eimear Byrne**, University College Dublin, **Michael Kiermaier**, University of Bayreuth, and **Alison Sneyd***, University College Dublin (1077-05-2412)

2:45PM (337) *Optimum Distance Profiles and Optimal Subcodes of Binary Self-Dual Type II Codes.* **Finley Freibert*** and **Jon-Lark Kim**, University of Louisville (1077-94-1621)

3:15PM (338) *A coding theory perspective on combinatorial neural codes.* **Carina Curto**, **Vladimir Itskov**, **Katherine Morrison***, **Zach Roth** and **Judy Walker**, University of Nebraska (1077-94-1546)

3:45PM (339) *Pseudocodewords and pseudoweights.* **Nigel Boston**, University of Wisconsin - Madison (1077-94-1270)

4:45PM (340) *Using Pseudocodewords to Convey Information.* Preliminary report. **Nathan Axvig**, Virginia Military Institute (1077-94-1763)

5:15PM (341) *Trellis Behavior Under Dualization.* Preliminary report. **Elizabeth Weaver*** and **Heide Gluesing-Luerssen**, University of Kentucky (1077-93-1129)

5:45PM (342) *Hybrid Noncoherent Network Coding.* **Vitaly Skachek***, **Olgica Milenkovic** and **Angelia Nedic**, University of Illinois at Urbana-Champaign (1077-94-1628)

AMS Special Session on Classical Fourier Analysis and Partial Differential Equations, II

2:15 PM – 5:35 PM

Organizers: **William O. Bray**, University of Maine
Mark A. Pinsky, Northwestern University

2:15PM (343) *Global harmonic analysis of eigenfunctions in the real and complex domain.* Preliminary report. **Steve Zelditch**, Northwestern University (1077-35-710)

3:15PM (344) *Gibbs phenomena and Pinsky phenomena for solutions to nonlinear Schrodinger equations.* **Michael E. Taylor**, University of North Carolina (1077-35-489)

4:15PM ► (345) *On the Pinsky phenomenon and the Kahane theorem for nonspherical partial Fourier integrals.* **Ravshan R Ashurov*** and **Almaz A Butaev**, University Putra Malaysia (1077-42-333)

4:45PM (346) *A relation between multiple Fourier series and lattice point problems.* **Shigehiko Kuratsubo**, Mathematical Society of Japan, Hirosaki University (1077-42-477)

5:15PM (347) *Estimates of Fourier Transforms.* Preliminary report. **William O. Bray**, University of Maine (1077-42-1239)

AMS Special Session on Difference Equations and Applications, II

2:15 PM – 6:05 PM

Organizer: **Michael Radin**, Rochester Institute of Technology

2:15PM (348) *On the Nature of Solutions of the Difference Equation* $x_{n+1} = x_n x_{n-3} - 1$. **Candace M. Kent***, Virginia Commonwealth University, and **Witold Kosmala**, Appalachian State University (1077-39-1500)

2:45PM (349) *Periodicity In General Delay Nonlinear Difference Equations Using Fixed Point Theory.* **Youssef N. Raffoul**, University of Dayton (1077-39-1340)

3:15PM (350) *Global Asymptotic Behavior of Some Periodically Forced Discrete Nonlinear Population Models.* Preliminary report. **Vlajko L Kocic**, Xavier University of Louisiana (1077-39-475)

3:45PM (351) *Global Dynamics of Certain Competitive System in the Plane.* **Mustafa R. S. Kulenovic***, **Orlando Merino**, The University of Rhode Island, and **Mehmed Nurkanovic**, University of Tuzla (1077-39-301)

4:15PM ► (352) *Patterns of Boundedness of Rational Systems in the Plane.* Preliminary report. **Emmanouil Drymonis**, University of Rhode Island (1077-39-1041)

4:45PM ► (353) *The Global Character of Solutions of Rational Systems in the Plane.* **Chris D Lynd**, The University of Rhode Island (1077-39-750)

5:15PM ► (354) *The Global Characteristics of a Family of Systems of Piecewise Linear Difference Equations.* **E Grove**, **G Ladas**, University of Rhode Island, **E Lapierre***, Johnson & Wales University, and **W Tikjha**, Mahidol University (1077-39-794)

5:45PM (355) *Positive solutions for a system of second order multipoint discrete boundary value problems.* **Johnny Henderson***, Baylor University, and **Rodica Luca**, Gh. Asachi Technical University (1077-39-30)

AMS Special Session on Dynamical Systems in Algebraic and Arithmetic Geometry, II

2:15 PM – 6:05 PM

Organizers: **Patrick Ingram**, University of Waterloo, Canada
Michelle Manes, University of Hawaii, Honolulu
Clayton Petsche, Hunter College (CUNY)

2:15PM ► (356) *Where geodesics go to die.* **James M Henle***, Smith College, and **Frederick V Henle**, athenahealth, Inc. (1077-53-61)

2:45PM (357) *Towards a Dynamical Analogue of Szpiro's Conjecture.* **Phillip O Williams**, The Kings College (1077-37-1474)

3:15PM (358) *Ritt's Theorem and refinements.* **Alice Medvedev*** and **Thomas W Scanlon**, UCBerkeley (1077-12-2891)

3:45PM (359) *Multiplier Spectra and the Moduli Space of Degree 3 Morphisms on* $\mathbb{P}^1$. **Benjamin Hutz**, Graduate Center of CUNY, and **Michael Tepper***, Division of Science and Engineering, Penn State Abington (1077-11-1228)

4:15PM (360) *Twisted matings of polynomials.* Preliminary report. **Xavier Buff**, Université Paul Sabatier, **Adam Epstein**, University of Warwick, and **Sarah Koch***, Harvard University (1077-37-1199)

4:45PM (361) *Extending the Polya-Carlson Theorem: When Uniform Limits of Rational Functions are Rational.* **Nathan L Walters**, University of Georgia (1077-11-2165)

5:15PM (362) *Towards a dynamical relative Manin-Mumford conjecture.*
Dragos Ghioca, University of British Columbia, **Liang-Chung Hsia**, National Taiwan Normal University, and **Thomas J Tucker***, University of Rochester (1077-11-1289)

5:45PM (363) *On a uniform bound for the number of exceptional linear subvarieties in the dynamical Mordell–Lang conjecture.*
Joseph H Silverman and **Bianca Viray***, Brown University (1077-37-717)

AMS Special Session on Fractal Geometry in Pure and Applied Mathematics (in memory of Benoit Mandelbrot), I

2:15 PM – 5:05 PM

Organizers: **Michael L. Lapidus**, University of California, Riverside
Erin Pearse, University of Oklahoma
Machiel van Frankenhuijsen, Utah Valley University

2:15PM ► (364) *Fractal structures in functions related to number theory.*
Jeffrey C . Lagarias, University of Michigan (1077-11-1469)

2:45PM (365) *Complex Dimensions of Cantor Strings and the Riemann Zeros.*
Machiel van Frankenhuijsen, Utah Valley University (1077-11-2341)

3:15PM (366) *Explicit tube formulas for p-adic fractal strings.*
Hung Lu*, Hawaii Pacific University, **Michel L. Lapidus**, University of California, Riverside, and **Machiel van Frankenhuijsen**, Utah Valley University (1077-51-1503)

3:45PM (367) *Multifractal spectra of certain self-similar measures as abscissa of convergence functions.*
Kate E. Ellis, California State University, Stanislaus, **Michel L. Lapidus**, University of California, Riverside, **Michael C. Mackenzie**, University of Connecticut, and **John A. Rock***, California State Polytechnic University, Pomona (1077-28-1181)

4:15PM (368) *Fractal Strings and the Invertibility of the Spectral Operator.*
Hafedh Herichi* and **Michel. L. Lapidus**, University of California, Riverside (1077-46-1805)

4:45PM (369) *Fractal Strings, the Riemann Hypothesis, Universality and Phase Transitions.*
Hafedh Herichi and **Michel L. Lapidus***, University of California, Riverside (1077-11-1609)

AMS Special Session on Generalized Cohomology Theories in Engineering Practice, II

2:15 PM – 5:55 PM

Organizer: **P. Robert Kotiuga**, Boston University

2:15PM ► (370) *Computing integrals using equivariant cohomology.*
Loring W. Tu, Tufts University (1077-55-2256)

3:15PM (371) *Expanders and K-Theory for Discrete Groups.*
Paul Frank Baum, Penn State University (1077-19-400)

4:15PM (372) *Fractional topological states in electronic flattened bands with non-zero Chern number.*
Claudio Chamon, Boston University (1077-82-2306)

5:15PM (373) *Generalized Cohomology Theories in Engineering Practice.* Preliminary report.
P. Robert Kotiuga, Boston University (1077-18-2400)

AMS Special Session on Groups, Algorithms, Complexity, and Theory of Security, II

2:15 PM – 6:05 PM

Organizers: **Maggie Habeeb**, City University of New York
Delaram Kahrobaei, City University of New York

2:15PM (374) *Polynomial-time Theory of Matrix Groups.*
László Babai*, University of Chicago, **Robert Beals**, Renaissance Technologies, and **Ákos Seress**, Ohio State University (1077-20-1481)

2:45PM (375) *Stackable groups.* Preliminary report.
Mark Brittenham and **Susan Hermiller***, University of Nebraska (1077-20-834)

3:15PM ► (376) *Security assumptions in non-commutative cryptography.* Preliminary report.
Vladimir Shpilrain, The City College of New York (1077-94-1322)

3:45PM (377) *Subgroups of semigroups freely generated by idempotent matrices.* Preliminary report.
John C. Meakin, University of Nebraska-Lincoln (1077-20-856)

4:15PM (378) *The submonoid membership problem for groups.*
Markus Lohrey, Institut für Informatik, Universität Leipzig, and **Benjamin Steinberg***, City College of New York (1077-20-1462)

4:45PM (379) *Generic properties of finitely presented groups.* Preliminary report.
Robert H Gilman, Stevens Institute of Technology, Hoboken, NJ (1077-20-1395)

5:15PM (380) *Extreme compression and efficient computation, with application to the word problem.* Preliminary report.
Will Dison, Bank of England, and **Tim Riley***, Cornell (1077-20-1682)

5:45PM (381) *On the Dimension of Matrix Representations of Nilpotent Groups.*
Maggie Habeeb* and **Delaram Kahrobaei**, CUNY Graduate Center (1077-68-1207)

AMS Special Session on Hyperbolicity in Manifolds and Groups, II

2:15 PM – 6:05 PM

Organizers: **David Futer**, Temple University
Genevieve Walsh, Tufts University

2:15PM (382) *Short geodesics in moduli space.*
Christopher J. Leininger*, University of Illinois at Urbana–Champaign, and **Dan Margalit**, Georgia Tech (1077-57-1798)

2:45PM (383) *Recurrence and unique ergodicity for Weil-Petersson geodesics and their ending laminations.*
Jeffrey F. Brock, Brown University (1077-37-2833)

3:15PM (384) *Recognizing 3-manifold groups.*
Daniel Groves, University of Illinois at Chicago, **Jason Fox Manning***, University at Buffalo, and **Henry Wilton**, University College London (1077-20-934)

3:45PM (385) *L-spaces vs. left-orderability.*
Liam Watson, UCLA (1077-57-591)

4:15PM (386) *Small knot complements, cyclic commensurability and hidden symmetries.*
Neil R Hoffman, Boston College (1077-57-1555)

4:45PM (387) *Divergence, thick groups, and morse geodesics.*
Jason Behrstock*, CUNY Lehman, and **Cornelia Drutu**, Exeter College, Oxford (1077-20-1272)

5:15PM (388) *Essential tori and Dehn twists in Outer space.* Preliminary report.
Kasra Rafi*, University of Oklahoma, and **Matt Clay**, Allegheny College (1077-51-1346)

5:45PM (389) *Groups acting on CAT(0) spaces and their Boundaries.* Preliminary report.
Kim Ruane, Tufts Univeristy (1077-20-2320)

AMS Special Session on Local Field Properties, Microstructure, and Multiscale Modeling of Heterogeneous Media, II

2:15 PM – 6:05 PM

Organizers: **Silvia Jiménez**, Worcester Polytechnic Institute

Bogdan Vernescu, Worcester Polytechnic Institute

2:15PM (390) *G-convergence approach to homogenization of nonlinear difference operators.*
Alexander Pankov, Morgan State University (1077-35-1203)

2:45PM (391) *Homogenization in periodically perforated domains.*
Rachad Zaki, Khalifa University of Science, Technology and Research, Abu Dhabi, UAE (1077-35-1498)

3:15PM ► (392) *On a novel idea for the local characterization for solutions of multiscale elliptic problems.*
Daniel T. Onofrei*, **Giles Auchmuty** and **Yuliya Gorb**, University of Houston (1077-35-1990)

3:45PM ► (393) *Bounds and optimal structures of three-material composites: Beyond the translation bound.* Preliminary report.
Andrej Cherkaev, University of Utah (1077-35-2135)

4:15PM (394) *Flux norm approach to finite-dimensional homogenization approximation with non-separated scales and high contrast.*
Leonid Berlyand*, Penn State University, and **Houman Owhadi**, Caltech (1077-35-1547)

4:45PM (395) *Mesoscopic continuum mechanics of particle systems.* Preliminary report.
Alexander Panchenko*, Washington State University, and **Lyudmyla Barannyk**, University of Idaho (1077-70-2090)

5:15PM (396) *On the Characterization of the Effective Yield Set in Polycrystal Plasticity.*
Marian Bocea, Loyola University Chicago (1077-49-1868)

5:45PM (397) *Multiscale analysis of the peridynamic equation of motion.*
Bacim Alali, University of Utah, **Robert Lipton**, Louisiana State University, and **Tadele Mengesha***, Penn State University (1077-46-2071)

AMS Special Session on Mathematics in Natural Resource Modeling, II

2:15 PM – 6:05 PM

Organizer: **Catherine Roberts**, College of the Holy Cross

2:15PM (398) *A Biomass Flow Approach to Population Models and Food Webs.*
Wayne M. Getz, Berkeley, California (1077-92-2945)

3:15PM (399) *Mathematical Modeling of Viral Zoonoses in Wildlife.*
L. J. S. Allen*, Texas Tech University, **V. L. Brown**, University of Michigan, **C. B. Jonsson**, University of Louisville, **S. L. Klein**, John Hopkins Bloomberg School of Public Health, **S. M. Laverty**, University of Utah, **K. Magwedere**, Directorate of Veterinary Services, **J. C. Owen**, Michigan State University, and **P. van den Driessche**, University of Victoria (1077-92-402)

3:45PM (400) *Models for the Spatial Management of Transboundary and Straddling Stocks and their Bioeconomic Implications for Marine Protected Areas.* Preliminary report.
Michael G. Neubert*, Woods Hole Oceanographic Institution, **Holly V. Moeller**, Stanford University, and **Guillermo E. Herrera**, Bowdoin College (1077-91-459)

4:15PM (401) *The influence of high trophic-level predators, data scarcity, parameter confounding, and model mis-specification on a multispecies age-structured assessment model for the Gulf of Alaska.*
Kray Van Kirk*, **Terrance J. Quinn II**, Juneau Center, School of Fisheries and Ocean Sciences, University of Alaska Fairbanks, and **Jeremy S. Collie**, Graduate School of Oceanography, University of Rhode Island (1077-92-1699)

4:45PM ► (402) *A Discrete-Time Age-Structured Model Of Exploited Fishery Systems.*
Nianpeng Li and **Abdul-Aziz Yakubu***, Howard University (1077-92-1451)

5:15PM (403) *Selecting Sites for a Fully Connected Reserve Network.*
Nahid Jafari* and **John Hearne**, RMIT University, Melbourne, Victoria, Australia. (1077-90-735)

5:45PM ► (404) *Dysfunction by Design: Consequences of Limitations on Transferability of Catch Shares in the Alaska Pollock Fishery.*
Keith R Criddle* and **James Strong**, University of Alaska Fairbanks (1077-91-326)

AMS Special Session on Optimal Control in Applied Mathematical Modeling, I

2:15 PM – 6:05 PM

Organizers: **Natali Hritonenko**, Prairie View A&M University

Yuri Yatsenko, Houston Baptist University

2:15PM (405) *Optimal control of HIV treatment.*
Ellina Grigorieva*, Texas Woman's University, **Evgenii Khailov**, Lomonosov Moscow State University, and **Andrei Korobeinikov**, Limerick University, Ireland (1077-49-1354)

2:45PM (406) *Similarity solutions for some model equations appearing in the gas dynamics.*
Anahit Galstyan, University of Texas-Pan American (1077-35-1983)

3:15PM (407) *Stationary distributions of semistochastic processes with disturbances at random times and with random severity.*
Maria C.A. Leite*, University of Toledo, **Nikola P. Petrov**, University of Oklahoma, and **Ensheng Weng Weng**, Department of Botany and Microbiology, University of Oklahoma (1077-60-606)

3:45PM ► (408) *Parameter Optimization of Glassy-winged Sharpshooter Population Model.* Preliminary report. **Jeong-Mi Yoon***, **Volodymyr Hrynkiv**, **Lisa Morano**, **Sara Wilder**, **Anh Tuan Nguyen**, University of Houston-Downtown, and **Forrest Michell**, Department of Entomology, Texas A&M University (1077-92-948)

4:15PM (409) *Large Deviations for Two-Time-Scale Systems Driven by Nonhomogeneous Markov Chains and Associated Optimal Control Problems.* **Qi He***, **George Yin**, Wayne State University, and **Qing Zhang**, University of Georgia (1077-60-272)

4:45PM ► (410) *Mathematical Modeling and Analysis of Atmospheric Vortices.* **Lynn R. Greenleaf**, University of Oklahoma, Norman, OK (1077-49-2047)

5:15PM (411) *Near Optimal Selling Rule for a Mean-Reverting Asset.* **Eunju Sohn*** and **Qing Zhang**, University of Georgia (1077-49-1345)

5:45PM ► (412) *Optimal control in age-dependent models in epidemiology and demography.* **Amie Rollie***, **Ryan Baxter** and **Natali Hritonenko**, Prairie View A&M University (1077-92-1993)

AMS Special Session on Set-Valued Optimization and Variational Problems, II

2:15 PM – 6:05 PM

Organizers: **Andreas H. Hamel**, Yeshiva University
Akhtar A. Khan, Rochester Institute of Technology
Miguel Sama, E.T.S.I. Industriales

2:15PM (413) *An Epigraph-Based Approach to Second-Order Sensitivity Analysis in Set-Valued Optimization.* Preliminary report. **Douglas E Ward**, Miami University (1077-49-485)

2:45PM (414) *Applications of Banach Space Geometry for Optimization Problems and Variational Inequalities.* **Yakov Alber**, Boston, MA (1077-49-2466)

3:15PM (415) *First and Second Order Tangent Cones and Their Applications in Set Constrained Optimization.* **Elena Constantin**, University of Pittsburgh-Johnstown (1077-90-179)

3:45PM (416) *Conical Regularization for Abstract Constrained Optimization Problems in Hilbert Spaces.* **Akhtar A. Khan***, Rochester Institute of Technology, and **Miguel Sama**, Universidad Nacional de Educacion a Distancia, Madrid Spain (1077-49-2196)

4:15PM (417) *Selection of an optimal source to make the optical tomography problem less ill-posed.* **Bonnie C. Jacob**, National Technical Institute for the Deaf at Rochester Institute of Technology (1077-46-2104)

4:45PM (418) *A set-valued approach to superhedging in markets with transaction costs.* **Birgit Rudloff***, Princeton University, and **Andreas Loehne**, Martin-Luther-University Halle-Wittenberg (1077-90-2070)

5:15PM (419) *On the characterization of solution sets of smooth and nonsmooth stochastic Nash games.* **Uma V Ravat*** and **Uday V Shanbhag**, University of Illinois at Urbana-Champaign (1077-91-1338)

5:45PM (420) *On the subdifferential regularity of functions of roots of polynomials.* **Julia Eaton***, University of Washington Tacoma, and **James V Burke**, University of Washington (1077-49-1976)

AMS Special Session on Several Complex Variables and Multivariable Operator Theory, II

2:15 PM – 6:05 PM

Organizers: **Ronald Douglas**, Texas A&M University
John McCarthy, Washington University

2:15PM (421) *Stable symmetric polynomials, the Grace-Walsh-Szego theorem, and the Schur-Agler class.* **Greg Knese**, University of Alabama (1077-47-548)

2:45PM (422) *To get (or not to get) uniform approximation by interpolating Blaschke products.* **Pamela B. Gorkin**, Bucknell University (1077-47-972)

3:15PM (423) *Realization and interpolation theory for the Herglotz-Agler class over the poly-right-halfplane.* Preliminary report. **Joseph A. Ball**, Virginia Tech (1077-47-198)

3:45PM (424) *Schatten norms of operator derivatives.* **Anna Skripka**, University of Central Florida (1077-47-679)

4:15PM (425) *Gaps for proper holomorphic maps between balls.* **Xiaojun Huang***, Rutgers University at New Brunswick, **Shanyu Ji**, University of Houston, and **Wanke Yin**, Wuhan University (1077-32-1113)

4:45PM (426) *"Noncommutative" Aleksandrov-Clark measures and function theory in the unit ball.* Preliminary report. **Michael T Jury**, University of Florida (1077-47-558)

5:15PM (427) *The truncated matrix valued multivariable K-moment problem.* **David P Kimsey**, Weizmann Institute, and **Hugo J Woerdeman***, Drexel University (1077-47-758)

5:45PM (428) *A non-semialgebraic interpolation body.* Preliminary report. **Brian J. Cole**, Brown University (1077-30-1066)

AMS Special Session on Stability Analysis for Infinite Dimensional Hamiltonian Systems, II

2:15 PM – 5:35 PM

Organizers: **Wilhelm Schlag**, University of Chicago
Gene Wayne, Boston University

2:15PM (429) *Radiative decay of bubble oscillations in a compressible fluid.* **Michael I. Weinstein**, Columbia University (1077-76-2796)

2:45PM (430) *Constructive methods for the global analysis of solutions of differential equations.* **Ovidiu Costin***, **Rodica D Costin**, The Ohio State University, **Min Huang** and **Wilhelm Schlag**, The University of Chicago (1077-34-2322)

3:15PM (431) *Solitons on manifolds.* **Jeremy L Marzuola**, University of North Carolina, Chapel Hill (1077-35-337)

3:45PM (432) *Global existence for water wave equations.* **Pierre M Germain**, Courant Institute, New York University (1077-35-506)

4:15PM (433) *Unstable manifolds and L^2 nonlinear instability of Euler equations.* **Zhiwu Lin** and **Chongchun Zeng***, Georgia Institute of Technology (1077-35-941)

4:45PM ► (434) *Enstrophy growth in the viscous Burgers equation.* **Dmitry Pelinovsky**, McMaster University (1077-35-279)

5:15PM (435) *Water waves over a rough bottom in the shallow water regime.*
Catherine Sulem, University of Toronto (1077-35-990)

AMS Special Session on Stochastic Analysis (in honor of Hui-Hsiung Kuo), II

2:15 PM – 6:05 PM

Organizers: **Julius Esunge**, University of Mary Washington
Aurel Stan, Ohio State University

2:15PM (436) *Renormalization, Lie algebras and infinite divisibility.* Preliminary report.
Luigi Accardi, Centro V. Volterra, UniversitÃ di Roma Torvergata (1077-00-2304)

3:15PM (437) *MRM triples associated with Brenke type generating functions.* Preliminary report.
Nobuhiro Asai, Aichi University of Education (1077-33-714)

3:45PM (438) *Recovering a Function from the Gauss Radon Transform in White Noise Analysis.*
Jeremy J Becnel, Stephen F. Austin State University (1077-46-1090)

4:15PM (439) *Smooth Measures and Stochastic Analysis in Abstract Wiener Space.*
Fariborz Asadian, Fort Valley State University (1077-60-695)

4:45PM (440) *The Clark Formula of Generalized Lévy Functionals.* Preliminary report.
Yuh-Jia Lee, National University of Kaphsiung (1077-60-808)

5:15PM (441) *Unitarizing measure for the representation of a Lie group.*
Habib Ouerdiane, University of Tunis El Manar, Tunisia (1077-60-2407)

5:45PM (442) *Free noise stochastics and geometry.*
Ambar Niel Sengupta, Louisiana State University (1077-60-1332)

AMS Special Session on Topological Graph Theory: Structure and Symmetry, II

2:15 PM – 5:05 PM

Organizers: **Jonathan L. Gross**, Columbia University
Thomas W. Tucker, Colgate University

2:15PM (443) *Orthogonal Heffter systems, current graphs, and bi-embedding graphs on surfaces.* Preliminary report.
Dan Archdeacon, The University of Vermont (1077-05-1827)

2:45PM (444) *Locally maximal embeddings of graph.*
Martin Skoviera*, Comenius University, Bratislava, Slovakia, and **Michal Kotrbcik**, Comenius University, Bratislava (1077-05-2335)

3:15PM ► (445) *On the total embeddings for some types of graphs.*
Yichao Chen, College of Mathematics and Econometrics, Hunan University (1077-05-1696)

3:45PM ► (446) *Genus Distributions of 4-Regular Outerplanar Graphs.*
Mehvish I. Poshni*, **Imran F. Khan** and **Jonathan L. Gross**, Department of Computer Science, Columbia University, New York (1077-05-2688)

4:15PM ► (447) *Genus Distribution of $P_3 \times P_n$.*
Imran F. Khan*, **Mehvish I. Poshni** and **Jonathan L. Gross**, Department of Computer Science, Columbia University (1077-05-2687)

4:45PM (448) *Embeddings for Bounded Treewidth and Bounded Degree.*
Jonathan L. Gross, Columbia University (1077-05-1655)

AMS Special Session on Trends in Representation Theory, II

2:15 PM – 6:05 PM

Organizers: **Donald King**, Northeastern University
Alfred Noel, University of Massachusetts, Boston

2:15PM (449) *Rational smoothness of K-orbits in the flag variety for GL(2n).*
William M. McGovern, University of Washington (1077-22-32)

2:45PM (450) *The singularities of slices in the nilpotent cone.* Preliminary report.
Eric Sommers, University of Massachusetts at Amherst (1077-22-186)

3:15PM (451) *Generalized Cartan subspaces.* Preliminary report.
Aloysius G Helminck, NC State University (1077-22-1342)

3:45PM Discussion

4:15PM (452) *The invariant Hilbert scheme of a spherical module.* Preliminary report.
Stavros Argyrios Papadakis, Instituto Superior Tecnico, and **Bart Van Steirteghem***, Medgar Evers College (City University of New York) (1077-20-1137)

4:45PM (453) *Changing highest weight theories for finite $\mathcal{W}$-algebras.*
Jonathan Scott Brown, University of Birmingham, UK (1077-20-117)

5:15PM (454) *A non commutative cluster structure on some hyperbolic algebras.* Preliminary report.
Ibrahim Abdou Saleh, Kansas State University (1077-05-271)

5:45PM (455) *Polynomial functors and categorifications.*
Oded Yacobi, University of Toronto (1077-20-2014)

AMS Special Session on the Mathematics of Decisions, Elections, and Games, II

2:15 PM – 6:05 PM

Organizers: **Karl-Dieter Crisman**, Gordon College
Michael Jones, *Mathematical Reviews*
Michael Orrison, Harvey Mudd College

2:15PM ► (456) *Changing Notions of Agreeability in Voting.*
Francis Edward Su, Harvey Mudd College (1077-05-1487)

2:45PM ► (457) *Double-Interval Societies.* Preliminary report.
Maria Klawe, Harvey Mudd College, **Kathryn L. Nyman***, Willamette University, **Jacob N. Scott**, UC Berkeley, and **Francis Edward Su**, Harvey Mudd College (1077-05-1485)

3:15PM ► (458) *N-Person Cake-Cutting: There May Be No Perfect Division.* Preliminary report.
Steven J. Brams*, New York University, **Michael A. Jones**, *Mathematical Reviews*, and **Christian Klamler**, University of Graz (Austria) (1077-91-1261)

3:45PM ► (459) *A Simple Bargaining Mechanism That Elicits Truthful Reservation Prices.*
Steven J. Brams, New York University, **Todd R. Kaplan**, University of Haifa, and **D. Marc Kilgour***, Wilfrid Laurier University (1077-91-1182)

4:15PM ► (460) *Dynamics of Consistent Bankruptcy Rules.* Preliminary report.
Michael A. Jones*, *Mathematical Reviews*, and **Jennifer M. Wilson**, Eugene Lang College of the New School for Liberal Arts (1077-91-1480)

4:45PM (461) *Two-Step Coaliton Values for Multichoice Games.*
Michael A. Jones, *Mathematical Reviews*, and **Jennifer Wilson***, Eugene Lang College the New School for Liberal Arts (1077-91-1398)

5:15PM ► (462) *On the possibility of manipulation in voting rules with several levels of approval.* Preliminary report.
Josep Freixas*, Technical University of Catalonia, Spain, and **Cameron Parker**, University of San Diego (1077-91-1350)

5:45PM ► (463) *Redistricting: from theory to practice.* Preliminary report.
Karen Saxe, Macalester College (1077-91-1830)

MAA Minicourse #3: Part A

2:15 PM – 4:15 PM

Problem-based courses for teachers, future teachers, and math majors.

Presenters: **Gail Burrill**, Michigan State University
Darryl Yong, Harvey Mudd College
Bowen Kerins, Education Development Center
James King, University of Washington

MAA Minicourse #7: Part A

2:15 PM – 4:15 PM

Study the masters: Using primary historical sources in mathematics teaching.

Presenters: **Daniel Otero**, Xavier University
David Pengelley, New Mexico State University

MAA Minicourse #11: Part A

2:15 PM – 4:15 PM

Teaching differential equations with modeling.

Presenters: **Michael Huber**, Muhlenberg College
Dan Flath, Macalester College
Tom LoFaro, Gustavus Adolphus College

AMS Session on Combinatorics and Graph Theory, II

2:15 PM – 5:25 PM

2:15PM (464) *K_3-decompositions of $\lambda_1 K_m \vee_{\lambda_2} \lambda_1 K_n$.*
Joseph R Chaffee* and **Chris Rodger**, Auburn University (1077-05-2708)

2:30PM (465) *The $(1,2)$-step competition number of a noninterval tree.*
K. A. Factor, Marquette University, **S. K. Merz*** and **S. Yun**, University of the Pacific (1077-05-2593)

2:45PM (466) *Refined Inversion Statistics on Permutations.*
Joshua Sack*, California State University Long Beach, and **Henning Arnor Ulfarsson**, Reykjavik University, School of Computer Science (1077-05-2672)

3:00PM (467) *Signed-graphic representations of matroids.*
Vaidy Sivaraman, The Ohio State University (1077-05-2653)

3:15PM ► (468) *Covering length-n permutations with n+1.*
Kathryn M Hawley*, Harvey Mudd College, and **Taylor Allison**, North Carolina State University (1077-05-2608)

3:30PM (469) *On Disjunctive Rado Numbers.*
Dusty Sabo*, Southern Oregon University, **Daniel Schaal**, **Donald Vestal**, South Dakota State University, and **Jacent Tokaz**, Georgia Institute of Technology (1077-05-2699)

3:45PM Break.

4:00PM (470) *Relation between the energy of a digraph and the energy of its underlying graph.* Preliminary report.
Nafiseh Jahanbakht*, New York, NY, and **Kourosh Tavakoli**, City University of New York (1077-05-2629)

4:15PM (471) *On $2-1$ Graph Achievement Games.*
Curtis Clark, Morehouse College (1077-05-2587)

4:30PM (472) *The spectra of several random graph families.*
Fan Chung, **Mary Radcliffe*** and **Stephen Young**, University of California, San Diego (1077-05-2509)

4:45PM ► (473) *Consecutive Matches in Permutations and cycle structures of permutations.*
Miles Eli Jones* and **Jeffrey Remmel**, University of California, San Diego (1077-05-2450)

5:00PM ► (474) *Hitting Set Size for Random Set Systems.*
Lucia C Petito*, University of Rochester, **Jessie Deering**, **Anant Godbole** and **William Jamieson**, East Tennessee State University (1077-05-2436)

5:15PM (475) *Descent pattern avoidance.*
Richard Ehrenborg and **JiYoon Jung***, University of Kentucky (1077-05-2487)

AMS Session on Finite Differences and Functional Equations: Sequences, Series, and Expansion

2:15 PM – 5:25 PM

2:15PM (476) *Existence of Solutions to Boundary Value Problems at Full Resonance.*
Kristen K Abernathy*, Winthrop University, and **Jesus Rodriguez**, North Carolina State University (1077-39-1389)

2:30PM ► (477) *Studying the Solutions and Stability of Difference Equations with Time-Varying Coefficients.*
Paul R Bouthellier, University of Pittsburgh-Titusville (1077-39-385)

2:45PM ► (478) *Difference equations for long-term simulation of mechanical systems.* Preliminary report.
Kenneth R. Ball* and **Dmitry V. Zenkov**, North Carolina State University (1077-39-113)

3:00PM (479) *Neutral Equation of Mixed.*
Charles L Lamb* and **Erik S Van Vleck**, University of Kansas (1077-39-2885)

3:15PM (480) *Asymptotic summation of right almost diagonal difference systems.*
Fei Xue*, University of Hartford, and **Harry Gingold**, West Virginia University (1077-39-539)

3:30PM ► (481) *The devil's series, did it fool Euler?* Preliminary report.
Thomas J. Osler, Rowan University (1077-40-1124)

3:45PM Break

4:00PM ► (482) *Optimality of spherical codes subject to symmetries.* Preliminary report.
Gregory Minton*, Massachusetts Institute of Technology, and **Henry Cohn**, Microsoft Research (1077-52-2363)

4:15PM (483) *Coset sum: an alternative to the tensor product in wavelet construction.*
Youngmi Hur and **Fang Zheng***, Johns Hopkins University (1077-41-1107)

4:30PM ► (484) *Asymptotic analysis in migration ecology and simple SIR epidemiology.*
Xiangsheng Wang* and **Jianhong Wu**, York University (1077-41-1277)

4:45PM ► (485) *Geometry of Numbers and Sumsets.*
Jaewoo Lee, The City University of New York (Borough of Manhattan Community College) (1077-52-1690)

5:00PM (486) *Piecewise C^1 Biorthogonal Multiwavelets on* $[-1,1]$.
Phan Nguyen, New Mexico State University (1077-41-807)

5:15PM (487) *Approximate Rational Solutions to Rational ODEs Defined on Discrete Differentiable Curves.*
Hongbo Li*, **Ruiyong Sun**, **Shoubin Yao** and **Ge Li**, Academy of Mathematics and Systems Science, Chinese Academy of Sciences (1077-41-810)

AMS Session on General Topology

2:15 PM – 4:10 PM

2:15PM (488) *Correspondences between ideals and z-filters for rings of continuous functions between C^* and C.*
Joshua Sack and **Saleem Watson***, California State University Long Beach (1077-54-2745)

2:30PM (489) *Amalgamating Factor Spaces of Generalized Inverse Limits.*
Scott M. Varagona, Auburn University (1077-54-2702)

2:45PM ► (490) *Numerability in sets, spaces and covers.* Preliminary report.
Nigar Tuncer Ozarslan, Istanbul (1077-54-2315)

3:00PM (491) *A P- and C*(D)-filters process of compactifications and any Hausdorff compactification.*
Hueytzen J. Wu*, Texas A & M University - Kingsville, and **Wan-Hong Wu**, University of Texas at San Antonio (1077-54-440)

3:15PM ► (492) *Knots in the canonical book representation of complete graphs.*
Dana P. Rowland* and **Andrea Politano**, Merrimack College (1077-54-1393)

3:30PM (493) *Homeomorphisms of Compact Sets in Certain Hausdorff Spaces.*
Arthur D. Grainger, Morgan State University (1077-54-165)

3:45PM (494) *Oriented skein relation and a biological application.* Preliminary report.
Candice R Price, University of Iowa (1077-54-2270)

4:00PM ► (495) *The Disambiguated Temperley-Lieb Algebra.* Preliminary report.
Ellie A Grano, University of California, Santa Barbara (1077-54-2761)

AMS Session on Mathematical Biology and Related Fields, II

2:15 PM – 5:40 PM

2:15PM ► (496) *Results on a discrete, age-class population model.* Preliminary report.
David Chan* and **Hye Jin Ban**, Virginia Commonwealth University (1077-92-2316)

2:30PM ► (497) *Construction of prior models for EEG source estimation with weighted graph descriptions of anatomical brain connectivity.* Preliminary report.
David K Hammond*, NeuroInformatics Center / University of Oregon, and **Benoit Scherrer**, Computational Radiology Laboratory / Children's Hospital / Harvard University (1077-92-2142)

2:45PM (498) *Toward a Vaccine: Modeling the Immune Response Against Shigella.*
Courtney L Davis, University of Maryland, College Park (1077-92-1848)

3:00PM (499) *Phenotype Sequencing.*
Marc Allen Harper, UCLA (1077-92-1807)

3:15PM (500) *A second-order finite difference approximation for a mathematical model of erythropoiesis.* Preliminary report.
Azmy S. Ackleh, University of Louisiana at Lafayette, and **Jeremy J. Thibodeaux***, Loyola University New Orleans (1077-92-1680)

3:30PM (501) *Studying the recovery algorithm for the time-dependent transmission rate in epidemic models.* Preliminary report.
Anna Mummert, Marshall University (1077-92-2697)

3:45PM (502) *Optimal Control for a VRE Model.* Preliminary report.
Mohammed Yahdi* and **Michael Dunlea**, Ursinus College (1077-92-2818)

4:00PM Break.

4:15PM ► (503) *Biodiversity dynamics under intransitive competition and habitat destruction.* Preliminary report.
Matthew J Labrum, Washington State University (1077-92-1606)

4:30PM (504) *Predicting the ecological outcomes of species invasions and parasite transmission in the upper Mississippi River.*
James P Peirce* and **Gregory J Sandland**, University of Wisconsin - La Crosse (1077-92-1505)

4:45PM (505) *Cancer Classification of Microarray Data by Denoising Methods on Graphs.* Preliminary report.
Yue Fan, **Mark A. Kon**, Department of Mathematics and Statistics and Program in Bioinformatics, Boston University, **Shinuk Kim**, **Charles DeLisi**, Program in Bioinformatics, Boston University, and **Louise A. Raphael***, Howard University (1077-92-338)

5:00PM ► (506) *Forecasting Cancer: Finding the Initial Conditions for Spatiotemporal Dynamical Models.* Preliminary report.
Eric J. Kostelich, Arizona State University (1077-92-2640)

5:15PM (507) *The Dynamics Underlying Pseudo-Plateau Bursting in a Pituitary Cell Model.* Preliminary report.
Wondimu W. Teka*, **Joel Tabak**, Florida State University, **Theodore Vo**, **Martin Wechselberger**, University of Sydney, and **Richard Bertram**, Florida State University (1077-92-1489)

5:30PM (508) *Homogenization of Large-Scale Movement Models in Ecology.*
Martha J. Garlick*, **James A. Powell**, Utah State University, **Mevin B. Hooten**, USGS Colorado Cooperative Fish and Wildlife Research Unit; Colorado State University, and **Leslie R. McFarlane**, Utah Division of Wildlife Resources (1077-92-1051)

AMS Session on Mechanics and Mathematical Physics, II

2:15 PM – 5:40 PM

2:15PM (509) *Computation of the linear and first-order solid fractions for a magneto-convective flow in an active mushy layer.*
Dambaru Bhatta, The University of Texas-Pan American (1077-76-647)

2:30PM (510) *Relative Equilibria in the Four-Vortex Problem with Two Pairs of Equal Vorticities.* Preliminary report. **Gareth E Roberts***, College of the Holy Cross, **Marshall Hampton**, University of Minnesota, Duluth, and **Manuele Santoprete**, Wilfrid Laurier University (1077-70-2598)

2:45PM (511) *A regularization technique for oscillating slender bodies in low Reynolds number flow.* **Bree Cummins**, Tulane University (1077-76-1394)

3:00PM (512) *Second Harmonic Generation at Metal/Dielectric Interfaces via Density Functional Theory.* Preliminary report. **Justin Droba**, Michigan State University (1077-78-343)

3:15PM ► (513) *Mathematical Problems in Residential Geothermal Heating Systems.* **B S Tilley**, Worcester Polytechnic Institute (1077-80-2766)

3:30PM (514) *Unsteady blood flow in an artery with an overlapping stenosis.* **Ranadhir Roy*** and **Daniel N Riahi**, University of Texas-Pan American (1077-76-95)

3:45PM Break.

4:00PM (515) *Exact solution to the 1d one component Coulomb gas at fixed energy.* **Timothy D Andersen**, Daniel H. Wagner Associates, Inc. (1077-82-837)

4:15PM (516) *The Reality Game: A Process Theory Approach to Quantum Foundations.* **William H Sulis**, McMaster University and The University of Waterloo (1077-81-2281)

4:30PM (517) *Periodic Ising model and Ising Correlations.* **Grethe Hystad**, The University of Arizona (1077-82-1752)

4:45PM (518) *Scalar Field Dark Matter and Spiral Structures of Galaxies: Higher Order Effects and Gravitational Lensing.* Preliminary report. **Nicholas P Robbins**, Gettysburg College (1077-85-2083)

5:00PM (519) *On conformal mappings of spherical domains.* **Lioudmila Bourchtein*** and **Andrei Bourchtein**, Pelotas State University, Brazil (1077-86-254)

5:15PM (520) *High dimension control for quantum system.* **Quan-Fang Wamg**, The Chinese University of Hong Kong (1077-81-19)

5:30PM (521) *3-D Vortex Rings Instabilities and Collision: Numerical Approach.* **Leon Kaganovskiy***, Touro College, NY, and **Robert Krasny**, University of Michigan, Ann Arbor (1077-76-809)

AMS Session on Probability Theory, Stochastic Processes, and Statistics, II

2:15 PM – 4:40 PM

2:15PM (522) *On the Stochastic Beverton-Holt Difference Equation with Survival Rates.* **Paul H Bezandry***, **Toka Diagana**, Howard University, and **Saber Elaydi**, Trinity University (1077-60-1957)

2:30PM ► (523) *Primitive Recursive Representations of "Skorokhod Sequences" for the Standard Normal.* **Marina Skyers**, Lehigh University (1077-60-1748)

2:45PM (524) *On Spectral Properties of Certain Large Matrices That Arise in the Study of Processor Shared Queues.* **Qiang Zhen***, University of North Florida, and **Charles Knessl**, University of Illinois at Chicago (1077-60-1484)

3:00PM ► (525) *Effects of cell division on stochastic intracelluar chemical reaction systems.* **John K McSweeney*** and **Lea Popovic**, Concordia University (1077-60-1191)

3:15PM (526) *Occupation Times for Stable-like Processes.* **Brian M. Whitehead**, Eastern Connecticut State University (1077-60-746)

3:30PM ► (527) *Target Shooting and Normal Distribution.* Preliminary report. **Zhaochi Zhang***, Northwestern Polytechnical University, and **Zengxiang Tong**, Otterbein University (1077-60-1475)

3:45PM (528) *Forecasting Foreign Exchange rates with Simultaneous Nearest Neighbor Algorithm using Mahalanobis Distance as the Distance Measure.* Preliminary report. **Vindya Kumari Pathirana*** and **Kandethody M Ramachandran**, University of South Florida (1077-60-2072)

4:00PM (529) *Rate of Convergence of Weak Euler Approximation for Nondegenerate Itô Diffusion and Jump Processes.* **C. Y. Zhang**, Xi'an Jiaotong-Liverpool University (1077-60-595)

4:15PM (530) *Percolation threshold bounds derived by the substitution method without a reference lattice.* Preliminary report. **John C Wierman**, Johns Hopkins University (1077-60-1243)

4:30PM ► (531) *Characterizations of Logistic Distribution via Distributional Properties of Order Statistics.* Preliminary report. **George P Yanev***, The University of Texas - Pan American, and **M Ahsanullah**, Rider University (1077-62-2496)

AMS Session on Undergraduate Research, II

2:15 PM – 4:40 PM

2:15PM ► (532) *On d-modular labelings of the union of two cycles.* **Joseph Buchanan***, **Ryan C. Bunge**, Illinois State University, **Erik Pelttari**, Northern Illinois University, **Greg Rasmuson**, Roanoke-Benson High School, IL, **Alexander Su**, Illinois State University High School, and **Sevasti Tagaris**, Illinois Wesleyan University (1077-05-2647)

2:30PM ► (533) *Extremal Graphs Without 4-Cycles.* **Frank A. Firke***, Carleton College, **Evan D. Nash**, University of Nebraska-Lincoln, and **Peter M. Kosek**, The College at Brockport, SUNY (1077-05-2136)

2:45PM ► (534) *The Abelian Sandpile Model.* **J K Herring***, **E Meza** and **C M Nieuwoudt**, Sam Houston State University (1077-05-2920)

3:00PM ► (535) *A Family of Algorithms Yielding a Solution to the Hermite Problem.* Preliminary report. **Sarah Peluse***, Lake Forest College and The University of Chicago, **Krishna Dasaratha**, Harvard University, **Laure Flapan**, Yale University, **Tom Garrity**, **Chansoo Lee**, Williams College, **Cornelia Mihaila**, Wellesley College, **Nicholas Neumann-Chun**, Williams College, and **Matt Stoffregen**, The University of Pittsburgh (1077-11-2325)

3:15PM ► (536) *A Generalized Family of Multidimensional Continued Fractions?* Preliminary report.
Krishna Dasaratha, Harvard University, **Laure Flapan**, Yale University, **Thomas Garrity**, **Chansoo Lee**, Williams College, **Cornelia Mihaila***, Wellesley College, **Nicholas Neumann-Chun**, Williams College, **Sarah Peluse**, Lake Forest College, University of Chicago, and **Matt Stoffregen**, University of Pittsburgh (1077-11-2614)

3:30PM ► (537) *Finite-Dimensional Frame Theory over Arbitrary Fields.* Preliminary report.
Suren Jayasuriya*, University of Pittsburgh, and **Pedro Perez**, Columbus State University (1077-15-294)

3:45PM ► (538) *Multidimensional Continued Fraction Pell Equations.* Preliminary report.
Michael Baiocchi, Stanford University, **Krishna Dasaratha**, Harvard University, **Laure Flapan***, Yale University, **Thomas Garrity**, **Chansoo Lee**, Williams College, **Cornelia Mihaila**, Wellesley College, **Nicholas Neumann-Chun**, Williams College, **Sarah Peluse**, University of Chicago, and **Matthew Stoffregen**, University of Pittsburgh (1077-11-2129)

4:00PM ► (539) *Unique Sequences for Multidimensional Continued Fractions.* Preliminary report.
Krishna Dasaratha*, Harvard University, **Thomas Garrity**, Williams College, **Laure Flapan**, Yale University, **Chansoo Lee**, Williams College, **Cornelia Mihaila**, Wellesley College, **Nicholas Neumann-Chun**, Williams College, **Sarah Peluse**, Chicago University, and **Matthew Stoffregen**, University of Pittsburgh (1077-11-2499)

4:15PM ► (540) *The n-House Problem.*
Amanda Kovacs, Molloy College (1077-11-2743)

4:30PM ► (541) *Fraction of Nonnegative Polynomials that are Sums of Squares.*
Caitlin A Lownes, Massachusetts Institute of Technology (1077-14-312)

MAA Session on Effective Use of Dynamic Mathematical Software in the Classroom, II

2:15 PM – 5:30 PM

Organizers: **M. E. Waggoner**, Simpson College
Therese Shelton, Southwestern University

2:15PM ► (542) *Becoming One with Bifurcations in 3D!*
Itai Seggev, Wolfram Research, Inc. (1077-D5-787)

2:35PM ► (543) *Taylor Polynomials in R.* Preliminary report.
Andrew J Rich*, **Daniel T. Kaplan**, Macalester College, **Randall J Pruim**, Calvin College, **Nicholas J Horton**, Smith College, and **JJ Allaire**, RStudio (1077-D5-778)

2:55PM ► (544) *Student Voice Waves: Investigations using Calculus and Freeware.* Preliminary report.
Phil Gustafson, Colorado Mesa University (1077-D5-2604)

3:15PM (545) *Communicating calculus concepts using graphically presented functions in Adobe Flash applets embedded in WeBWorK.*
Daniel J Gries, Hopkins School (1077-D5-2616)

3:35PM ► (546) *Team Activities for the First Day of Class Using a Computer Algebra System.* Preliminary report.
J Alfredo Jimenez, Penn State Hazleton (1077-D5-2453)

3:55PM ► (547) *Taking Instruction with Numerical Computations to the Next Octave.*
Talitha M Washington, Howard University (1077-D5-1554)

4:15PM ► (548) *Teaching Transformations of Functions Using Sage.* Preliminary report.
Susan L Schmoyer, Worcester State University (1077-D5-2556)

4:35PM ► (549) *Mystery Plots: Motivating Algebraic Function Models using Dynamic Mathematics Software.*
Michael Todd Edwards*, Miami University, **Robert M. Klein**, Ohio University, and **Steve Phelps**, Madeira High School and University of Cincinnati - Clermont College (1077-D5-1357)

4:55PM ► (550) *The Power of Symbolic Spreadsheets.*
Rejoice Mudzimiri, Montana State University (1077-D5-2589)

5:15PM ► (551) *Visualizing Lagrange Multiplier Optimization using CalcPlot3D.* Preliminary report.
Paul E Seeburger, Monroe Community College (1077-D5-1952)

MAA Session on Innovative and Effective Ways to Teach Linear Algebra, I

2:15 PM – 5:50 PM

Organizers: **David Strong**, Pepperdine University
Gil Strang, Massachusetts Institute of Technology
David Lay, University of Maryland

2:15PM ► (552) *Discovery learning in linear algebra using dynamical geometry software.*
Martha Ellen Waggoner, Simpson College (1077-F1-1720)

2:35PM ► (553) *Using Dynamic Geometry Software to Foster Students' Understanding of Vectors.*
Tanya Berezovski, St. Joseph's University, Philadelphia, and **Tyler Gaspich***, St. Josephs' University, Philadelphia (1077-F1-872)

2:55PM ► (554) *Teaching geometry using linear algebra.* Preliminary report.
Dragu Atanasiu*, University of Boras, Sweden, and **Piotr Mikusinski**, University of Central Florida (1077-F1-828)

3:15PM ► (555) *Using N-dimensional Geometry as a Thread to Increase Geometric and Abstract Reasoning in Linear Algebra.* Preliminary report.
Stephen Hilbert, Ithaca College, Ithaca NY (1077-F1-2689)

3:35PM ► (556) *Group Theory in the Linear Algebra Classroom.* Preliminary report.
Paul E. Becker* and **Mark Medwid**, Penn State Erie, The Behrend College (1077-F1-1698)

3:55PM ► (557) *A Physical Laboratory for Linear Algebra.*
Jeffrey M Hokanson*, **Steven J Cox** and **Mark Embree**, Rice University (1077-F1-2686)

4:15PM ► (558) *Discrete Dynamical Fibonacci.*
Edward Early, St. Edward's University (1077-F1-711)

4:35PM ► (559) *Combinatorial Scheduling: a way to motivate matrix multiplication and other important concepts.*
Donna A. Dietz, University of Pennsylvania (1077-F1-274)

4:55PM ► (560) *Linear Algebra Projects for Computer Science Majors in Costa Rica.* Preliminary report.
Michael Josephy, Universidad de Costa Rica (1077-F1-879)

5:15PM (561) *A Hypothetical Learning Trajectory for Conceptualizing Matrices as Linear Transformations.*
Megan Wawro*, Virginia Tech, and **Christine Larson**, Vanderbilt University (1077-F1-2328)

5:35PM *Linear: Maxima Edition.*
► (562) **Don Spickler**, Salisbury University (1077-F1-1071)

MAA Session on Mathematics and Sports, II

2:15 PM – 6:10 PM

Organizer: **R. Drew Pasteur**, College of Wooster

2:15PM *Rule of Tangent for Win-By-Two Games.*
► (563) **Reza D Noubary**, Bloomsburg University (1077-G1-2571)

2:35PM *Hot Hands on the PGA Tour.* Preliminary report.
► (564) **Roland Minton**, Roanoke College (1077-G1-2364)

2:55PM *A Logistic Regression Analysis of the NFL Overtime.*
► (565) **Nicholas Gorgievski***, Nichols College, and **Thomas C. DeFranco**, University of Connecticut (1077-G1-2844)

3:15PM *The Quarterback Passer Rating: Analyzing and*
► (566) *Tweaking the QBPR.*
Paul von Dohlen, William Paterson University (1077-G1-2098)

3:35PM *An Adjustment to the Colley Matrix Method.*
► (567) **Mike Weimerskirch**, Augsburg College (1077-G1-1091)

3:55PM *Paradoxes in Colley Matrix Sports Rankings.*
► (568) **T. S. Michael**, U. S. Naval Academy (1077-G1-2049)

4:15PM *Using Sports Ranking in a Numerical Linear*
► (569) *Algebra Course.*
Chuck Wessell, Gettysburg College (1077-G1-2685)

4:35PM *Modeling a Baseball Defense as a Network.*
(570) **Tina Hartley**, United States Military Academy (1077-G1-2508)

4:55PM *A Century of Baseball Statistics.* Preliminary report.
► (571) **Alan Levine**, Franklin and Marshall College (1077-G1-1361)

5:15PM *Pythagorean Prognostication.*
► (572) **Yousuf George**, Nazareth College (1077-G1-2858)

5:35PM *A Connection Between Cross Country Scoring and*
► (573) *Election Tallying.* Preliminary report.
Jacob Erb, Taylor University (1077-G1-2837)

5:55PM *An introduction to quantitative analysis in hockey.*
► (574) **Brian A. Macdonald**, United States Military Academy (1077-G1-2930)

MAA Session on Touch It, Feel It, Learn It: Tactile learning Activities in the Undergraduate Mathematics Classroom, II

2:15 PM – 5:30 PM

Organizers: **Jessica Mikhaylov**, U.S. Military Academy

Julie Barnes, Western Carolina University

2:15PM *The Cheese Stands Alone.* Preliminary report.
► (575) **Sarah E. Wright**, College of the Holy Cross (1077-O1-2710)

2:35PM *The Touchy-Feely Integral and Basic Properties of*
► (576) *Integration.*
Benjamin J Thirey* and **Robert D Wooster**, West Point (1077-O1-2810)

2:55PM *Using Models to Help Students Understand Calculus*
► (577) *Topics.*
Sharon L Crumpton, Belmont University; Nashville, TN (1077-O1-373)

3:15PM *Raising Calculus to the Surface.*
► (578) **Aaron D Wangberg**, Winona State University (1077-O1-2696)

3:35PM *Using 3-D Manipulatives to Teach Calculus.*
► (579) **Dennis C. Ebersole**, Northampton Community College (1077-O1-2709)

3:55PM *The Chain Rule Dance.*
► (580) **Mariah Birgen**, Wartburg College (1077-O1-1033)

4:15PM *Getting the "feel" for centers of mass.*
► (581) **James A Sellers**, Penn State University (1077-O1-709)

4:35PM *Curve Sketching with Puzzle Pieces.*
► (582) **Teena Carroll**, St. Norbert College (1077-O1-847)

4:55PM *Grocery Bags and Lasers.*
► (583) **Randall E Cone**, Virginia Military Institute (1077-O1-1578)

5:15PM *Project CAGE: Integrating mathematical and moral*
► (584) *imagination through a hands-on learning project.* Preliminary report.
Rebecca Bamford, **Aminul Huq** and **Wei Wei***, Center for Learning Innovation, University of Minnesota Rochester (1077-O1-2016)

MAA Session on the Capstone Course: Innovations and Implementations, II

2:15 PM – 5:30 PM

Organizers: **Kathryn Weld**, Manhattan College

Agnes Rash, St. Joseph's College

2:15PM *Communication, Problem Solving and Independence*
► (585) *in a Capstone Course.*
Kristin A Camenga, Houghton College (1077-C1-2198)

2:35PM *Optimizing Capstone With Multiple Constraints.*
(586) **Risto Atanasov***, **Tuval Foguel** and **Jeffrey Lawson**, Western Carolina University (1077-C1-410)

2:55PM *A Vertically Integrated Model for a Mathematics*
► (587) *"Capstone".*
Aaron Luttman*, **Joseph Skufca**, Clarkson University, **Brian Leventhal**, University of Pittsburgh, and **Clarice Dziak**, Clarkson University (1077-C1-280)

3:15PM *Surveying U.S. Mathematics Teacher Preparation*
► (588) *Programs: What is the status of the capstone course?* Preliminary report.
Dana C. Cox, Miami University, and **Mary Beisiegel***, Harvard University (1077-C1-770)

3:35PM *A Capstone Course in January.* Preliminary report.
► (589) **Jeremy Case**, Taylor University (1077-C1-2823)

3:55PM *Fostering Communication Skills and Independence*
(590) *in a Capstone Project.* Preliminary report.
Karrolyne Fogel* and **Chris Brown**, California Lutheran University (1077-C1-2690)

4:15PM *A formative three-semester capstone experience.*
(591) **Daniel E. Otero** and **Joseph F. Wagner***, Xavier University (1077-C1-1121)

4:35PM *Senior Seminar, Across a Department and Across*
► (592) *the Years.* Preliminary report.
Meredith L Greer* and **Chip Ross**, Bates College (1077-C1-151)

4:55PM *Online Discussion Boards in Seminar: Discovering*
► (593) *Exciting Tidbits Missed Inside the Classroom Walls on the Outside.*
Daniel R. Shifflet, Clarion University of Pennsylvania (1077-C1-2592)

5:15PM *Starting a capstone experience: A user's guide.*
► (594) Preliminary report.
Kurt Herzinger*, **Beth Schaubroeck** and **Dale Peterson**, United States Air Force Academy (1077-C1-2449)

MAA Session on the Mathematics of Sudoku and Other Pencil Puzzles, I

2:15 PM – 4:50 PM

Organizers: **Laura Taalman**, James Madison University
Jason Rosenhouse, James Madison University

2:15PM ► (595) *A Sampler of Sudoku Studies.* **Jason Rosenhouse*** and **Laura Taalman**, James Madison University (1077-H1-2053)

2:35PM ► (596) *Al-Maghribi meets Sudoku.* **Andrew J Simoson***, King College, and **Ilhan M Izmirli**, George Mason University (1077-H1-1036)

2:55PM ► (597) *Clue-Symmetric Sudoku.* **Darrah P. Chavey**, Beloit College (1077-H1-2330)

3:15PM ► (598) *Minimal connected Shidoku symmetry groups.* **Rebecca E Field***, **Beth Arnold**, **Steve Lucas** and **Laura Taalman**, James Madison University (1077-H1-2861)

3:35PM ► (599) *MultiSudoku: A Game of Divisors and Multiples.* **Agnes M. Rash**, Saint Joseph's University (1077-H1-2003)

3:55PM ► (600) *Counting on KenKen Puzzles.* Preliminary report. **Robert W. Vallin**, Slippery Rock University (1077-H1-367)

4:15PM ► (601) *Minimal 6×6 Ken Ken puzzles.* **Philip Cobb**, Queensborough Community College (1077-H1-2639)

4:35PM ► (602) *Critical sets in Futoshiki squares.* Preliminary report. **Daniel J Katz**, Guilford College (1077-H1-1423)

MAA Session on the Scholarship of Teaching and Learning in Collegiate Mathematics, II

2:15 PM – 5:50 PM

Organizers: **Jacqueline Dewar**, Loyola Marymount University
Thomas Banchoff, Brown University
Pam Crawford, Jacksonville University
Edwin Herman, University of Wisconsin-Stevens Point
Nathan Wodarz, University of Wisconsin-Stevens Point

2:15PM ► (603) *How does mathematics contribute to a liberal education?* **Curtis D. Bennett*** and **Jacqueline M. Dewar**, Loyola Marymount University (1077-N1-2791)

2:35PM ► (604) *Using Wikis in a Geometry Class for Future Teachers.* **Gregory A Kelsey**, Immaculata University (1077-N1-1560)

2:55PM ► (605) *Implementing Mathematics Research Experiences into Teacher Preparation Programs.* **David D Barker***, **Saad El-Zanati**, Illinois State University, and **Wendy O'Hanlon**, Illinois Central College (1077-N1-2377)

3:15PM (606) *A First Attempt at Categorizing and Assessing Different Levels of Student Understanding.* Preliminary report. **Paula Shorter*** and **Mairead Greene**, Rockhurst University (1077-N1-2747)

3:35PM ► (607) *Using Inquiry Based Learning to Enhance Student Attitudes in Complex Analysis.* Preliminary report. **Edwin P Herman**, University of Wisconsin-Stevens Point (1077-N1-2740)

3:55PM ► (608) *Does "Thinking about Thinking" Impact Completion Rates of Pre-class Assignments?* Preliminary report. **James S Rolf***, **Lauren Scharff** and **Thomas Hodge**, United States Air Force Academy (1077-N1-1972)

4:15PM ► (609) *Collaborative peer review between two IBL number theory courses.* **Dana C. Ernst***, Plymouth State University, **Angela Hodge**, University of Nebraska of Omaha, and **Andrew Schultz**, Wellesley College (1077-N1-1154)

4:35PM ► (610) *A Semi-IBL Finite Mathematics Course: Is it possible and can it be successful?* Preliminary report. **Mindy Capaldi**, Valparaiso University (1077-N1-1032)

4:55PM (611) *An analysis of the effectiveness of using exclusively workshop-style instruction in the College Algebra classroom.* Preliminary report. **Jennifer Vandenbussche***, **Christina Scherrer**, **Alexandra Brigham** and **Anasstasia Semenova**, Southern Polytechnic State University (1077-N1-793)

5:15PM (612) *A cross-disciplinary analysis of math students' writing.* Preliminary report. **Patrick Bahls***, University of North Carolina, Asheville, **Amy Mecklenburg-Faenger**, **Marguerite Scott-Copses** and **Chris Warnick**, College of Charleston (1077-N1-47)

5:35PM (613) *Pedagogy in large lectures and the age of digital media: Keep up or be left out!* **Fabiana Cardetti*** and **Amit Savkar**, University of Connecticut (1077-N1-2051)

MAA General Contributed Paper Session: Assessment and Outreach

2:15 PM – 6:10 PM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

2:15PM ► (614) *Math Days for Women.* **Violeta Vasilevska***, Utah Valley University, and **Clare Wagner**, University of South Dakota (1077-VA-2892)

2:30PM ► (615) *Investigating Gender Differences in UMTYMP Entrance Exam.* **Justin Edward Sukiennik**, University of Minnesota (1077-VA-2538)

2:45PM ► (616) *Strategies to Help Underrepresented and First Generation Students in the STEM Fields.* **Joseph E Hibdon, Jr***, **Melissa Yates**, **Marilyn Saavedra-Leyva** and **Stephanie Levi**, Northeastern Illinois University (1077-VA-1913)

3:00PM ► (617) *Report on the First Kenyan Maths Camp.* **Tom Denton***, York University, **Emily Hobbs**, Queens College, London, **David Stern**, **Zach Mbasu**, **Michael Obiero**, Maseno University, Kenya, and **Jeff Goodman**, London, England (1077-VA-645)

3:15PM ► (618) *ABACUS International Math Challenge.* **Tivadar Diveki**, Grace Church School, and **Zsuzsanna Szaniszlo***, Valparaiso University (1077-VA-2540)

3:30PM ► (619) *Closing the loop!* **Noureen Khan**, Unversity of North Texas at Dallas (1077-VA-314)

3:45PM ► (620) *Increasing Math Proficiency in High School Teaching.*
Bradley Forrest, **Pamela Kosick*** and **Chia-Lin Wu**, Richard Stockton College of New Jersey (1077-VA-452)

4:00PM ► (621) *Another approach to Pre-service Teachers' preparation programs.*
Ali S Shaqlaih, University of North Texas at Dallas (1077-VA-2551)

4:15PM ► (622) *Teacher Created Multiple-Choice Assessments and the Use of Assessment Data for Planning Instruction.*
Sue Brown, University of Houston-Clear Lake (1077-VA-462)

4:30PM ► (623) *Mathematics Parterning with Computer Science to Improve Calculus Instruction and Investigate Student Learning Difficulties.*
Marilyn Reba, **Calvin Williams**, **Roy Pargas**, **Allen Guest** and **Ellen Breazel***, Clemson University (1077-VA-2134)

4:45PM ► (624) *What Calculus do students learn after Calculus?* Preliminary report.
Todd Moore, Kansas State University (1077-VA-1977)

5:00PM ► (625) *An effort to coordinate conceptual development in math and physics education for engineering undergraduate students.* Preliminary report.
Gregory R Baker, The Ohio State University (1077-VA-1881)

5:15PM ► (626) *Development and validation of an instrument to assess college student's statistical inference-an argument based approach to validity.* Preliminary report.
Jiyoon Park* and **Robert delMas**, University of Minnesota (1077-VA-1373)

5:30PM (627) *How to start a discussion on your campus about assessing general education mathematics.*
Leah Childers, **Karla Childs*** and **Bobby Winters**, Pittsburg State University (1077-VA-993)

5:45PM ► (628) *CONNECT Math: A Partnership in Higher Education.*
Rebecca C. Metcalf, Bridgewater State University (1077-VA-691)

6:00PM ► (629) *An Alternative Approach to Assessing Instructional Effectiveness: Implications to Teaching and Learning Undergraduate Mathematics.*
Jerry C Obiekwe, The University of Akron-Wayne College (1077-VA-931)

MAA General Contributed Paper Session: Calculus

2:15 PM – 5:40 PM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

2:15PM (630) *Student understanding and misconceptions of infinite repeating decimals in a Sequences and Series Bridge course.* Preliminary report.
Rebecca J. Schmitz*, Michigan Technological University, and **Harvey Keynes**, University of Minnesota (1077-VC-1859)

2:30PM ► (631) *Convergences of Catalan Series.*
Thomas Koshy and **Zhenguang Gao***, Framingham State University (1077-VC-2178)

2:45PM ► (632) *Search for the Stokes-vergence Theorem.* Preliminary report.
Todd G Will*, University of Wisconsin - La Crosse, and **David Finn**, Rose-Hulman Institute of Technology (1077-VC-2368)

3:00PM ► (633) *Reverse Mathematics and the Lost Proofs of Calc One.*
Stephen M Walk, St. Cloud State University, St. Cloud, Minnesota (1077-VC-2618)

3:15PM ► (634) *Generalized trigonometric substitution.*
Robert D. Poodiack, Norwich University (1077-VC-2798)

3:30PM ► (635) *Resequencing Calculus: An Early Multivariate Approach.* Preliminary report.
Mark E Gruenwald and **David J Dwyer***, University of Evansville (1077-VC-1130)

3:45PM (636) *Enhancing Student Learning: The Use of CalcPlot3D Graphing Technology in Developing Core Competencies in Multivariable Calculus.* Preliminary report.
Karen L. Hulsebosch*, Olympic College, and **Paul E. Seeburger**, Monroe Community College (1077-VC-2636)

4:00PM (637) *Analysis of Student Achievement and Retention Regarding Online Calculus Homework.*
Daniel L Kern, Florida Gulf Coast University (1077-VC-2601)

4:15PM (638) *Multiple Choice Versus Open Response Assessment in Calculus.*
Shannon R Lockard* and **Irina Seceleanu**, Bridgewater State University (1077-VC-929)

4:30PM ► (639) *The Big 'BUT' about Blogs in Online Calculus.* Preliminary report.
Denise LeGrand, University of Arkansas at Little Rock (1077-VC-529)

4:45PM ► (640) *The POGIL project: Student-Centered Learning in Calculus.* Preliminary report.
Laurie Lenz*, Marymount University, **Jill Guerra**, University of Arkansas Fort Smith, **Catherine Beneteau**, University of South Florida, and **Zdenka Guadarrama**, Rockhurst University (1077-VC-1448)

5:00PM ► (641) *Moving Toward a More Effective Learning Environment in First Semester Calculus.* Preliminary report.
Javier Garza, Tarleton State University (1077-VC-2654)

5:15PM (642) *Reducing anxiety and increasing interest in business calculus.*
Janet L Fierson, La Salle University (1077-VC-2909)

5:30PM ► (643) *Using students' tests to improve teaching and learning.* Preliminary report.
Radoslav Dimitric, CUNY (1077-VC-97)

MAA General Contributed Paper Session: Mathematics and Technology, II

2:15 PM – 5:25 PM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

2:15PM ► (644) *Time management and student success using the computer-based instructional system Aleks.* Preliminary report.
Steven D. Wallace, Macon State College (1077-VI-999)

2:30PM (645) *A Decade of Improving Pass Rates in Mathematics using Interactive Software.*
Michelle DeDeo, University of North Florida (1077-VI-2620)

2:45PM ► (646) *Mobile Mathlets with Google Web Toolkit.* Preliminary report.
Thomas E Leathrum, Jacksonville State University (1077-VI-2670)

3:00PM ► (647) Lurch, *a free math word processor that can check your work.*
Nathan C Carter*, Bentley University, and **Kenneth G Monks**, University of Scranton (1077-VI-2534)

3:15PM (648) *Learning with the iPad: Does this technology help or hinder student understanding?*
Eric Thornburg*, **Benjamin Hung** and **John Jackson**, United States Military Academy (1077-VI-1955)

3:30PM ► (649) *Wiki Technology Supporting Learning (I).* Preliminary report.
Elizabeth Thoren*, University of California, Santa Barbara, and **Brian Katz**, Augustana College (1077-VI-1622)

3:45PM (650) *Wiki Technology Supporting Learning (II).* Preliminary report.
Brian Katz*, Augustana College, and **Elizabeth Thoren**, University of California, Santa Barbara (1077-VI-1620)

4:00PM ► (651) *Increasing Student Engagement in Undergraduate Mathematics with Tablet PCs.*
Carla A Romney*, **Juan Pedro Paniagua** and **Fabian Torrres-Ardila**, Boston University (1077-VI-164)

4:15PM ► (652) *Teaching mathematics online, is it even possible?*
Aldo R. Maldonado, Park University (1077-VI-2725)

4:30PM ► (653) *Perspectives on the Use of Dynamic Mathematical Software in Classrooms.* Preliminary report.
Heba Bakr Khoshaim, Ohio university/ Ministry of Higher Education, Kingdom of Saudi Arabia (1077-VI-2641)

4:45PM ► (654) *Virtual Pin Board Pinterest.com Motivating Gen Ed Group Project and Connecting Math Majors.* Preliminary report.
Daniel Kiteck, Indiana Wesleyan University (1077-VI-1652)

5:00PM ► (655) *Neuro Mathematics Education and Technology.*
Alexander Y Vaninsky, City University of New York, Hostos Community College (1077-VI-756)

5:15PM ► (656) *A Nomograph For The Trigonometric Functions.*
Timothy Hall, PQI Consulting (1077-VI-273)

MAA-AMS Invited Paper Session on the Philosophy of Mathematics

2:15 PM – 6:40 PM

Organizers: **Thomas Drucker**, University of Wisconsin-Whitewater
Bonnie Gold, Monmouth University
Daniel Sloughter, Furman University

2:15PM ► (657) *Is Mathematics the Language of Physics?*
Arthur M Jaffe, Harvard University (1077-AJ-71)

3:00PM ► (658) *Structuralism and its discontents.*
Charles Parsons, Harvard University (1077-AJ-1755)

3:45PM ► (659) *Explanation and Existence.* Preliminary report.
Stephen Yablo, Massachusetts Institute of Technology (1077-AJ-59)

4:30PM ► (660) *A Trivialist Account of Mathematics.*
Agustin Rayo, MIT (1077-AJ-83)

5:15PM ► (661) *The relationship of derivations in artificial languages to ordinary rigorous mathematical proof.* Preliminary report.
Jody Azzouni, Tufts University (1077-AJ-1994)

6:00PM ► (662) *Turing and Wittgenstein.* Preliminary report.
Juliet Floyd, Boston University (1077-AJ-1045)

SIAM Minisymposium on Vistas in Applied, Computational, and Discrete Mathematics

2:15 PM – 6:00 PM

Organizers: **Zuhair Nashed**, University of Central Florida
Luminita Vese, University of Californina Los Angeles

2:15PM ► (663) *Finding Needles in Exponential Haystacks.* Preliminary report.
Joel Spencer, Courant Institute (1077-05-832)

3:15PM (664) *Frames and applied harmonic analysis.*
John J Benedetto, Norbert Wiener Center, University of Maryland, College Park (1077-43-877)

4:15PM (665) *MINOTAUR: A New Toolkit for Mixed-Integer and Nonlinear Optimization.*
Sven Leyffer* and **Ashutosh Mahajan**, Argonne National Laboratory (1077-90-2357)

5:15PM ► (666) *Recent Results in Computational Geometry.*
Erik D. Demaine, Massachusetts Institute of Technology (1077-68-2755)

AMS-MAA Joint Panel Discussion

2:15 PM – 3:35 PM

Administrative strategies for dealing with budget cuts.

Organizers: **Al Boggess**, Texas A&M University
Don Allen, Texas A&M University
Jill Zarestky, Texas A&M University

YMN/Project NExT Poster Session

2:15 PM – 4:15 PM

Organizers: **Mike Axtell**, University of St. Thomas
Kim Roth, Juniata College

MAA Panel Discussion

2:15 PM – 3:35 PM

Reporting progress: A minisymposium of projects from the NSF Mathematics and Science Partnership program.

Organizers: **Richard Alo**, National Science Foundation
Ron Buckmire, National Science Foundation
Daniel Maki, Indiana University
Lee Zia, National Science Foundation

Panelists: **Amy Cohen**, Rutgers University
Sabrina Hessinger, Armstrong Atlantic State University
Jim Lewis, University of Nebraska
Glenn Stevens, Boston University

SIGMAA on Statistics Education/ASA-MAA Joint Committee on Statistics Education Panel Discussion

2:15 PM – 3:35 PM

Statistics and probability in the Common Core State Standards.

Organizers: **Nancy Boynton**, SUNY Fredonia
Gail Burrill, Michigan State University
Ann Watkins, California State University, Northridge

Panelists: **Christine Franklin**, University of Georgia
Joan Garfield, University of Minnesota
Roxy Peck, California Polytechnic State University, San Luis Obispo
J. Michael Shaughnessy, National Council of Teachers of Mathematics
Andrew Zieffler, University of Minnesota

AWM Panel Discussion

2:15 PM – 3:40 PM

Maintaining an active research career through collaboration.
Organizers: **Christina Sormani**, CUNY and Lehman College
Ami Radunskaya, Pomona College
Ruth Haas, Smith College
Moderator: **Ami Radunskaya**
Panelists: **Ruth Haas**
Trachette L. Jackson, University of Michigan
Jill Pipher, Brown University
Urlica Wilson, Morehouse College

MAA Invited Address

3:20 PM – 4:10 PM

(667) *Phylogenetic algebraic geometry.*
Seth M. Sullivant, North Carolina State University (1077-A0-5)

AWM Business Meeting

3:45 PM – 4:15 PM

MAA Panel Discussion

3:50 PM – 5:10 PM

Reporting progress: A minisymposium of projects from the NSF Course, Curriculum, and Laboratory Improvement/Transforming Undergraduate Education in STEM program.
Organizers: **Richard Alo**, National Science Foundation
Ron Buckmire, National Science Foundation
Lee Zia, National Science Foundation
Panelists: **Patrick Van Fleet**, University of St. Thomas
Jerry Lodder, New Mexico State University
Lang Moore, Duke University
Deborah Nolan, University of California, Berkeley

MAA Section Officers

4:00 PM – 5:00 PM

Chair: **Rick Gillman**, Valparaiso University

Reception for Undergraduate Students

4:00 PM – 5:00 PM

AMS Committee on the Profession Panel Discussion

4:30 PM – 6:00 PM

Supply, demand, and the math Ph.D. program.
Organizer: **Julius Zelmanowitz**, University of California, Berkeley
Moderator: **Julius Zelmanowitz**
Panelists: **Nancy Heinschel**, National Science Foundation
Ellen Kirkman, Wake Forest University

MAA Minicourse #5: Part A

4:45 PM – 6:45 PM

Dance and mathematics.
Presenters: **Leon Harkleroad**, Bowdoin College
Karl Schaffer, De Anza College

MAA Minicourse #12: Part A

4:45 PM – 6:45 PM

Using randomization methods to build conceptual understanding of statistical inference.
Presenters: **Robin Lock**, St. Lawrence University
Patti Frazer Lock, St. Lawrence University
Kari F. Lock, Harvard University/Duke University
Eric F. Lock, University of North Carolina
Dennis F. Lock, Iowa State University

SIGMAA on the History of Mathematics Reception, Business Meeting, and Guest Lecture

5:30 PM – 7:15 PM

5:30PM Reception and business meeting.
6:30PM *Heron, Newton, Euler, and Barney.*
► (668) **William Dunham**, Muhlenberg College (1077-A0-2560)

Reception for Graduate Students and First-Time Participants

5:30 PM – 6:30 PM

AMS Josiah Willard Gibbs Lecture

8:30 PM – 9:30 PM

(669) *A 250-year argument: Belief, behavior, and the bootstrap.*
Bradley Efron, Stanford University (1077-62-13)

Thursday, January 5

Joint Meetings Registration

7:30 AM – 4:00 PM

AMS-MAA Special Session on the History of Mathematics, III

8:00 AM – 11:50 AM

Organizers: **Sloan Despeaux**, Western Carolina University
Craig Fraser, University of Toronto
Deborah Kent, Hillsdale College

8:00AM ► (670) *The Genius in Mathematics.* **Anjing Qu**, Northwest University, Xian, China (1077-01-1459)

8:30AM (671) *Analogies between algebra and number theory: Some uses of congruences in France between 1801 and 1850.* **Jenny Boucard**, Institut de Mathématiques de Jussieu (Paris) (1077-01-1816)

9:00AM (672) *The teaching of Algebra in France (1809-1914).* **Caroline Ehrhardt**, ENS-Lyon/Institut français de l'éducation, Service d'histoire de l'éducation (1077-01-2033)

9:30AM (673) *Linear groups in Galois fields between France and the U.S.A. at the turn of the 20th century.* **Frédéric Brechenmacher**, University of Lille-North of France (U. Artois). Laboratoire de mathématiques de Lens. (1077-01-1248)

10:00AM (674) *Hans Frederik Blichfeldt.* **Sebastien Gauthier**, Institut Camille Jordan, Université Lyon 1 - Claude Bernard (1077-01-1514)

10:30AM ► (675) *Cambridge mathematics in the north: Peter Guthrie Tait, Philip Kelland and the local nature of mathematics in Edinburgh, 1858-1865.* **Josipa Petrunic**, Institute for the History and Philosophy of Science and Technology, University of Toronto (1077-01-1532)

11:00AM ► (676) *Mathematics for Public Consumption: Augustus De Morgan's Anonymous Reviews for the Athenaeum.* Preliminary report. **Sloan Evans Despeaux**, Western Carolina University (1077-01-1530)

11:30AM ► (677) *Rhetorics of international communication and cooperation: Mittag-Leffler and Swedish mathematics, 1880-1920.* Preliminary report. **Laura E. Turner**, University of Artois (1077-01-2385)

AMS-SIAM Special Session on the Mathematics of Computation: Differential Equations, Linear Algebra, and Applications, II

8:00 AM – 11:50 AM

Organizers: **Chi-Wang Shu**, Brown University
Susanne C. Brenner, Louisiana State University

8:00AM (678) *A balanced finite element method for singularly perturbed reaction-diffusion problems.* **Runchang Lin***, Texas A&M International University, and **Martin Stynes**, National University of Ireland (1077-65-635)

8:30AM (679) *Finite Element Methods for the Displacement Obstacle Problem of Clamped Plates.* **Susanne C. Brenner**, **Li-yeng Sung**, **Hongchao Zhang** and **Yi Zhang***, Louisiana State University (1077-65-1754)

9:00AM (680) *Finite dimensional approximations of nonlocal diffusion and peridynamic models.* **Qiang Du**, Penn State University (1077-65-2140)

9:30AM (681) *Domain decomposition preconditioners for the discontinuous Petrov-Galerkin method.* Preliminary report. **Andrew T. Barker***, **Susanne C. Brenner** and **Li-Yeng Sung**, Louisiana State University (1077-65-1579)

10:00AM (682) *HDG Methods for the Vorticity-Velocity-Pressure Formulation of the Stokes Problem.* **Bernardo Cockburn** and **Jintao Cui***, University of Minnesota (1077-65-528)

10:30AM (683) *Analysis of HDG methods for the Navier-Stokes equations.* Preliminary report. **Aycil Cesmelioglu***, University of Minnesota, **Bernardo Cockburn**, University of Minnesota, **Ngoc Cuong Nguyen** and **Jaime Peraire**, Department of Aeronautics and Astronautics, Massachusetts Institute of Technology (1077-65-1583)

11:00AM ► (684) *A non-conforming Generalized Finite Element Method for Transmission Problems.* **Anna L. Mazzucato**, **Victor Nistor** and **Qingqin Qu***, Penn State University (1077-65-2220)

11:30AM (685) *A Two-grid Method for Semilinear Interface Problems.* Preliminary report. **Holst Michael**, **Ryan Szypowski** and **Yunrong Zhu***, University of California at San Diego (1077-65-1482)

AMS-ASL Special Session on the Life and Legacy of Alan Turing, III

8:00 AM – 11:40 AM

Organizers: **Damir Dzhafarov**, University of Chicago and University of Notre Dame
Jeff Hirst, Appalachian State University
Carl Mummert, Marshall University

8:00AM (686) *E-Recursion Theory.* **Gerald E. Sacks**, Harvard University, MIT (1077-03-1686)

9:00AM ► (687) *The universal Turing machine, and Turing operators.* **Julia F. Knight**, University of Notre Dame (1077-03-449)

9:30AM ► (688) *Turing's Influence on Computational Complexity.* **Lance Fortnow**, Northwestern University (1077-68-398)

10:00AM (689) *A small step beyond the Turing degrees.* **Joseph S. Miller**, University of Wisconsin - Madison (1077-03-2897)

10:30AM (690) *Ordinal logics and proof theory.* **Grigori Mints**, Stanford University (1077-03-388)

11:00AM (691) *The Mathematics of Relative Definability.* **Theodore A Slaman**, University of California, Berkeley (1077-03-2706)

AMS Special Session on Classical Fourier Analysis and Partial Differential Equations, III

8:00 AM – 11:50 AM

Organizers: **William O. Bray**, University of Maine
Mark A. Pinsky, Northwestern University

8:00AM (692) *Stationary Navier-Stokes equations with singular external forces.* **Cong Phuc Nguyen**, Louisiana State University, and **Tuoc Van Phan***, University of Tennessee (1077-35-510)

8:30AM (693) *The critical density property and Harnack's inequality in spaces of homogeneous type.* Preliminary report.
Sharad Deep Silwal*, **Diego Maldonado**, Kansas State University, and **Sapto Indratno**, Bandung Institute of Technology (1077-35-74)

9:00AM (694) *Exponential Operator Splitting for the generalized Kawahara equation.*
Pablo U Suarez, Delaware State University (1077-35-183)

9:30AM (695) *Dispersive estimates for Schrödinger operators in dimension two with obstructions at zero energy.*
M Burak Erdoğan, University of Illinois at Urbana-Champaign, and **William R Green***, Eastern Illinois University (1077-35-64)

10:00AM (696) *The regularity problem for the Lamé system on curvilinear polygons in two dimensions.*
Katharine Ott*, University of Kentucky, and **Irina Mitrea**, Temple University (1077-35-1836)

10:30AM (697) *A proof of a Theorem of Boutet de Monvel.* Preliminary report.
Matthew B. Stenzel, Ohio State University at Newark (1077-58-1928)

11:00AM (698) *Unimodular Fourier Multipliers On Modulation Spaces.* Preliminary report.
Jiecheng Chen, Zhejiang University, P.R.China, **Dashan Fan** and **Lijing Sun***, University of Wisconsin-Milwaukee (1077-35-526)

11:30AM (699) *The Muckenhoupt-type estimations for the best constants in multidimensional modular inequalities over spherical cones.*
Chang-pao Chen*, Hsuan Chuang University, **Jin-Wen Lan**, National Tsing Hua University, and **Dah-Chin Luor**, I-Shou University (1077-42-1056)

AMS Special Session on Climate Modeling and Geophysical Fluid Dynamics, I

8:00 AM – 11:20 AM

Organizers: **Qingshan Chen**, Florida State University
Nathan Glatt-Holtz, Indiana University
Mickael Chekroun, University of California, Los Angeles

9:00AM (700) *Impact of Non-Gaussian Random Boundary Conditions on a Burgers-Boussinesq System.*
Jinqiao Duan, Institute for Pure and Applied Math, Los Angeles & Dept of Applied Math, Illinois Institute of Technology, Chicago (1077-60-2529)

9:30AM (701) *Parameter estimation for energy balance models with memory.* Preliminary report.
Mickael D. Chekroun*, Department of Atmospheric & Oceanic Sciences and IGPP, UCLA, **Lionel Roques**, UR 546 Biostatistique et Processus Spatiaux, INRA, **Michel Cristofol**, Université Aix-Marseille, LATP, **Samuel Soubeyrand**, UR 546 Biostatistique et Processus Spatiaux, INRA, and **Michael Ghil**, Geosciences Department and Laboratoire de Météorologie Dynamique (CNRS and IPSL) (1077-35-2575)

10:00AM ► (702) *Uncertainty quantification in the simulation of quasi-one-dimensional nozzle flow.* Preliminary report.
Yanyan He*, **Yousuff Hussaini** and **Jonghoon Bin**, Florida State University (1077-60-2126)

10:30AM ► (703) *Correcting flow estimates in Chesapeake Bay using data assimilation.*
Matthew J Hoffman, Rochester Institute of Technology (1077-86-2741)

11:00AM ► (704) *A stochastic model for tropical rainfall and extreme events.*
Samuel N Stechmann*, Department of Mathematics, and Department of Atmospheric and Oceanic Sciences, University of Wisconsin-Madison, and **J David Neelin**, Department of Atmospheric and Oceanic Sciences, and Institute of Geophysics and Planetary Physics, UCLA (1077-60-2405)

AMS Special Session on Combinatorial Geometry of Polytopes, I

8:00 AM – 11:50 AM

Organizers: **Egon Schulte**, Northeastern University
Asia Ivic Weiss, York University

8:00AM (705) *Semiregular Polytopes and Amalgamated C-Groups.* Preliminary report.
Egon Schulte, Northeastern University (1077-05-801)

8:30AM ► (706) *Resent developments about Colorful Polytopes.* Preliminary report.
Deborah Oliveros*, UNAM, **Gabriela Araujo**, **Hubard Isabel**, UNAM., and **Egon Schulte**, Northeastern University (1077-51-1483)

9:00AM ► (707) *Theory and examples of ghost symmetry.*
David Richter, Western Michigan University (1077-51-544)

9:30AM (708) *Strengthening Fary's Theorem: Convex and Star-Shaped Realizations of Polyhedral Complexes.*
Stedman M. Wilson* and **Igor Pak**, University of California, Los Angeles (1077-52-878)

10:00AM (709) *Constructing self-Petrie and self-dual covers of regular polyhedra.*
Gabe Cunningham, Northeastern University (1077-52-814)

10:30AM (710) *The width of 4-prismatoids.*
Francisco Santos, Universidad de Cantabria, **Tamon Stephen***, Simon Fraser University, and **Hugh Thomas**, University of New Brunswick (1077-52-1301)

11:00AM ► (711) *Two-Orbit Polytopes with Two Facet Types.* Preliminary report.
Ilanit Helfand, Northeastern University (1077-05-811)

11:30AM Discussion

AMS Special Session on Computational and Applied Topology (Mathematics Research Communities session), I

8:00 AM – 11:50 AM

Organizers: **Radmila Sazdanovic**, University of Pennsylvania
Daniel Muellner, Stanford University
Mikael Vejdemo-Johansson, University of St. Andrews

8:00AM (712) *Oscillatory solutions of fourth order conservative systems via the Conley index.*
Miroslav Kramar*, Rutgers, **J Van den Berg** and **R. Van der Vorst**, Free University Amsterdam (1077-55-1002)

8:30AM (713) *Quantifying Patterns in a Coupled-Patch Population Model.*
Sarah Day*, The College of William and Mary, and **Benjamin Holman**, University of Arizona (1077-37-1362)

9:00AM (714) *Homology and Robustness of Level and Interlevel Sets.*
Paul Bendich, Duke University, **Herbert Edelsbrunner**, IST Austria, **Dmitriy Morozov***, Lawrence Berkeley National Lab, and **Amit Patel**, Rutgers University (1077-55-2265)

9:30AM ► (715) *Computing Well Diagrams for Vector Fields in $\mathbb{R}^n$.*
Primoz Skraba, Jozef Stefan Institute (1077-68-2114)

10:00AM (716) *Obstruction-Theoretic Sensing.* Preliminary report.
Justin Michael Curry, University of Pennsylvania (1077-55-1709)

10:30AM ► (717) *Evasion Paths in Mobile Sensor Networks.* Preliminary report.
Henry Adams, Stanford University (1077-55-1678)

11:00AM ► (718) *Persistent homology and statistical inference.* Preliminary report.
Peter Bubenik, Cleveland State University (1077-55-2042)

11:30AM (719) *Finite Coverage Processes and Homology of Random Sets.* Preliminary report.
Rafal Komendarczyk and **Jeffrey Pullen***, Tulane University (1077-57-985)

AMS Special Session on Differential Algebraic Geometry and Galois Theory (in memory of Jerald Kovacic), I

8:00 AM – 11:50 AM

Organizers: **Phyllis Joan Cassidy**, Smith College and the City University of New York
Richard Churchill, Hunter College and Graduate Center at CUNY
Claude Mitschi, Université de Strasbourg, France
Michael Singer, North Carolina State University

8:00AM (720) *Automorphisms of Hurwitz series.*
William F. Keigher*, Rutgers University, Newark Campus, and **V. Ravi Srinivasan**, Catholic University of America (1077-13-1231)

8:30AM (721) *Cohomology of Differential Schemes.* Preliminary report.
Raymond T Hoobler, City College of New York and Graduate Center, CUNY (1077-14-511)

9:00AM (722) *Classification of Algebraic Subgroups of Lower Order Unipotent Algebraic Groups.* Preliminary report.
V. Ravi Srinivasan, Catholic University of America (1077-12-530)

9:30AM (723) *Higher variationnal equations between Kolchin solvability and virtual Abelianity.*
Guillaume Duval, INSA de Rouen (France) (1077-20-394)

10:00AM (724) *Descent for differential Galois theory of difference equations. Confluence and q-dependency.* Preliminary report.
Lucia Di Vizio*, Laboratoire de Mathématiques de Versailles, and **Charlotte Hardouin**, Institut de mathématiques de Toulouse (1077-39-968)

10:30AM (725) *Solvability of difference Riccati equations.*
Seiji Nishioka, Aoyama Gakuin University (1077-12-299)

11:00AM (726) *Galois theory of strongly normal differential and difference extensions.*
Michael Wibmer, RWTH Aachen (1077-12-600)

11:30AM (727) *The ring of global sections of a differential scheme.*
Dmitry Trushin, Hebrew University of Jerusalem (1077-12-596)

AMS Special Session on Fractal Geometry in Pure and Applied Mathematics (in memory of Benoit Mandelbrot), II

8:00 AM – 11:50 AM

Organizers: **Michael L. Lapidus**, University of California, Riverside
Erin Pearse, University of Oklahoma
Machiel van Frankenhuijsen, Utah Valley University

8:00AM (728) *The algebraic geometry of Harper operators.*
Dan Li, Florida State University (1077-70-1960)

8:30AM ► (729) *Extreme risk and fractal regularity in finance.*
Laurent E Calvet, Department of Finance, HEC Paris (1077-91-2303)

9:00AM (730) *The Weierstrass function and Fractional Brownian motion.*
Murad S. Taqqu, Boston University (1077-60-898)

9:30AM ► (731) *Magic fractal distribution trees in living systems: 1-Implication for evolution theory 2-Role of randomness.* Preliminary report.
Bernard Sapoval, Physique de la Matière Condensée,Ecole Polytechnique-CNRS (1077-92-1494)

10:00AM ► (732) *The landscape of Anderson localization in a disordered medium.*
Marcel Filoche*, Ecole Polytechnique, CNRS, and **Svitlana Mayboroda**, University of Minnesota (1077-35-2011)

10:30AM ► (733) *Fractal Antennas, Resonators, and Invisibility Cloaks: Nuggets from the Tortuous Path.*
Nathan Cohen, Fractal Antenna Systems,Inc. (1077-94-2760)

11:00AM ► (734) *Fractal geometry: a pathway to understanding biodiversity.*
Mark E Ritchie, Syracuse University (1077-92-2516)

11:30AM (735) *Physical Analogues of Peano Curves: from genome folding to new symmetries.*
Adrian Sanborn, **Jian Li**, Harvard University, and **Erez Lieberman Aiden***, Harvard Society of Fellows (1077-92-2339)

AMS Special Session on Groups, Algorithms, Complexity, and Theory of Security, III

8:00 AM – 11:50 AM

Organizers: **Maggie Habeeb**, City University of New York
Delaram Kahrobaei, City University of New York

8:00AM (736) *A More Efficient Approach to Bayesian Variable Selection.*
Eric R Ruggieri, Duquesne University (1077-62-1198)

8:30AM (737) *Schreier graphs and Schreier dynamical system of the action of Thompson's group F on the Cantor set.*
Dmytro M Savchuk, Binghamton University (1077-20-1887)

9:00AM (738) *Some Observations Involving the Baumslag groups $G(m,n)$.*
Anthony E Clement, Brooklyn College, City University of New York (1077-20-1297)

9:30AM (739) *From indexed languages to generating functions.*
Jared Adams, **Eric M Freden***, Southern Utah University, and **Marni Mishna**, Simon Fraser University (1077-05-864)

10:00AM (740) *Abelian extensions of orthogonal Lie algebras in E_6 and E_8.*
Andrew Douglas*, **Delaram Kahrobaei**, City University of New York, and **Joe Repka**, University of Toronto (1077-17-1454)

10:30AM (741) *Twin Towers of Hanoi: diameters of coupled graphs.* Preliminary report.
Zoran Sunic, Texas A&M University (1077-20-2767)

11:00AM ► (742) *Permutational isomorphism of permutation groups.*
László Babai, The University of Chicago, **Paolo Codenotti***, IMA, University of Minnesota, and **Youming Qiao**, Tsinghua University (1077-68-1334)

11:30AM ► (743) *Quantum Algorithms for Fixed Points and Invariant Subgroups.*
Stephen Majewicz, Kingsborough Community College (1077-20-902)

AMS Special Session on Hyperbolicity in Manifolds and Groups, III

8:00 AM – 11:50 AM

Organizers: **David Futer**, Temple University
Genevieve Walsh, Tufts University

8:00AM (744) *How do you build examples?*
David Ben McReynolds, Purdue University (1077-20-1826)

8:30AM (745) *Hyperbolicity and measure in Teichmüller space.*
Spencer Dowdall, UIUC, **Moon Duchin***, Tufts University, and **Howard Masur**, University of Chicago (1077-51-1685)

9:00AM (746) *Dynamics of non-classical interval exchanges.*
Vaibhav Gadre, Harvard University (1077-51-933)

9:30AM (747) *On convex and non-convex Fuchsian polyhedral realizations of hyperbolic surfaces with a single conical singularity.*
Jaejeong Lee, Seoul, South Korea, and **Kei Nakamura***, Temple University (1077-57-2910)

10:00AM (748) *Hyperbolic directions in Teichmuller space equipped with the Lipschitz metric.*
Jing Tao, University of Utah (1077-51-1007)

10:30AM ► (749) *Embeddability between Right-Angled Artin Groups.*
Sang-hyun Kim*, KAIST, and **Thomas Koberda**, Harvard University (1077-20-1209)

11:00AM (750) *The geometry of right-angled Artin subgroups of mapping class groups.*
Matt T. Clay, Allegheny College, **Christopher J. Leininger**, University of Illinois at Urbana-Champaign, and **Johanna Mangahas***, Brown University (1077-57-1331)

11:30AM (751) *Invariant random subgroups of Lie groups.*
Ian P Biringer, New Haven (1077-51-2347)

AMS Special Session on Knot Theory, I

8:00 AM – 11:50 AM

Organizers: **Tim Cochran**, Rice University
Shelly Harvey, Rice University

8:00AM (752) *Virtual Knot Theory - State Sum Invariants.* Preliminary report.
Louis H Kauffman, University of Illinois at Chicago (1077-57-699)

8:30AM (753) *Virtual knots and Khovanov Homology.*
Heather A Dye*, McKendree University, **Louis Kauffman**, University of Illinois at Chicago, and **Aaron Kaestner**, North Park University (1077-57-508)

9:00AM (754) *A new generalization of the Khovanov Homology.* Preliminary report.
Ik Jae Lee, Kansas State University (1077-18-114)

9:30AM (755) *Strong L-Spaces and Left Orderability.*
Adam Simon Levine*, Brandeis University, and **Sam Lewallen**, Princeton University (1077-57-1801)

10:00AM (756) *A relationship between categorified braid invariants from representation theory and Floer theory.* Preliminary report.
Denis Auroux, University of California, Berkeley, **J. Elisenda Grigsby***, Boston College, and **Stephan M. Wehrli**, Syracuse University (1077-57-1882)

10:30AM (757) *A new filtration of the Magnus kernel of the Torelli group.*
R. Taylor McNeill, Rice University (1077-57-1343)

11:00AM (758) *Embeddings of contact solid tori and Legendrian cable knots.*
Douglas J LaFountain*, Aarhus University, **John B Etnyre** and **Bülent Tosun**, Georgia Institute of Technology (1077-57-749)

11:30AM (759) *Unstable Vassiliev theory.*
Chad D Giusti, Willamette University (1077-55-98)

AMS Special Session on Mathematics in Natural Resource Modeling, III

8:00 AM – 11:50 AM

Organizer: **Catherine Roberts**, College of the Holy Cross

8:00AM ► (760) *The environmental impact on sustainable forest management.* Preliminary report.
Natali Hritonenko*, Prairie View A&M University, **Yuri Yatsenko**, HBU, and **Renan Goetz**, University of Girona (1077-92-608)

8:30AM (761) *Optimally Fragmenting Graphs Against Stochastically-located Threats: Balancing Preventative and Real-time Actions in Wildfire Containment.*
Gwen Spencer* and **David Shmoys**, Cornell University (1077-90-1978)

9:00AM ► (762) *Effect of Gravity in Diffusive Thermal Instabilities of Diffusion Flames.*
Joseph E Hibdon, Jr*, Northeastern Illinois University, and **Moshe Matalon**, University of Illinois at Urbana-Champaign (1077-76-1864)

9:30AM ► (763) *Multiscale methods for seismic imaging.*
Susan E. Minkoff, University of Maryland Baltimore County (1077-86-2488)

10:00AM ► (764) *A Bayesian Model Identifying Locations At Risk From Human-Transported Exotic Pathogens.*
Steven C McKelvey*, St. Olaf College, **Frank H Koch**, **William D Smith**, USDA Forest Service, and **Kelly R Hawley**, Best Buy, Inc. (1077-60-648)

10:30AM ► (765) *Temporally variable dispersal and demography can accelerate the spread of invading species.*
Stephen P. Ellner, Cornell University, and **Sebastian J. Schreiber***, University of California, Davis (1077-92-1571)

11:00AM ► (766) *Mathematical modeling for the improvement of sustainable pest management: a trap cropping example.*
Matthew H. Holden*, Cornell University, **Stephen P Ellner**, Ecology and Evolutionary Biology/Cornell University, **Doo-Hyung Lee**, **Jan P Nyrop** and **John P Sanderson**, Entomology/Cornell University (1077-92-690)

11:30AM ► (767) *To eradicate or not to eradicate: Economic optima for spatial immunizing infections.*
Petra Klepac, Princeton University (1077-92-1871)

AMS Special Session on New Perspectives in Multiplicative Number Theory (Mathematics Research Communities session), I

8:00 AM – 11:40 AM

Organizers: **Leo Goldmakher**, University of Toronto
Jonathan Kish, University of Colorado at Boulder
Micah Milinovich, University of Mississippi
Paul Pollack, University of British Columbia/Simon Fraser University

8:00AM (768) *A Weighted Selberg Sieve.* Preliminary report.
C S Franze, Central Michigan University (1077-11-2445)

8:30AM (769) *On the maximum number of consecutive integers on which a character is constant.*
Enrique Trevino, Swarthmore (1077-11-1736)

9:00AM (770) *The distribution of character sums.*
Jonathan W Bober*, University of Washington, and **Leo Goldmakher**, University of Toronto (1077-11-2214)

9:30AM (771) *On the divisors of $x^n - 1$.*
Lola Thompson, Dartmouth College (1077-11-2093)

10:00AM (772) *Large odd order character sums.*
Youness Lamzouri*, University of Illinois at Urbana-Champaign, and **Leo Goldmakher**, University of Toronto (1077-11-1742)

10:30AM (773) *When is a multiplicative function small on average?*
Dimitris Koukoulopoulos, CRM, Universite de Montreal (1077-11-2166)

11:00AM (774) *The latest pretensions.* Preliminary report.
Andrew Granville, University of Montreal (1077-11-1619)

AMS Special Session on Optimal Control in Applied Mathematical Modeling, II

8:00 AM – 11:50 AM

Organizers: **Natali Hritonenko**, Prairie View A&M University
Yuri Yatsenko, Houston Baptist University

8:00AM (775) *Two-dimensional interaction of weakly nonlinear solitary waves in shallow water: Mach reflection for the Benney-Luke equation and the KP equation.*
Kenichi Maruno*, The University of Texas - Pan American, **Yuji Kodama**, Ohio State University, **Hidekazu Tsuji**, Kyushu University, and **Bao-Feng Feng**, The University of Texas - Pan American (1077-76-1190)

8:30AM (776) *Nonlinear parametric Neumann problems with bifurcation and control properties.*
Dumitru Motreanu, University of Perpignan, France (1077-35-515)

9:00AM (777) *Optimization under Uncertainty and Algorithmic Correlation of Random Variables - Practice.*
Thomas R Fielden*, Portland, Oregon, and **Steven A Bleiler**, Portland State University (1077-60-1659)

9:30AM (778) *Optimization under Uncertainty and Algorithmic Correlation of Random Variables: Theory.* Preliminary report.
Steven A Bleiler*, Portland State University, and **Thomas R Fielden**, Portland, Oregon (1077-60-1105)

10:00AM (779) *Optimal Control of Variational Inequalities.*
Janos Turi* and **Alain Bensoussan**, University of Texas at Dallas (1077-49-936)

10:30AM (780) *Time-and-age distributed controls in economic and management applications.*
Natali Hritonenko*, Prairie View A&M University, and **Yuri Yatsenko**, Houston Baptist University (1077-90-721)

11:00AM (781) *Optimal R & D Spending and Competition Between Firms.* Preliminary report.
Jannett Highfill and **Michael McAsey***, Bradley University (1077-49-365)

11:30AM (782) *Stochastic Multi-scale Modeling Suggests the Molecular Basis of Calcium-Entrained Cardiac Arrhythmia.*
M. Saleet Jafri*, **Minh Tuan Hoang-Trong**, George Mason University, **George S. B. Williams** and **W. Jonathan Lederer**, University of Maryland Baltimore (1077-92-2345)

AMS Special Session on Progress in Free Analysis, I

8:00 AM – 11:40 AM

Organizers: **J. William Helton**, University of California, San Diego
Paul S. Muhly, University of Iowa

8:00AM (783) *Convex Positivstellensatz, linear matrix inequalities and complete positivity.* Preliminary report.
Igor Klep*, Univerza v Ljubljani, **J. William Helton**, University of California at San Diego, **Scott McCullough**, University of Florida, Gainesville, and **Markus Schweighofer**, University of Konstanz (1077-46-1227)

9:00AM (784) *Free Biholomorphic Functions and Operator Model Theory.*
Gelu F Popescu, University of Texas at San Antonio (1077-47-509)

10:00AM (785) *Some Applications of Non-Commutative Functions in Free Analysis.*
Mihai Popa, Queen's Unversity (1077-46-1791)

11:00AM ► (786) *What are the eigenvalues of the sum of two Hermitian matrices? A quantum information inspired answer.*
Alan Edelman, Massachusetts Institute of Technology (1077-60-2170)

AMS Special Session on Rational Points on Varieties, I

8:00 AM – 11:50 AM

Organizers: **Jennifer Balakrishnan**, Massachusetts Institute of Technology
Bjorn Poonen, Massachusetts Institute of Technology
Bianca Viray, Brown University
Kirsten Wickelgren, Harvard University

8:00AM (787) *The rational points on a recalcitrant genus 12 curve.*
Ralph Greenberg, University of Washington, **Karl Rubin**, UCI, **Michael Stoll**, Universitat Bayreuth, and **Alice Silverberg***, University of California, Irvine (1077-11-777)

8:30AM (788) *Twists of Shimura Curves.*
James Henry Stankewicz, University of Georgia (1077-11-1155)

9:00AM (789) *A descent map for curves with totally degenerate semi-stable reduction.*
Shahed Sharif, CSU San Marcos (1077-11-1592)

9:30AM (790) *Siegel's Theorem and the Shafarevich Conjecture.* Preliminary report.
Aaron Levin, Michigan State University (1077-11-1753)

10:00AM (791) *Hilbert's Tenth Problem for function fields of positive characteristic.*
Kirsten Eisentraeger, The Pennsylvania State University (1077-11-1200)

10:30AM (792) *Integral points on elliptic curves and explicit valuations of division polynomials.*
Katherine E Stange, Stanford University (1077-11-1233)

11:00AM (793) *The Distribution of 2-Selmer Ranks of Quadratic Twists of Elliptic Curves.*
Zev Klagsbrun, University of Wisconsin - Madison (1077-11-1268)

11:30AM (794) *Elliptic division and unramified correspondence.*
Fedor A. Bogomolov, Courant Institute of Mathematical Sciences, New York University (1077-11-1884)

AMS Special Session on Theory and Applications of Stochastic Differential and Partial Differential Equations, I

8:00 AM – 11:50 AM

Organizers: **Edward Allen**, Texas Tech University
Mahmoud Anabtawi, American University of Sharjah
Armando Arciniega, University of Texas at San Antonio
Gangaram S. Ladde, University of South Florida
Sivapragasam Sathananthan, Tennessee State University

8:00AM ► (795) *Energy/Lyapunov Function Method for Solving Stochastic Differential Equations.*
Gangaram S. Ladde, University of South Florida at Tampa (1077-34-1092)

8:30AM (796) *Qualitative Analysis of Stochastic Theta Methods for SDEs.*
Henri Schurz, Southern Illinois University (1077-60-1065)

9:00AM (797) *Stochastic Differential Equations of the Wick Type.* Preliminary report.
Fariborz Asadian, Fort Valley State University (1077-60-915)

9:30AM (798) *Stability properties of stochastic logistic models.* Preliminary report.
Janusz S Golec, Fordham University (1077-60-1003)

10:00AM ► (799) *Hybrid Impulsive Control of Stochastic Systems with Multiplicative Noise under Markovian Switching.*
S. Sathananthan, **N. Jordan Jameson*** and **M. J. Knap**, Tennessee State University (1077-93-325)

10:30AM (800) *Pathwise Convergence Rate for Numerical Solutions of Stochastic Differential Equations.*
Son Luu Nguyen*, Carleton University, and **George Yin**, Wayne State University (1077-60-1797)

11:00AM (801) *Asymptotic Properties of Consensus-Type Algorithms for Networked Systems with Regime-Switching Topologies.*
G. Yin, **Yu Sun*** and **Le Yi Wang**, Wayne State University (1077-60-330)

11:30AM (802) *Existence Results for Some Higher-Order Nonautonomous Differential Equations in Hilbert Space.* Preliminary report.
Toka Diagana, Howard University - Washington DC (1077-34-681)

AMS Special Session on the Geometry of Real Projective Structures (Mathematics Research Communities session), I

8:00 AM – 11:50 AM

Organizers: **Jeffrey Danciger**, Stanford University
Kelly Delp, Buffalo State College
Sean Lawton, University of Texas, Pan American
Kathryn Mann, University of Chicago

8:00AM (803) *Open problems in real projective structures on low-dimensional orbifolds.*
Suhyoung Choi, KAIST (1077-57-970)

9:00AM ► (804) *On Embedded Spheres of Closed Affine Manifolds.* Preliminary report.
Weiqiang Wu, University of Maryland - College Park (1077-51-408)

9:30AM ► (805) *Bi-Lipschitz Extension from Boundaries of Certain Gromov Hypebolic Spaces.*
Anton Lukyanenko, University of Illinois Urbana-Champaign (1077-51-371)

10:00AM (806) *Two-holed cross surfaces and their affine deformations.*
Todd A. Drumm*, Howard University, **Virginie Charette**, University of Sherbrooke, and **William M. Goldman**, University of Maryland, College Park (1077-51-1456)

11:00AM (807) *The Simple S^2-branched Cover Area of a Surface.* Preliminary report.
Aldo-Hilario Cruz-Cota* and **Teresita Ramirez-Rosas**, Grand Valley State University (1077-57-309)

11:30AM (808) *Volumes of Complex Hyperbolic Orbifolds.*
Ilesanmi Adeboye, Wesleyan University (1077-57-621)

AMS Session on Calculus of Variations, Optimal Control, and Optimization

8:00 AM – 9:40 AM

8:00AM ► (809) *Optimal Control of Projectile Motion with Sensitivity-Based Optimization.*
David C. Szurley, Francis Marion University (1077-49-2448)

8:15AM (810) *A Comparison of Derivative-Free Optimization Methods with Constraint Methods.*
Ahmad R Almomani* and **Katie R. Fowler**, Clarkson University (1077-49-1734)

8:30AM ► (811) *Existence of isoperimetric regions in R^n with density.*
Frank Morgan*, Williams College, and **Aldo Pratelli**, Universita di Pavia (1077-49-224)

8:45AM (812) *Solution of optimal control problems via combined block-pulse functions and polynomial series.*
Mohsen Razzaghi, Mississippi State University (1077-49-634)

9:00AM (813) *Geometric Applications of the Maximum Principle.*
Mostafa Ghandehari, University of Texas at Arlington (1077-49-180)

9:15AM (814) *A variational characterization of the effective yield set for ionic polycrystals.*
Farhod Abdullayev, North Dakota State University (1077-49-1034)

9:30AM (815) *Identification of Nerves in Ultrasound Scans Using a Modified Mumford-Shah Functional and Prior Information.*
Jung-Ha An*, California State University, Stanislaus, **Paul Bigeleisen**, Department of Anesthesiology/University of Maryland, and **Steven Damelin**, Georgia Southern University (1077-49-1645)

AMS Session on Combinatorics and Graph Theory, III

8:00 AM – 11:25 AM

8:00AM ► (816) *On the Permanent Rank of Matrices.*
Keivan Hassani Monfared, Graduate Student / University of Wyoming (1077-05-2438)

8:15AM ► (817) *Zero Forcing Numbers and Graph Powers.*
Carolyn Kim, Harvard University (1077-05-2793)

8:30AM ► (818) *Weak Discrepancy of Grids.* Preliminary report.
Katherine V. Johnson* and **A. J. Radcliffe**, University of Nebraska-Lincoln (1077-05-2425)

8:45AM (819) *Spectral properties of complex unit gain graphs.*
Nathan H Reff, Binghamton University (1077-05-2387)

9:00AM ► (820) *Fair Duels, Bad Shots, and Thue-Morse.*
Joshua N Cooper and **Aaron M Dutle***, University of South Carolina (1077-05-2473)

9:15AM ► (821) *Counting Large Distances in Convex Polygons: A Computational Approach.*
Filip Morić and **David Pritchard***, EPFL (1077-05-2386)

9:30AM Break.

9:45AM ► (822) *Some Results on Permutation Patterns.* Preliminary report.
Taylor F Allison, North Carolina State University (1077-05-2372)

10:00AM ► (823) *Maximizing the number of edges in optimal k-rankings.*
Rigoberto Florez, University of South Carolina Sumter, and **Darren A Narayan***, Rochester Institute of Technology (1077-05-2358)

10:15AM ► (824) *Degree Matrices of k-edge Colored Graphs.*
Kathleen M. Ryan* and **Garth Isaak**, Lehigh University (1077-05-2351)

10:30AM (825) *Generating Differential Equations for Multi-restricted Stirling numbers.* Preliminary report.
Ji Young Choi, Shippensburg University of PA (1077-05-2348)

10:45AM ► (826) *The negative q-Binomial.*
Shishuo Fu*, KAIST, Republic of Korea, **Victor Reiner**, **Dennis Stanton**, University of Minnesota, and **Nathaniel Thiem**, University of Colorado at Boulder (1077-05-2310)

11:00AM ► (827) *Modular-Distance Labelings of Graphs.* Preliminary report.
Joshua Hanes*, Mississippi University for Women, and **Tristan Denley**, Austin Peay State University (1077-05-2548)

11:15AM (828) *Strong Circuit Double Cover Conjecture in Special Cubic Graphs.* Preliminary report.
Wenliang Tang*, West Virginia University, **Erling Wei**, Renmin University of China, and **Cunquan Zhang**, West Virginia University (1077-05-2284)

AMS Session on Geometry and Differential Geometry, I

8:00 AM – 9:40 AM

8:00AM (829) *Large autotopism groups on translation planes.* Preliminary report.
Oscar Vega*, California State University, Fresno, **N. L. Johnson**, University of Iowa, and **Vikram Jha**, Glasgow United Kingdom. (1077-51-1591)

8:15AM (830) *A note on a topological geometrical interpretation of Bell's inequality and Hardy's quantum entanglement.*
S. I. Nada*, University of Qatar, and **El-naschie**, Alexandrie university,Egypt (1077-51-1211)

8:30AM ► (831) *Tetrahedron Discovers Itself : Frequency & Scale Change.* Preliminary report.
John Arden Hiigli, Le Jardin a l'Ouest (1077-51-1162)

8:45AM (832) *The Chen-type of some isoparametric hypersurfaces in the unit sphere.* Preliminary report.
Ivko M Dimitric, Pennsylvania State University Fayette, The Eberly Campus (1077-53-2899)

9:00AM (833) *Complete geometry on a Riemannian $\mathcal{A}$-module. Sylvester's theorem.*
Adaeze Christiana Anyaegbunam, University of Port Harcourt, Nigeria. (1077-51-65)

9:15AM ► (834) *Tiling a triangle with congruent triangles.*
Michael Beeson, San Jose State University (1077-51-488)

9:30AM (835) *Differential forms on contact quotients.* Preliminary report.
Fatima Mahmood, Cornell University (1077-53-2485)

AMS Session on Manifolds, Cell Complexes, and Global Analysis, I

8:00 AM – 10:40 AM

8:00AM (836) *Paths in the pants complex and bridge splittings of knots.*
Alexander M Zupan, University of Iowa (1077-57-2952)

8:15AM (837) *The sl(3) skein module.*
Jeffrey Boerner, Westminster College (1077-57-2806)

8:30AM (838) *The asymptotic expansion of the Witten-Reshetikhin-Turaev invariants.*
Benjamin Himpel* and **Jørgen Ellegaard Andersen**, Aarhus University, Denmark (1077-57-2374)

8:45AM (839) *Knots in handlebodies with handlebody surgeries.*
R. Sean Bowman, University of Texas, Austin (1077-57-2123)

9:00AM (840) *Squarepegs and Inscribed Polygons.* Preliminary report.
Jason Cantarella, University of Georgia, Athens, **Elizabeth Denne***, Smith College, and **John McCleary**, Vassar College (1077-57-1536)

9:15AM (841) *Mapping Cylinder Neighborhoods in Manifold Stratified Pairs.* Preliminary report.
Stacy L. Hoehn* and **C. Bruce Hughes**, Vanderbilt University (1077-57-2116)

9:30AM ► (842) *Genus 2 mutation of knots.* Preliminary report.
Allison H Moore, The University of Texas at Austin (1077-57-2235)

9:45AM (843) *Algebras Counting Minimal Intersection and Self-Intersection Numbers of Loops on a Surface.*
Patricia Cahn, Dartmouth College (1077-57-2121)

10:00AM (844) *The adjoint action on homotopy-associative H-spaces.*
Nicholas D. Nguyen, University of California San Diego (1077-57-1401)

10:15AM (845) *Circle Valued Generating Families and Legendrian Link Invariants.*
Christopher A Micklewright, Bryn Mawr College (1077-57-860)

10:30AM (846) *On the rotation class of knotted Legendrian tori in* $\mathbb{R}^5$. Preliminary report.
Ben McCarty* and **Scott Baldridge**, Louisiana State University (1077-57-760)

AMS Session on Probability Theory, Stochastic Processes, and Statistics, III

8:00 AM – 10:40 AM

8:00AM ► (847) *Beta-cauchy distribution and its applications.* Preliminary report.
Etaf Alshawarbeh*, **Felix Famoye** and **Carl Lee**, Central Michigan University (1077-62-1436)

8:15AM (848) *Invariant Theory for Hypothesis Testing on Graphs.*
Andrey Rukhin, Naval Surface Warfare Center Dahlgren Division (1077-62-428)

8:30AM ► (849) *Investigation of a Random Graph Model for Neuronal Connectivity.*
David J. Marchette*, Naval Surface Warfare Center, Dahlgren, VA, **Carey E. Priebe**, Johns Hopkins University, **Rebecca F. Goldin** and **Giorgio A. Ascoli**, George Mason University (1077-62-424)

8:45AM ► (850) *Solving Tolerance Optimization Problems for Complex Manufacturing Systems.*
Paul L. Goethals*, United States Military Academy, **Gregory L. Boylan** and **Byung Rae Cho**, Clemson University (1077-62-269)

9:00AM (851) *Identifying Gene Set Differences Between B-cell and T-cell Acute Lymphocytic Leukemia.* Preliminary report.
Jacob A Gagnon, Worcester Polytechnic Institute (1077-62-112)

9:15AM (852) *A Bayesian Semiparametric Approach for Incorporating Longitudinal Information on Exposure History for Inference in Case-Control Studies.*
Dhiman Bhadra*, Worcester Polytechnic Institute, **Michael Joseph Daniels**, University of Florida, Gainesville, **Sung Duk Kim**, Biostatistics and Bioinformatics Branch, Division of Epidemiology, Statistics, and Prevention Research, NIH, **Malay Ghosh**, University of Florida, Gainesville, and **Bhramar Mukherjee**, Department of Biostatistics, University of Michigan, Ann Arbor (1077-62-2202)

9:30AM ► (853) *On a hybrid method for variable selection.*
Daniel Vasiliu, Christopher Newport University (1077-62-2870)

9:45AM (854) *A Study on Tests of Symmetry with Ordered Alternatives in Higher Dimensional Contingency Tables.*
Ping Ye*, Quincy University, and **Bhaskar Bhattacharya**, Southern Illinois University, Carbondale (1077-62-138)

10:00AM (855) *Law of the iterated logarithm for the* L_2 *error of the wavelet density estimator.* Preliminary report.
Lu Lu, University of Connecticut (1077-62-119)

10:15AM ► (856) *Multivariate Nonparametric Ranking and Selection.* Preliminary report.
Jeremy Entner, Syracuse University (1077-62-144)

10:30AM (857) *Combinatorics and statistical issues related to the Kruskal-Wallis statistic.*
Raymond N. Greenwell*, Hofstra University, and **Anna E. Bargagliotti**, Loyola Marymount University (1077-62-53)

AMS Session on Undergraduate Research, III

8:00 AM – 11:25 AM

8:00AM ► (858) *Diagram vectors of frames and the tight frame scaling problem.*
Martin S. Copenhaver*, Georgia Institute of Technology, **Cortney Logan**, Stonehill College, **Kyanne Mayfield**, University of Portland, and **Jonathan Sheperd**, University of Notre Dame (1077-15-118)

8:15AM ► (859) *Pondering and Posing Problems and Proofs Pertaining to Perfect Order Subset Groups.* Preliminary report.
Ashley R. Taylor*, Univeristy of Central Oklahoma, and **Devin C Smith**, University of Central Oklahoma (1077-20-2020)

8:30AM ► (860) *Ecological Systems, Nonlinear Boundary Conditions, and* Σ*-Shaped Bifurcation Curves.* Preliminary report.
Kathryn Lois Ashley*, Clemson University, **Jerome Goddard II**, Auburn University Montgomery, and **Victoria Sincavage**, Clemson University (1077-34-1293)

8:45AM ► (861) *An Analytical Approach to Solving Green Oxidation Processes.*
Diego Torrejon, George Mason University (1077-34-1156)

9:00AM ► (862) *Tear-film dehydration of a soft contact lens.* Preliminary report.
Mihail Sharov, George Mason University (1077-35-1888)

9:15AM ► (863) *Modeling the Effects of the Fukushima Daiichi Nuclear Meltdown on the Marine Environment.* Preliminary report.
Bernard R Lipat* and **Rusty Laracuenti**, New Jersey City University (1077-35-2065)

9:30AM ► (864) *On Li-Yorke Measurable Sensitivity.* Preliminary report.
Lucas Manuelli, Princeton University, **Jared Hallett*** and **Cesar E. Silva**, Williams College (1077-37-2394)

9:45AM Break.

10:00AM ► (865) *Global Dynamics of Pulse-Coupled Oscillators.* Preliminary report.
Allison L. Corish*, **Sarah Day** and **M. Drew LaMar**, College of William & Mary (1077-37-2591)

10:15AM ► (866) *Nabla Discrete Fractional Calculus.*
Kevin Ahrendt, University of Nebraska-Lincoln, **Lucas Castle***, Lamar University, **Holm Michael**, University of Nebraska-Lincoln, and **Kathryn Yochman**, Rose Hulman Institute of Technology (1077-39-1406)

10:30AM ► (867) *Tilings with nonconvex pentagons.* Preliminary report.
Ping Ngai Chung*, Massachusetts Institute of Technology, **Niralee K. Shah**, Williams College, **Luis A. Sordo Vieira**, Wayne State University, and **Miguel A. Fernandez**, Truman State University (1077-51-1486)

10:45AM (868) *Minimal Pentagonal Tilings.*
Niralee Shah*, Williams College, **Luis Sordo Vieira**, Wayne State University, **Ping Ngai Chung**, Massachusetts Institute of Technology, and **Miguel Fernandez**, Truman State University (1077-51-2565)

11:00AM (869) *Some Applications of Differential Geometry in Studying Grain Growth and Non-local Calculus.*
Thinh D Le, Penn State University (1077-51-2771)

11:15AM ► (870) *The Wecken Property for Random Maps on Surfaces with Boundary.*
Matthew Donovan Griisser*, Georgia Institute of Technology, **Allison Miller**, Pomona College, and **Jacqueline Brimley**, Fairfield University (1077-55-1936)

MAA Session on Arts and Mathematics, Together Again, II

8:00 AM – 11:55 AM

Organizer: **Douglas E. Norton**, Villanova University

8:00AM ► (871) *Fourier Transform helps relaxation.*
Ricardo V Teixeira, University of Houston - Victoria (1077-B1-207)

8:20AM ► (872) *Semigroups, L-Systems, and Algorithmic Composition.* Preliminary report.
Marcus Pendergrass, Hampden-Sydney College (1077-B1-2954)

8:40AM ► (873) *On the geometry of music.* Preliminary report.
Benjamin Himpel, Aarhus University, Denmark (1077-B1-2365)

9:00AM ► (874) *Exploring the Mathematics of Tuning a Musical Instrument using Straws.*
Christine von Renesse, Westfield State University, MA (1077-B1-698)

9:20AM ► (875) *Composing with Mathematics: Final Projects in a Math and Music Course.*
Gareth E Roberts, College of the Holy Cross (1077-B1-2572)

9:40AM ► (876) *Three stories from the math-art frontier.* Preliminary report.
Luke Wolcott, University of Washington (1077-B1-894)

10:00AM ► (877) *Math/Art: Collaborative Practices.*
William Kronholm*, Whittier College, and **Aaron Bocanegra**, SCI-Arc (1077-B1-559)

10:20AM ► (878) *Creative Variations.*
Jennifer Wilson, Eugene Lang College the New School for Liberal Arts (1077-B1-2825)

10:40AM ► (879) *Fostering Artistic Explorations with Geometer's Sketchpad.*
Debra L. Hydorn, University of Mary Washington (1077-B1-2486)

11:00AM ► (880) *Improv Techniques for the Mathematics Classroom.* Preliminary report.
Andrea N Young, Ripon College (1077-B1-229)

11:20AM ► (881) *Mathematics in Literature and Cinema.* Preliminary report.
Mark Kozek, Whittier College (1077-B1-2296)

11:40AM ► (882) *Artists Respond to the Enigma of Alan Turing.*
Michael Olinick and **Robert P. Martin***, Middlebury College (1077-B1-219)

MAA Session on Mathematics Experiences in Business, Industry, and Government

8:00 AM – 11:15 AM

Organizers: **Carla D. Martin**, James Madison University
Phil Gustafson, Mesa State College
Michael Monticino, University of North Texas

8:00AM (883) *Reduction of the operation cost via optimal control of an industrial wastewater biotreatment process.*
Ellina V. Grigorieva*, Texas Woman's University, **Evgenii N. Khailov**, Lomonosov Moscow State Univeristy, Russia, and **Andrei Korobeinikov**, University of Limerick, Ireland (1077-G5-1378)

8:20AM ► (884) *Tires, Insurance and Clutches: Applications of Undergraduate Consulting.* Preliminary report.
John R Ramsay, The College of Wooster (1077-G5-2780)

8:40AM ► (885) *Visualizing semantic data through the use of partially ordered sets.* Preliminary report.
Emilie Hogan* and **Cliff Joslyn**, Pacific Northwest National Laboratory (1077-G5-2674)

9:00AM ► (886) *Cubic Splines, Local Extrema, and the Harmonic Mean: An Application to Graph Editors.*
James H. Fife, Educational Testing Service (1077-G5-324)

9:20AM ► (887) *Optimization in Fourier imaging for laser remote sensing.*
Thomas Höft, Tufts University (1077-G5-1922)

9:40AM ► (888) *Modeling GPS Interference.*
Joseph J. Rushanan, The MITRE Corporation (1077-G5-2112)

10:00AM ► (889) *Using Regression to Determine Cost Estimating Relationships for Costing of FAA Software.*
William S. Barfield, Quantech Services, Inc. (1077-G5-2293)

10:20AM ► (890) *New Metrics to Detect Suicide Bombers.*
William P. Fox, Naval Postgraduate School, Monterey, CA (1077-G5-520)

10:40AM ► (891) *Math in the City.*
Ananthnarayan Hariharan and **Lauren Keough***, University of Nebraska - Lincoln (1077-G5-775)

11:00AM ► (892) *"Careers in Mathematics" speakers series.*
Michael Dorff, Brigham Young University (1077-G5-2397)

MAA Session on My Most Successful Math Club Activity

8:00 AM – 11:55 AM

Organizers: **Jacqueline Jensen**, Slippery Rock University
Deanna Haunsberger, Carleton College

8:00AM ► (893) *Math Club Bingo.*
Jacqueline A. Jensen-Vallin, Slippery Rock University (1077-J5-658)

8:20AM (894) *The Calculus Bowl: A Fundraising Activity for the Mathematics Club.*
H. Smith Risser, **Casey Clark***, **Jay Rosencrantz**, **JoAnne McAllister**, **Jeff Winter** and **Stuart Fortier**, Montana Tech (1077-J5-2111)

8:40AM ► (895) *The Amazing Mathematical Race.*
Brooke E Buckley* and **Bethany A Noblitt**, Northern Kentucky University (1077-J5-755)

9:00AM (896) *Bringing Down The House?*
Kathryn Behrend Andrist, Utah Valley University (1077-J5-1099)

9:20AM ► (897) *Solidly Platonic: Hood College's Math Tea Love Affair with Vi Hart.*
Jill Bigley Dunham* and **Ann Stewart**, Hood College (1077-J5-2030)

9:40AM ► (898) *Origami for Math Clubs.*
Dale K Hathaway, Olivet Nazarene University (1077-J5-1386)

10:00AM ► (899) *Celebrating Pi-Day with a Piathlon!*
Daniel M. Look, St. Lawrence University (1077-J5-732)

10:20AM ► (900) *University of Rochester's Annual Pi-Day Festival.*
Alicia M Cornelia, University of Rochester (1077-J5-1723)

10:40AM ► (901) *Interdisciplinary Lecture Series.*
Jennifer McLoud-Mann* and **Christina Graves**, The University of Texas at Tyler (1077-J5-1397)

11:00AM ► (902) *Art Museum Field Trip.*
Kathi Crow, Salem State University (1077-J5-2043)

11:20AM ► (903) *Beautiful Minds: Getting hooked on Math through Literature.*
Maria Falidas, American Community Schools of Athens (1077-J5-2267)

11:40AM ► (904) *Math Awareness Week: Students Engaging Students.* Preliminary report.
Monika Kiss and **Jacci White***, Saint Leo University (1077-J5-871)

MAA Session on Research on the Teaching and Learning of Undergraduate Mathematics, I

8:00 AM – 11:15 AM

Organizers: **Sean Larsen**, Portland State University
Stacy Brown, Pitzer College
Karen Marrongelle, Portland State University

8:00AM (905) *Students' Understanding of Two-Variable Functions and Rates of Change.*
Eric David Weber, Arizona State University (1077-M1-33)

8:20AM ► (906) *A circle of radius one: Pre-service teachers' notions of the unit circle.*
Kevin C. Moore*, **Kevin R. LaForest** and **Hee Jung Kim**, University of Georgia (1077-M1-142)

8:40AM ► (907) *Introducing the Concept of Derivative via the Calculus Triangle.*
Michael A. Tallman* and **Eric Weber**, Arizona State University (1077-M1-292)

9:00AM ► (908) *The Proof is in the Practice? Graduate Teaching Assistants and Future Teachers.*
Kimberly Cervello Rogers, Michigan State University (1077-M1-796)

9:20AM ► (909) *To Prove or Disprove: How Do Undergraduate Students Decide?* Preliminary report.
Kelly M. Bubp, Ohio University (1077-M1-805)

9:40AM ► (910) *Authority dynamics in mathematics discussions.* Preliminary report.
Rebecca A. Dibbs, **David M. Glassmeyer*** and **Michael C. Oehrtman**, University of Northern Colorado (1077-M1-922)

10:00AM ► (911) *Building Symbolic Meaning Through Dynamically-Connected Representations in Abstract Algebra.*
Douglas A. Lapp, Central Michigan University (1077-M1-1004)

10:20AM ► (912) *Experts' Reification of Complex Variables Concepts: The Role of Metaphor.*
Hortensia Soto-Johnson*, **Michael Oehrtman**, **Kristin Noblet**, **Lee Roberson** and **Sarah Rozner**, University of Northern Colorado (1077-M1-1586)

10:40AM ► (913) *Reaching for the Familiar: Example Generation in the Proving Process.*
James T Sandefur*, Georgetown University, **John Mason**, **Gabriel J. Stylianides** and **Anne Watson**, Oxford University (1077-M1-1714)

11:00AM ► (914) *A Model of Students' Combinatorial Thinking.*
Elise N Lockwood, University of Wisconsin - Madison (1077-M1-1241)

MAA Session on Touch It, Feel It, Learn It: Tactile learning Activities in the Undergraduate Mathematics Classroom, III

8:00 AM – 11:15 AM

Organizers: **Jessica Mikhaylov**, U.S. Military Academy
Julie Barnes, Western Carolina University

8:00AM ► (915) *Riding the Ferris Wheel: A Sinusoidal Model.*
Kathleen Cage Mittag*, The University of Texas at San Antonio, and **Sharon Taylor**, Georgia Southern University (1077-O1-1351)

8:20AM ► (916) *Building Art Galleries for Geometric Proofs.*
B. Carrigan, Auburn University (1077-O1-1420)

8:40AM (917) *Learning Through Re-Arrangement of Patterns.*
John C Mayer* and **William O Bond**, University of Alabama at Birmingham (1077-O1-2442)

9:00AM ► (918) *Geometric Models in Many Classrooms.* Preliminary report.
Teresa E. Moore*, Ithaca College, and **L. Christine Kinsey**, Canisius College (1077-O1-2553)

9:20AM ► (919) *Building Mathematics Understanding with Toys.*
Mike Long, Shippensburg University (1077-O1-2554)

9:40AM ► (920) *Investigating Polytopes of the Fourth Dimension by Building Models.*
John F Putz, Alma College (1077-O1-1426)

10:00AM ► (921) *Tearing Plastic: A laboratory exercise on fractals and hyperbolic geometry.*
Ron Taylor* and **Todd Timberlake**, Berry College (1077-O1-2597)

10:20AM ► (922) *Traffic Jam: Teaching Critical Thinking through Games.* Preliminary report.
Melissa A Stoner, Salisbury University (1077-O1-1689)

10:40AM ► (923) *Hands-on Activity for Mutually Orthogonal Latin Squares.*
Julie F Rogers, Auburn University (1077-O1-2343)

11:00AM ► (924) *Hands-On SET®.*
Ellizabeth McMahon*, Lafayette College, and **Rebecca Gordon**, Queen Margaret College, Wellington NZ (1077-O1-2843)

MAA General Contributed Paper Session: Research in Analysis

8:00 AM – 11:55 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:00AM (925) *Minimizing the Jacobian Integral.*
Colin Carroll, Rice University (1077-VJ-2942)

8:15AM (926) *The Poisson Geometry of SU(1,1).*
McKenzie R Lamb*, Ripon College, and **Philip Foth**, University of Arizona (1077-VJ-2736)

8:30AM ► (927) *Looking for a few good means.*
Bruce R. Ebanks, Mississippi State University (1077-VJ-1335)

8:45AM (928) *a CLT for independent non-identical processes.*
Yuping Yang, Texas A&M University (1077-VJ-2869)

9:00AM ► (929) *Benford's Law and Dependent Random Variables.*
Thealexa G Becker*, Smith College, **Alec Greaves-Tunnell**, Williams College, **Ryan Ronan**, Cooper Union, and **Steven J Miller**, Williams College (1077-VJ-2495)

9:15AM (930) *The Necessary Condition For $\bar{\partial}$-equation in Hölder space in $\mathbb{C}^3$.*
Young Hwan You, Indiana University East (1077-VJ-2578)

9:30AM ► (931) *Dynamical deltoids.* Preliminary report.
Joshua P. Bowman, Stony Brook University (1077-VJ-1360)

9:45AM (932) *Existence of Solutions for Nonconvex n^{th} Order Differential Inclusions.*
Michael Fulkerson and **Kristi Karber***, University of Central Oklahoma (1077-VJ-1077)

10:00AM ► (933) *Bifurcations of Inverse Functions: A Story of Undergraduate Research.*
Jody M Sorensen, Augsburg College (1077-VJ-2559)

10:15AM (934) *Proof of the density hypothesis.*
Yuanyou F. Cheng, Waltham, MA (1077-VJ-949)

10:30AM (935) *On quasi-diagonality of continuous fields.* Preliminary report.
Jose L. Lugo, Purdue University (1077-VJ-1706)

10:45AM ► (936) *How Fast does a Sequence of Positive Integers Grow? An Elementary Perspective based on Multiplication.* Preliminary report.
Michael A Brilleslyper* and **Bradley A Warner**, U. S. Air Force Academy, Colorado Springs, CO (1077-VJ-845)

11:00AM (937) *A tail of two series.* Preliminary report.
Johann A Thiel, United States Military Academy (1077-VJ-2564)

11:15AM ► (938) *Low-lying zeros of cuspidal Maass forms.*
Liyang Zhang*, **Steven J Miller**, Williams College, **Oleg Lazarev**, Princeton University, **Geoffrey Iyer**, University of Michigan, and **Nadine Amersi**, University College London (1077-VJ-740)

11:30AM (939) *Quantitative Approximation by Fractional Smooth General Singular Operators.*
George A Anastassiou, University of Memphis, and **Razvan A. Mezei***, Lander University (1077-VJ-450)

11:45AM ► (940) *On the Linear Generating Function for the Charlier Polynomials.* Preliminary report.
Daniel Joseph Galiffa, Penn State Erie, The Behrend College (1077-VJ-2638)

MAA General Contributed Paper Session: Statistics

8:00 AM – 11:40 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:00AM (941) *Estimation of eigenvalues and their multiplicities of a covariance operator.*
Krishna Kaphle*, Illinois Wesleyan University, **Frits H. Ruymgaart** and **George Gaines**, Texas Tech University (1077-VE-2346)

8:15AM ► (942) *Linear Tests of Uniformity for Data Defined on Distance Transitive Graphs.* Preliminary report.
Connor Ahlbach, **John Choi**, **Michael Orrison**, Harvey Mudd College, **Laura Passarelli**, Scripps College, and **Shujing Xu***, Claremont Graduate University (1077-VE-2286)

8:30AM (943) *Approximation to the Generalized Gamma Distribution.*
Salam Md. Mahbubush Khan, Alabama A&M University (1077-VE-2009)

8:45AM (944) *Detection of slightly expressed changes in random environment.*
Veera Holdai, Salisbury University (1077-VE-1317)

9:00AM ► (945) *Prediction on Random Fields with Maximum Entropy Models.*
Priya Kohli* and **Mohsen Pourahmadi**, Texas A&M University (1077-VE-1117)

9:15AM (946) *Bounded influence nonlinear signed-rank regression.*
Huybrechts Bindele* and **Asheber Abebe**, Auburn University (1077-VE-954)

9:30AM (947) *Rank-based estimation for generalized linear models.*
Guy-vanie M Miakonkana* and **Ashere Abebe**, Auburn University (1077-VE-478)

9:45AM (948) *A Robust Dispersion Estimator and its Applications.*
Jianfeng Zhang*, Chattanooga TN, **David Olive**, Southern Illinois Univeristy Carbondale, and **Ping Ye**, Quincy University (1077-VE-293)

10:00AM (949) *Exact Confidence Intervals for the Ratio of Two Proportions.*
Paul R. Coe, Dominican University (1077-VE-2753)

10:15AM ► (950) *Using Linear Mixed-Effects Models to Examine Correlates of stress, anxiety, depression to find the factors affecting psychosocial attributes.*
Sumona Mondal*, Clarkson University, **Tina Norton**, Lycoming College, **Sarah Andres**, **Hosana Mamata**, Clarkson University, and **Steven Foti**, University of Florida at Gainesville (1077-VE-2350)

10:30AM (951) *Using Mixed Distributions to Model Count Data with Application.*
Mehdi Razzaghi, Bloomsburg University (1077-VE-2947)

10:45AM (952) *Life Expectancy Estimate with Bivariate Weibull Distribution using Archimedean Copula.*
Seung-Hwan Lee*, Illinois Wesleyan University, and **Eun-Joo Lee**, Millikin University (1077-VE-951)

11:00AM ► (953) *Census at School: An Outreach Program to Teach Statistical Problem Solving in Grades 4-12 Using Real Student Data.*
Rebecca Nichols, American Statistical Association (1077-VE-2627)

11:15AM ► (954) *Teaching Statistics through the years: What works? What doesn't? What's next?*
Barbara A. Wainwright, Salisbury University (1077-VE-1422)

11:30AM ► (955) *Introducing The Idea of Fitting a Distribution to Data in a Probability Course.* Preliminary report.
Christopher J Lacke, Rowan University (1077-VE-2948)

SIAM Minisymposium on Computational Geometry

8:00 AM – 11:25 AM

Organizer: **Suresh Venkatasubramanian**, University of Utah

8:00AM (956) *Computing interesting topological features on surface embedded graphs.*
Erin Chambers, Saint Louis University (1077-68-2460)

8:30AM (957) *Optimal stochastic planarization.*
Anastasios Sidiropoulos, Toyota Technological Institute at Chicago (1077-68-1790)

9:00AM ► (958) *An Introduction to Davenport-Schinzel Sequences, Forbidden 0-1 Matrices, and Their Geometric Applications.*
Seth Pettie, University of Michigan (1077-05-2046)

9:30AM (959) *Toward understanding complex data: graph Laplacians on singular manifolds.*
Mikhail Belkin, **Qichao Que**, **Yusu Wang***, The Ohio State University, and **Xuanyuan Zhou**, University of Chicago (1077-68-1943)

10:00AM (960) *Horoball Hulls and Extents in Positive Definite Space.*
P. Thomas Fletcher, **John Moeller**, **Jeff M Phillips** and **Suresh Venkatasubramanian***, University of Utah (1077-51-2840)

10:30AM (961) *Computational Geometry on Uncertain Data.*
Jeff M Phillips, University of Utah (1077-51-2277)

11:00AM ► (962) *Geometric Aspects of Compressive Sensing.*
Eric Price, MIT (1077-51-2732)

Employment Center

8:00 AM – 6:00 PM

AMS Special Session on Enumerative and Algebraic Combinatorics, I

8:30 AM – 11:50 AM

Organizers: **Ira Gessel**, Brandeis University
Alexander Postnikov, Massachusetts Institute of Technology
Richard Stanley, Massachusetts Institute of Technology

8:30AM ► (963) *On the bunkbed conjecture and related problems.*
Svante Linusson, KTH, Stockholm, Sweden. (1077-05-2062)

9:00AM ► (964) *Monotone Hurwitz numbers and the HCIZ integral.*
Jonathan Novak, Massachusetts Institute of Technology (1077-05-1569)

9:30AM (965) *The Potts model on random lattices.*
Olivier Bernardi, MIT (1077-05-1438)

10:00AM (966) *Enumerations deciding the weak Lefschetz property.*
David W. Cook II* and **Uwe Nagel**, University of Kentucky (1077-05-545)

10:30AM ► (967) *Lifted generalized permutohedra and composition polynomials.* Preliminary report.
Federico Ardila*, San Francisco State University, and **Jeffrey Doker**, University of California, Berkeley (1077-05-2311)

11:00AM ► (968) *Flow polytopes and the Kostant partition function for signed graphs.*
Alejandro H. Morales*, MIT, and **Karola Mészáros**, University of Michigan (1077-05-1965)

11:30AM (969) *Algebra based on real hyperplane arrangements.*
Marcelo Aguiar*, Texas A&M University, and **Swapneel Mahajan**, IIT Mumbai (1077-05-1574)

AMS Special Session on Some Nonlinear Partial Differential Equations: Theory and Application, I

8:30 AM – 11:50 AM

Organizers: **Jerry L. Bona**, University of Illinois, Chicago
Laihan Luo, New York Institute of Technology

8:30AM (970) *Concentration compactness and KdV-NLS solitary waves.*
John P Albert* and **Santosh Bhattarai**, University of Oklahoma (1077-35-2704)

9:00AM (971) *Comparisons between Uni-directional and Bi-directional Models for Surface Water Waves.*
Jerry L Bona, University of Illinois at Chicago (1077-35-2119)

9:30AM (972) *Asymptotic Behavior of Solutions to the Liquid Crystals Systems in $\mathbb{R}^3$.*
Mimi Dai*, **Jie Qing** and **Maria Schonbek**, University of California, Santa Cruz (1077-35-1932)

10:00AM (973) *Recent Developments in Conformal Ricci Flow.*
Arthur E Fischer, University of California, Santa Cruz (1077-53-2015)

10:30AM (974) *Solutions to the Sine-Gordon Equation of Low Differentiability.* Preliminary report.
Josef F Dorfmeister, Technische Universitat Munchen, and **Ivan C Sterling***, St. Mary's College of Maryland (1077-53-2863)

11:00AM (975) *Periodic Rippling in Hyperbolic Non-Euclidean Plates.*
John Gemmer* and **Shankar Venkataramani**, University of Arizona (1077-35-1729)

11:30AM (976) *Global Well Posedness for a system of KdV-type Equations with Coupled Quadratic nonlinearities.*
Jerry L. Bona, University of Illinois, Chicago, **Jonathan Cohen*** and **Gang Wang**, DePaul University (1077-35-2013)

AMS Special Session on Stability Analysis for Infinite Dimensional Hamiltonian Systems, III

8:30 AM – 11:20 AM

Organizers: **Wilhelm Schlag**, University of Chicago
Gene Wayne, Boston University

8:30AM (977) *Global Stability Results for Relativistic Fluids in Expanding Spacetimes.*
Jared Speck, Massachusetts Institute of Technology (1077-35-736)

9:00AM (978) *On the modulational instability for the Benjamin-Ono equation.*
Vera Mikyoung Hur, University of Illinois at Urbana-Champaign (1077-35-2370)

9:30AM (979) *Phase-driven interaction of widely separated nonlinear Schrödinger solitons.*
Justin Holmer* and **Quanhui Lin**, Brown University (1077-35-1701)

10:00AM ► (980) *On the continuum limit for discrete NLS with long-range lattice interactions.*
Gigliola Staffilani*, MIT, **Kay Kirkpatrick**, UIUC, and **Enno Lenzmann**, University of Basel (1077-35-1632)

10:30AM (981) *Stability analysis via Backlund transform in completely integrable PDE.*
Aaron Hoffman, Franklin W. Olin College of Engineering (1077-35-1784)

11:00AM (982) *Stability of Solitary Waves on Water of Finite Depth.*
Shu-Ming Sun, Virginia Tech (1077-76-705)

MAA Session on Innovative and Effective Ways to Teach Linear Algebra, II

8:40 AM – 11:55 AM

Organizers: **David Strong**, Pepperdine University
Gil Strang, Massachusetts Institute of Technology
David Lay, University of Maryland

8:40AM (983) *Web 2.0 for Linear Algebra Classes.* **Tom Edgar**, Pacific Lutheran University (1077-F1-2712)

9:00AM (984) *On Generating Large Dimensional, Hand-Calculable Exercises and Applications.* **Jeff R. Knisley**, East Tennessee State University (1077-F1-1585)

9:20AM (985) *Mobile Math Applications for the Second Course of Linear Algebra.* **Sang-Gu Lee**, Sungkyunkwan University (1077-F1-1813)

9:40AM (986) *Full Sage Contents of Introductory Linear Algebra.* **Sang-Gu Lee** and **Kyung-Won Kim***, Sungkyunkwan University (1077-F1-1812)

10:00AM (987) *Reinforcing Basic Linear Algebra Skills Using Computer Animation.* **Nathan M Wodarz**, University of Wisconsin - Stevens Point (1077-F1-920)

10:20AM ► (988) *Muggle Magic with Matrix Arithmetic.* **Tim Chartier**, Davidson College (1077-F1-1437)

10:40AM ► (989) *The Wronskian as a method for introducing vector spaces.* **Daniel A. Ramras**, New Mexico State University (1077-F1-1022)

11:00AM ► (990) *LINE (Linear Algebra in New Environments): Using Learning Theories to Design Linear Algebra Modules.* Preliminary report. **William O. Martin***, North Dakota State University, **Jeff Suzuki**, Brooklyn College, **Draga Vidakovic**, Georgia State University, **Sergio Loch**, Grand View University, **Laurel A Cooley**, Brooklyn College, City University of New York, **Catalin Ciuperca**, North Dakota State University, and **Scott Dexter**, Brooklyn College, City University of New York (1077-F1-1193)

11:20AM (991) *A Comparison of Different Pedagogical Approaches to Linear Algebra.* **Sukanya Basu**, Grand Valley State University (1077-F1-1242)

11:40AM ► (992) *Connecting Linear Algebra Concepts.* **C. Ray Rosentrater**, Westmont College (1077-F1-421)

MAA Invited Address

9:00 AM – 9:50 AM

(993) *The sound of geometry.* **Carolyn Gordon**, Dartmouth College (1077-A0-3)

MAA Invited Paper Session on the Beauty and Power of Number Theory

9:00 AM – 11:45 AM

Organizers: **Thomas Koshy**, Framingham State University
Shannon Lockard, Bridgewater State University

9:00AM (994) *Patterns in partitions.* **Amanda Folsom**, Yale University (1077-AC-1670)

9:45AM ► (995) *The beauty and power of some recent REU papers in number theory.* **Ken Ono**, Emory University (1077-AC-52)

10:30AM ► (996) *Number Theory and Dynamical Systems.* Preliminary report. **Joseph H. Silverman**, Brown University (1077-AC-176)

11:15AM (997) $1+2+3+4+\cdots$. **Frank H Thorne**, University of South Carolina (1077-AC-857)

MAA Minicourse #4: Part A

9:00 AM – 11:00 AM

Elementary mathematics in architecture.

Presenter: **Alexander J. Hahn**, University of Notre Dame

MAA Minicourse #13: Part A

9:00 AM – 11:00 AM

Interactive applets for calculus and differential equations.

Presenter: **Haynes Miller**, Massachusetts Institute of Technology

MAA Minicourse #1: Part A

9:00 AM – 11:00 AM

Mathematics and backgammon.

Presenters: **Arthur Benjamin**, Harvey Mudd College
Robert Koca, Community College of Baltimore County

MAA Session on Preparing College Students for Calculus

9:00 AM – 11:15 AM

Organizer: **Andrew Bennett**, Kansas State University

9:00AM (998) *Making connections with Precalculus.* **Ramanjit K Sahi**, Austin Peay State University (1077-K5-903)

9:20AM ► (999) *Tangent lines: a multifaceted concept.* **Peter J. Byers**, Boston University (1077-K5-2801)

9:40AM ► (1000) *Preparing students for proofs and deeper conceptual thinking by implementing collaborative learning projects in Intermediate Algebra and Trigonometry.* **Alla Morgulis*** and **Claire Wyn Wladis**, BMCC/CUNY (1077-K5-2684)

10:00AM (1001) *Mathematical Reasoning in Calculus: Moving Between Representations.* **Mairead Greene*** and **Paula Shorter**, Rockhurst University (1077-K5-2721)

10:20AM (1002) *Identifying Crucial Concepts and Skills, and Preparing College Students for Success in Calculus.* Preliminary report. **Alison Ahlgren***, University of Illinois, and **Marc Harper**, UCLA (1077-K5-1271)

10:40AM ► (1003) *Long-Term National Impact of the Calculus Reform Initiative.* Preliminary report. **Susan L Ganter***, East Carolina University, and **Jack Bookman**, Duke University (1077-K5-2880)

11:00AM (1004) *Preparing your calculus students: An inquiry-based algebra review.*
Angie Hodge, University of Nebraska at Omaha (1077-K5-1565)

MAA Poster Session on Mathematical Outreach Programs for Underrepresented Populations

9:00 AM – 11:00 AM

Organizer: **Elizabeth Yanik**, Emporia State University

MAA Panel Discussion

9:00 AM – 10:20 AM

Are we selling mathematics as a major?
Organizers: **Steve Deckelman**, University of Wisconsin Stout
Mary Kay Abbey, Montgomery College
Panelists: **Michael Dorff**, Brigham Young University
Sandy Ganzell, St. Mary's College
Daniel Kaplan, Macalester College
Theresa Anderson, Brown University

MAA Committee on Graduate Students/Young Mathematicians Network Panel Discussion

9:00 AM – 10:20 AM

Graduate school: Choosing one, getting in, staying in.
Organizers: **Aaron Luttman**, Clarkson University
Kristi Meyer, Wisconsin Lutheran College
Panelists: **Richard McGehee**, University of Minnesota
Kim Ruane, Tufts University
Bogdan Vernescu, Worcester Polytechnic Institute

MAA Session for Chairs

9:00 AM – 10:20 AM

Timely and timeless aspects of chairing a mathematical sciences department.
Organizers: **Daniel Maki**, Indiana University
Catherine M. Murphy, Purdue University Calumet
Panelists: **Richard Cleary**, Bentley University
Dennis Luciano, Western New England College
Catherine Roberts, College of the Holy Cross
Sheryl Stump, Ball State University

Student Hospitality/Information Center

9:00 AM – 5:00 PM

MAA Session on Trends in Undergraduate Mathematical Biology Education

9:20 AM – 11:55 AM

Organizer: **Timothy D. Comar**, Benedictine University

9:20AM ► (1005) *Deviation from the Norms – Algebra, Trigonometry, & Calculus for the Aspiring Life Scientist.*
Mike Martin, Johnson County Community College (1077-P1-352)

9:40AM (1006) *So, why do you require Calculus?*
Carrie Diaz Eaton, Unity College (1077-P1-728)

10:00AM (1007) *Undergraduate Research Projects in Mathematical Biology: Modeling and Simulation in MATLAB.*
Timothy D Comar, Benedictine University (1077-P1-561)

10:20AM ► (1008) *Mathematical epidemiology without differential equations.* Preliminary report.
Matthew Glomski, Marist College (1077-P1-1288)

10:40AM (1009) *Mathematical Concepts and Methods in Modern Biology: Using Modern Discrete Models - A Book in Progress.*
Terrell L. Hodge*, Western Michigan University, and **Raina Robeva**, Sweet Briar College (1077-P1-2849)

11:00AM (1010) *Undergraduate Research in Modeling the Response of Chaparral Plants to Wildfires.*
Timothy A Lucas, Pepperdine University (1077-P1-2145)

11:20AM ► (1011) *Cross Disciplinary Research by Undergraduates in Mathematics and Biology to Examine Cellular Processes.*
Sepideh Khavari, **Tara Sansom**, **Bradley Slabe**, **Jonathan Caguiat** and **George T Yates***, Youngstown State University (1077-P1-1860)

11:40AM ► (1012) *When the Bloom is Off the Rose, or, How to Avoid Depression After the Stimulus Package Runs Out.*
Christopher C. Leary, SUNY Geneseo (1077-P1-2482)

Exhibits and Book Sales

9:30 AM – 5:30 PM

AWM Emmy Noether Lecture

10:05 AM – 10:55 AM

(1013) *Conservation Laws - Not Exactly a la Noether.*
Barbara Lee Keyfitz, The Ohio State University (1077-35-1665)

AMS Special Presentation

10:30 AM – NOON

A conversation on nonacademic employment.
Moderator: **C. Allen Butler**, Daniel H. Wagner Associates, Inc.

SIGMAA Officers Meeting

10:30 AM – NOON

Chair: **Amy Shell-Gelasch**, Beloit College

MAA Panel Discussion

10:35 AM – 11:55 AM

Improving college mathematics teaching through faculty development.
Organizers: **Jerry Kobylski**, U. S. Military Academy
Alex Heidenberg, U. S. Military Academy
Hilary Fletcher, U. S. Military Academy
Howard McInvale, U. S. Military Academy

Panelists: **Molli Jones**, Immaculata College
Laurice Garrett, Edison State College
Cindy Soderstrom, Salt Lake Community College
Philip Darcy, Dutchess Community College

MAA Workshop

10:35 AM – 11:55 AM

Proposal writing for grant applications to the NSF Division of Undergraduate Education.

Organizers: **Richard Alo**, National Science Foundation
Ron Buckmire, National Science Foundation
Lee Zia, National Science Foundation

SIAM Invited Address

11:10 AM – NOON

(1014) *Navier-Stokes, Euler, and other relevant equations.* **Edriss S. Titi**, University of California at Irvine, and the Weizmann Institute of Science (1077-35-2719)

AMS Special Presentation

11:15 AM – 12:15 PM

Report on the findings of the 2010 CBMS survey of undergraduate mathematical and statistical sciences in the U.S.

Organizer: **James W. Maxwell**, American Mathematical Society

Presenter: **Ellen Kirkman**, Wake Forest University

AMS Colloquium Lectures: Lecture II

1:00 PM – 1:50 PM

(1015) *Langlands program, trace formulas, and their geometrization, II.* **Edward Frenkel**, University of California Berkeley (1077-14-11)

AMS-MAA Special Session on the History of Mathematics, IV

1:00 PM – 3:50 PM

Organizers: **Sloan Despeaux**, Western Carolina University
Craig Fraser, University of Toronto
Deborah Kent, Hillsdale College

► 1:00PM (1016) *Mathematics in the Republic of China: A Centennial Overview.* Preliminary report. **Yibao Xu***, Borough of Manhattan Community College, CUNY, and **Wann-Sheng Horng**, National Taiwan Normal University (1077-01-418)

► 1:30PM (1017) *How to Assess Influence: Wu Wen-Tsun's Work in Measure, Number and Weight.* **Jiri Hudecek**, Needham Research Institute, Cambridge (1077-01-1508)

2:00PM (1018) *Elevating the ranking of American mathematics departments 1900-1940.* **David E Zitarelli**, Temple University (1077-01-1276)

► 2:30PM (1019) *"It Is No Good Baking Cakes If Pies Are Wanted": The American Mathematics Community in the 1970s Job Market Crisis.* Preliminary report. **Alma Steingart**, MIT (1077-01-1562)

► 3:00PM (1020) *On Pre Robinsonian Non-Standard Theories of the Twentieth-Century.* Preliminary report. **Emil Sargsyan**, Indiana University (1077-01-2898)

► 3:30PM (1021) *The Design of Intuition: Computing and Mathematical Proof.* **Stephanie Dick**, Harvard University, Department of History of Science (1077-01-2031)

AMS-ASL Special Session on the Life and Legacy of Alan Turing, IV

1:00 PM – 3:40 PM

Organizers: **Damir Dzhafarov**, University of Chicago and University of Notre Dame
Jeff Hirst, Appalachian State University
Carl Mummert, Marshall University

► 1:00PM (1022) *Alan Turing and Voice Encryption.* Preliminary report. **Craig Bauer**, NSA Scholar-in-Residence (1077-01-433)

2:00PM (1023) *Turing's work and Hilbert's Tenth Problem.* **Kirsten Eisentraeger**, The Pennsylvania State University (1077-11-1202)

2:30PM (1024) *Quantum Money from Knots.* **Peter W. Shor**, Massachusetts Institute of Technology (1077-68-2759)

► 3:00PM (1025) *Gödel's theorems, Turing's machines, and mathematical minds.* **Wilfried Sieg**, Carnegie Mellon University (1077-03-983)

AMS-AWM Special Session on Nonlinear Hyperbolic Partial Differential Equations, I

1:00 PM – 3:50 PM

Organizers: **Barbara Lee Keyfitz**, Ohio State University
Charis Tsikkou, Ohio State University

1:00PM (1026) *On the size of the Navier - Stokes singular set.* **Walter Craig**, McMaster University (1077-35-1222)

1:30PM (1027) *Global well-posedness and decay for the viscous surface wave problem without surface tension.* **Ian T Tice**, Universite Paris-Est Creteil, LAMA (1077-35-1589)

2:00PM (1028) *Nonrelativistic Euler-Maxwell systems.* **Michael Sever**, The Hebrew University, Jerusalem, Israel (1077-35-141)

► 2:30PM (1029) *Broad Band Solitons in a Periodic and Nonlinear Maxwell System.* **Dmitry Pelinovsky**, McMaster University (1077-35-277)

3:00PM (1030) *Blow Up of Solutions to the Generalized Proudman Johnson Equation.* Preliminary report. **Alejandro Sarria** and **Ralph Saxton***, University of New Orleans (1077-35-2274)

3:30PM (1031) *Two Phase Flow in Porous Media: the Saffman-Taylor Instability Revisited.* **Michael Shearer***, **Kim Spayd** and **Zhengzheng Hu**, NC State University (1077-35-1037)

AMS Special Session on Classical Fourier Analysis and Partial Differential Equations, IV

1:00 PM – 3:50 PM

Organizers: **William O. Bray**, University of Maine
Mark A. Pinsky, Northwestern University

1:00PM (1032) *Problems related to the concentration of eigenfunctions.*
Christopher D Sogge, Johns Hopkins University (1077-42-670)

2:00PM (1033) *Regularity properties of Green functions in non-smooth domains.*
Irina Mitrea, Temple University (1077-35-2458)

3:00PM (1034) *Approximate reconstruction from circular mean data via classical summability.* Preliminary report.
W. R. Madych, Univ. of Connecticut, Storrs, CT 06269 (1077-42-2041)

3:30PM (1035) *Applications of linear and multi-linear generalized Radon transforms.*
Alex Iosevich, University of Rochester (1077-42-2959)

AMS Special Session on Climate Modeling and Geophysical Fluid Dynamics, II

1:00 PM – 3:20 PM

Organizers: **Qingshan Chen**, Florida State University
Nathan Glatt-Holtz, Indiana University
Mickael Chekroun, University of California, Los Angeles

► 1:00PM (1036) *Dynamic Transition Theory for Thermohaline Circulation.*
Shouhong Wang, IN (1077-86-2929)

1:30PM (1037) *Dynamic Transitions and Hexagonal Patterns in Surface Tension Driven Convection.*
M Taylan Sengul*, **Shouhong Wang**, Indiana University, and **Henk Dijkstra**, Utrecht University (1077-76-1969)

2:00PM (1038) *Suppression of chaos at slow variables by rapidly mixing fast dynamics.*
Rafail V. Abramov, University of Illinois at Chicago (1077-37-2019)

2:30PM (1039) *Stochastic perturbations to dynamical systems: a response theory approach.*
Valerio Lucarini, Klimacampus, University of Hamburg (1077-82-2454)

3:00PM (1040) *A Discrete Dynamical Systems Model to Study the Interaction Between Arctic Sea-Surface Temperature and Sea-Ice Cover.*
Sukanya Basu*, Grand Valley State University, **Auroop R. Ganguly** and **Evan Kodra**, Department of Civil and Environmental Engineering, Northeastern University (1077-39-2240)

AMS Special Session on Combinatorial Geometry of Polytopes, II

1:00 PM – 3:50 PM

Organizers: **Egon Schulte**, Northeastern University
Asia Ivic Weiss, York University

1:00PM (1041) *Euler flag enumeration of Whitney stratified spaces.*
Richard Ehrenborg, University of Kentucky, **Mark Goresky**, Institute for Advanced Study, and **Margaret Readdy***, University of Kentucky (1077-05-896)

1:30PM ► (1042) *Combinatorial constructions of polytopes.* Preliminary report.
T. Bisztriczky, University of Calgary (1077-52-917)

2:00PM ► (1043) *Matrices associated with polar dual pairs of polytopes.* Preliminary report.
Jim Lawrence, George Mason University (1077-52-1841)

2:30PM (1044) *Deformations of surfaces and convex polytopes.*
Satyan L Devadoss, Williams College (1077-52-284)

3:00PM ► (1045) *Minkowski length of 2D and 3D lattice polytopes.* Preliminary report.
Olivia Beckwith, Harvey Mudd College, **Matthew Grimm**, UCSD, **Jenya Soprunova***, Kent State University, and **Bradley Weaver**, Grove City College (1077-52-945)

3:30PM ► (1046) *Graphs of Polytopes.* Preliminary report.
Margaret M Bayer* and **William Espenschied**, University of Kansas (1077-05-2099)

AMS Special Session on Computational and Applied Topology (Mathematics Research Communities session), II

1:00 PM – 3:50 PM

Organizers: **Radmila Sazdanovic**, University of Pennsylvania
Daniel Muellner, Stanford University
Mikael Vejdemo-Johansson, University of St. Andrews

1:00PM ► (1047) *Φ-somap: Estimating Intrinsic Distance Using Persistent Homology.* Preliminary report.
Paul Louis Bendich*, Duke University, and **Jacob Harer**, North Carolina State University (1077-55-986)

1:30PM (1048) *Stratification Learning through Local Homology Transfer.*
Paul Bendich, Duke University, **Bei Wang***, SCI Institute, University of Utah, and **Sayan Mukherjee**, Duke University (1077-55-2288)

2:00PM (1049) *Topological dimensionality reduction.*
Vin de Silva, Pomona College (1077-68-461)

2:30PM (1050) *Sheaf invariants for temporal logic.*
Michael Robinson, University of Pennsylvania (1077-94-225)

3:00PM (1051) *Directed sheaf homology and information.* Preliminary report.
Sanjeevi Krishnan, University of Pennsylvania (1077-55-2262)

3:30PM (1052) *Topology of Spaces of Micro-Images and Applications.*
Jose Perea*, Duke University, and **Gunnar Carlsson**, Stanford University (1077-00-1013)

AMS Special Session on Control Theory and Inverse Problems for Partial Differential Equations, I

1:00 PM – 3:50 PM

Organizers: **Shitao Liu**, University of Helsinki
Ting Zhou, Massachusetts Institute of Technology

1:00PM (1053) *Optimal control of PDE population models involving resources.*
Suzanne Lenhart, University of Tennessee (1077-35-926)

1:30PM (1054) *Rational decay rates for fluid-structure interactive dynamics.*
George Avalos, University of Nebraska-Lincoln (1077-35-2187)

2:00PM (1055) *On the linearization of a fluid-nonlinear elasticity interaction.*
Lorena Bociu, North Carolina State University (1077-35-2355)

2:30PM (1056) *Uniform decays of energy and blow up of steady states in unstable systems arising in fluid structure interactions.*
Irena Lasiecka and **Yongjin Lu***, University of Virginia (1077-35-666)

3:00PM (1057) *Structural decomposition, spectral analysis, and exponential stability for a third order PDE arising in high-intensity ultrasound.*
Richard J. Marchand*, U.S. Air Force Academy/Slippery Rock University, **Timothy J. McDevitt**, Elizabethtown College, and **Roberto Triggiani**, University of Virginia (1077-35-1725)

3:30PM (1058) *Attractor for a non-dissipative von Karman plate with damping in free boundary conditions.*
Lorena Bociu, North Carolina State University, and **Daniel Toundykov***, University of Nebraska-Lincoln (1077-35-1630)

AMS Special Session on Dynamical Systems in Algebraic and Arithmetic Geometry, III

1:00 PM – 3:50 PM

Organizers: **Patrick Ingram**, University of Waterloo, Canada
Michelle Manes, University of Hawaii, Honolulu
Clayton Petsche, Hunter College (CUNY)

► 1:00PM (1059) *Recent results in arithmetic dynamics.* Preliminary report.
Michael E. Zieve, University of Michigan (1077-11-2550)

1:30PM (1060) *Prime Divisors of Certain Polynomial Orbits.*
Kalyani K. Madhu, State University of New York at Brockport (1077-11-2313)

2:00PM (1061) *Bounding the Height of a Postcritically Finite Map.*
Alon Levy, Brown University (1077-11-2307)

2:30PM (1062) *Computing small canonical heights in arithmetic dynamics.*
Robert L. Benedetto, Amherst College (1077-11-597)

3:00PM (1063) *Equidistribution of Preimages in Berkovich Projective Space.*
William Gignac, University of Michigan (1077-37-2229)

3:30PM (1064) *Ergodic theory of p-adic rational maps.*
Juan Rivera-Letelier, Pontificia Universidad Catolica de Chile (1077-37-1540)

AMS Special Session on Enumerative and Algebraic Combinatorics, II

1:00 PM – 3:50 PM

Organizers: **Ira Gessel**, Brandeis University
Alexander Postnikov, Massachusetts Institute of Technology
Richard Stanley, Massachusetts Institute of Technology

1:00PM (1065) *Stable multivariate Eulerian polynomials and generalized Stirling permutations.*
J. Haglund* and **M. Visontai**, University of Pennsylvania (1077-05-1950)

1:30PM (1066) *The negative q-binomial.*
Dennis Stanton, University of Minnesota (1077-05-1880)

► 2:00PM (1067) *Matrices with restricted entries and q-analogues of permutations.*
Joel Brewster Lewis*, MIT, **Ricky Ini Liu**, University of Michigan, **Alejandro H. Morales**, MIT, **Greta Panova**, UCLA, **Steven V Sam** and **Yan X Zhang**, MIT (1077-05-1935)

2:30PM (1068) *Major Index for 01-Fillings of Moon Polyominoes.*
Catherine Yan*, Texas A&M University, **William Chen**, Nankai University, China, **Svetlana Poznanovik**, Goergia Institute of Technology, and **Arthur Yang**, Nankai University, China (1077-05-1328)

► 3:00PM (1069) *Bijections between k-triangulations, k-fans of Dyck paths, and certain pipe dreams.*
Luis G Serrano* and **Christian Stump**, Universite du Quebec a Montreal (1077-05-1636)

3:30PM (1070) *The Möbius function of generalized subword order.*
Peter R. W. McNamara*, Bucknell University, and **Bruce E. Sagan**, Michigan State University (1077-06-1135)

AMS Special Session on Frontiers in Geomathematics, I

1:00 PM – 3:50 PM

Organizers: **Willi Freeden**, University of Kaiserslautern
Volker Michel, University of Siegen
M. Zuhair Nashed, University of Central Florida
Thomas Sonar, Technical University of Braunschweig

1:00PM (1071) *Approximation based on integral formulas for star-shaped surfaces.*
Willi Freeden, Geomathematics Group, University of Kaiserslautern (1077-41-1163)

2:00PM (1072) *Integration and approximation on the sphere.*
Ian H Sloan, University of New South Wales (1077-65-1730)

► 3:00PM (1073) *Spherical Multiscale Methods and Applications in Geomagnetic Modeling.*
Christian Gerhards, TU Kaiserslautern (1077-41-2300)

► 3:30PM (1074) *Modern Meteorology: An Overview over the Methods used in Numerical Weather Prediction and its Application to Hurricane Irene.*
Martin J. Fengler, St. Gallen, Switzerland (1077-86-1986)

AMS Special Session on Knot Theory, II

1:00 PM – 3:50 PM

Organizers: **Tim Cochran**, Rice University
Shelly Harvey, Rice University

1:00PM (1075) *Knot Floer homology and Murasugi sum.* Preliminary report.
Matthew Hedden*, Michigan State University, and **Sucharit Sarkar**, Columbia University (1077-57-1793)

1:30PM (1076) *A categorification of the Tutte polynomial.* Preliminary report.
Moshe Cohen, Bar-Ilan University, and **Adam M Lowrance***, University of Iowa (1077-57-1333)

2:00PM (1077) *Graph Floer homology.*
Shelly Harvey, Rice University, and **Danielle O'Donnol***, Smith College (1077-57-1413)

2:30PM (1078) *Why you should infect your knots with links.* Preliminary report.
John R. Burke, Rhode Island College (1077-57-2018)

3:00PM (1079) *Classification of 0-solvable links.*
Taylor E Martin, Rice University (1077-57-2148)

3:30PM (1080) *Cosmetic crossing changes on knots.*
Effie Kalfagianni, Michigan State University (1077-57-1253)

AMS Special Session on Linear Algebraic Groups: Their Arithmetic, Geometry, and Representations, I

1:00 PM – 3:50 PM

Organizers: **R. Skip Garibaldi**, Emory University
George McNinch, Tufts University

1:00PM (1081) *A Unified Solution to Some Linear Preserver Problems.*
Hernando Bermudez*, **Skip Garibaldi** and **Victor Larsen**, Emory University (1077-20-751)

1:30PM (1082) *The gamma filtration on projective homogeneous varieties.*
Kirill Zainoulline, University of Ottawa (1077-14-1368)

2:00PM (1083) *Parity Sheaves and Tilting Modules.*
Daniel Juteau, Uni. de Caen/CNRS, **Carl Mautner***, Harvard Univ./NSF, and **Geordie Williamson**, MPIM Bonn (1077-22-2027)

► 2:30PM (1084) *Unipotent Classes in Disconnected Algebraic Groups.*
Robert M Guralnick* and **Jason Fulman**, University of Southern California (1077-20-123)

3:00PM (1085) *Weakly commensurable S-arithmetic subgroups in simple algebraic groups of types B_n and C_n.*
Andrei Rapinchuk, University of Virginia (1077-11-217)

3:30PM (1086) *Cohomology for Finite Groups of Lie Type.*
Daniel K. Nakano, University of Georgia (1077-20-774)

AMS Special Session on Mathematics in Industry, II

1:00 PM – 3:40 PM

Organizers: **Kirk E. Jordan**, IBM T. J. Watson Research
Donald Schwendeman, Renssalaer Polytechnic Institute
Burt S. Tilley, Worcester Polytechnic Institute
Suzanne L. Weekes, Worcester Polytechnic Institute

► 1:00PM (1087) *Impact of Modeling and Simulation on Decision-Making: Infectious Diseases.*
Sara Y Del Valle, Los Alamos National Laboratory (1077-92-873)

1:30PM (1088) *Mathematical Problems in Metal Processing.*
Bogdan Vernescu, WPI (1077-35-2814)

2:00PM (1089) *Design of radar and communication signals with perfect correlation properties.*
Andrzej K Brodzik, The MITRE Corporation (1077-05-584)

2:30PM (1090) *Optimization Algorithms on a Quantum Computer.* Preliminary report.
Richard H. Warren, Lockheed Martin Corporation, King of Prussia, PA (1077-81-646)

3:00PM Panel discussion on doing mathematics outside of academia moderated by Suzanne L. Weekes.

AMS Special Session on Mathematics in Natural Resource Modeling, IV

1:00 PM – 3:50 PM

Organizer: **Catherine Roberts**, College of the Holy Cross

1:00PM ► (1091) *On the Complexity of Competition.*
Roland H Lamberson, Humboldt State University (1077-92-411)

1:30PM (1092) *Co-viability modelling for the sustainable management of biodiversity.*
Luc Doyen, CNRS, Paris, France (1077-93-643)

2:00PM (1093) *The math and algorithms of mapping and valuing ecosystem services.* Preliminary report.
Erik J Nelson, Department of Economics, Bowdoin College (1077-92-1152)

2:30PM ► (1094) *A Mathematical Model of Harbor Seal Haul-out.*
Jonathan D Cowles, Department of Biology, Andrews University, **Shandelle M. Henson***, Andrews University, and **James L Hayward**, Department of Biology, Andrews University (1077-92-2562)

3:00PM ► (1095) *Model of Marine Iguana Haulout on Fernandina, Galapagos.* Preliminary report.
Brianna G Payne*, **James L Hayward**, Department of Biology, Andrews University, **Shandelle M. Henson**, Andrews University, **Libby C Megna**, Department of Biology, Andrews University, and **Susana del Rocio Velastegui Chavez**, Colegio Adventista del Ecuador (1077-92-1349)

3:30PM (1096) *The NW Power Conservation Council's Regional Portfolio Model and the R-tic PHOX computation environment: Overview.* Preliminary report.
Steven A Bleiler*, Portland State University, and **Thomas R Fielden**, Portland, Oregon (1077-60-1103)

AMS Special Session on Rational Points on Varieties, II

1:00 PM – 3:50 PM

Organizers: **Jennifer Balakrishnan**, Massachusetts Institute of Technology
Bjorn Poonen, Massachusetts Institute of Technology
Bianca Viray, Brown University
Kirsten Wickelgren, Harvard University

1:00PM (1097) *Failure of the Hasse principle on general K3 surfaces.*
Brendan Hassett and **Anthony Varilly-Alvarado***, Rice University (1077-11-797)

1:30PM (1098) *Density of rational points on Del Pezzo surfaces of degree one.*
Ronald van Luijk*, Universiteit Leiden, and **Cecilia Salgado**, Max Planck Institute, Bonn (1077-14-2153)

2:00PM (1099) *Manin's Conjecture and Balanced line bundles.*
Sho Tanimoto, Courant Institute of Mathematical Sciences, New York University (1077-14-1139)

2:30PM (1100) *Some Explicit Moduli Spaces of Elliptic Curves and Generalizations.* Preliminary report.
Wei Ho, Columbia University (1077-11-1295)

3:00PM (1101) *Rational elliptic surfaces with Mordell-Weil lattice E_8 and multiplicative reduction.*
Abhinav Kumar*, Massachusetts Institute of Technology, and **Tetsuji Shioda**, Rikkyo University (1077-11-2430)

3:30PM (1102) *Abelian varieties with homotheties.* Preliminary report.
Yuri Zarhin, Pennsylvania State University (1077-14-386)

AMS Special Session on Reaction Diffusion Equations and Applications, I

1:00 PM – 3:50 PM

Organizers: **Jerome Goddard II**, Auburn University Montgomery
Junping Shi, College of William and Mary
Ratnasingham Shivaji, University of North Carolina Greensboro

1:00PM (1103) *Steady-states for a chemotaxis system.*
Marcello Lucia*, City University of New York, CSI, and **Dirk Horstmann**, University of Cologne (1077-35-1283)

1:30PM (1104) *Alternate Stable States in Ecosystems.*
Sarath Sasi, Mississippi State University (1077-35-1101)

2:00PM (1105) *Asymptotic properties of perturbed parabolic equations.*
Juraj Foldes, Vanderbilt University (1077-35-655)

► 2:30PM (1106) *A Nonlinear Stability Analysis of Vegetative Turing Pattern Formation for an Interaction-Diffusion Plant-Surface Water Model System in an Arid Flat Environment.*
Bonni J Kealy* and **David J Wollkind**, Washington State University (1077-35-55)

3:00PM (1107) *Analysis of classes of elliptic equations with nonlinear boundary conditions arising in combustion theory.*
Eunkyung Ko, Mississippi State University (1077-35-305)

3:30PM (1108) *Existence of Multiple Positive Solutions to Some Semipositone Systems.*
Maya Chhetri, University of North Carolina–Greensboro, **Sarah Raynor*** and **Stephen Robinson**, Wake Forest University (1077-35-2737)

AMS Special Session on Several Complex Variables and Multivariable Operator Theory, III

1:00 PM – 3:50 PM

Organizers: **Ronald Douglas**, Texas A&M University
John McCarthy, Washington University

1:00PM (1109) *A Metric from a Reproducing Kernel Hilbert Space.* Preliminary report.
Richard Rochberg, Washington University, St. Louis (1077-47-876)

1:30PM (1110) *Function algebras invariant under group actions.* Preliminary report.
Alexander J. Izzo, Bowling Green State University (1077-32-415)

2:00PM (1111) *Schroeder's Equation in Several Variables.*
Robert A Bridges, Purdue University (1077-32-439)

2:30PM (1112) *On a pair of commuting isometries.*
Rongwei Yang, SUNY at Albany (1077-47-572)

► 3:00PM (1113) *Rational inner functions and the Nevanlinna-Pick problem on D^n.* Preliminary report.
David Scheinker, Drexel University (1077-32-959)

3:30PM (1114) *Polynomial Hulls of Certain Compact Manifolds.*
John Wermer, Providence, RI (1077-30-1015)

AMS Special Session on Stochastic Analysis (in honor of Hui-Hsiung Kuo), III

1:00 PM – 3:50 PM

Organizers: **Julius Esunge**, University of Mary Washington
Aurel Stan, Ohio State University

1:00PM (1115) *Stationary Solutions of Parabolic Equations in Gauss-Sobolev Space.*
Pao-Liu Chow, Wayne State University (1077-60-414)

1:30PM (1116) *On the 2D Navier-Stokes and Euler equations: A statistical study.*
Fernanda Cipriano, FCT-UNL and GFM-UL (1077-60-2101)

2:00PM (1117) *Ergodic control for two-dimensional stochastic Navier-Stokes equations.* Preliminary report.
P. Sundar, Louisiana State University (1077-60-1431)

2:30PM (1118) *Solvability of Forward-Backward Stochastic Partial Differential Equations.*
Hong Yin, State University of New York, Brockport (1077-60-1425)

3:00PM (1119) *A Stochastic Delay Model for Pricing Corporates Liabilities.*
Elisabeth Kemajou, Southern Illinois University Carbondale (1077-60-1446)

3:30PM (1120) *Portfolio Optimization under Convex Incentive Schemes.*
Maxim Bichuch and **Stephan Sturm***, Princeton University, ORFE Department (1077-91-1728)

AMS Special Session on Topological Graph Theory: Structure and Symmetry, III

1:00 PM – 3:50 PM

Organizers: **Jonathan L. Gross**, Columbia University
Thomas W. Tucker, Colgate University

1:00PM (1121) *The distinguishing chromatic numbers of graphs on surfaces.*
Seiya Negami, Yokohama National University (1077-05-748)

1:30PM (1122) *Distinguishability of Infinite Groups, Graphs, and Graph Products.*
Simon Mark Smith, Syracuse University, **Thomas W. Tucker**, Colgate University, and **Mark E. Watkins***, Syracuse University (1077-05-1229)

2:00PM (1123) *Vertex Transitive Infinite Median Graphs.*
Wilfried Imrich, Montanuniversity Leoben, Austria (1077-05-1894)

2:30PM (1124) *Embeddability of infinite graphs.*
Robin Christian, **R. Bruce Richter**, Department of Combinatorics and Optimization, University of Waterloo, and **Gelasio Salazar***, Instituto de Fisica. Universidad Autonoma de San Luis Potosi (Mexico) (1077-05-1834)

3:00PM (1125) *Topological Models of 3-configurations.* Preliminary report.
Arthur T. White, Western Michigan University (1077-05-80)

3:30PM (1126) *An orthogonal latin square construction for orientable hamiltonian embeddings of $K_{n,n,n}$.* Preliminary report.
M. N. Ellingham and **Justin Z. Schroeder***, Vanderbilt University (1077-05-1679)

AMS Special Session on Trends in Representation Theory, III

1:00 PM – 3:50 PM

Organizers: **Donald King**, Northeastern University
Alfred Noel, University of Massachusetts, Boston

1:00PM (1127) *On the adjoint representation of $\mathfrak{sl}_n$ and the Fibonacci numbers.*
Pamela E Harris, University of Wisconsin Milwaukee (1077-00-910)

1:30PM (1128) *Weights and Combinatorics Appearing in Certain Demazure Crystals.*
Julie Beier, Mercer University (1077-17-1674)

2:00PM (1129) *Krein spaces and local deformation in representation theory of super Lie groups.*
Roland Knevel, Bar-Ilan-University Ramat Gan, Israel (1077-43-1232)

2:30PM (1130) *Restriction to a maximal compact subgroup in the p-adic case.* Preliminary report.
Monica Nevins, University of Ottawa (1077-22-830)

3:00PM (1131) *Formal degrees of discrete series for classical affine Hecke algebras and p-adic groups.*
Dan Ciubotaru*, University of Utah, and **Syu Kato**, Kyoto University (1077-22-1380)

3:30PM (1132) *Geometric Structure in the Representation Theory of Reductive p-adic Groups.*
Paul Frank Baum, Penn State University (1077-22-86)

AMS Special Session on the Geometry of Real Projective Structures (Mathematics Research Communities session), II

1:00 PM – 3:40 PM

Organizers: **Jeffrey Danciger**, Stanford University
Kelly Delp, Buffalo State College
Sean Lawton, University of Texas, Pan American
Kathryn Mann, University of Chicago

1:00PM (1133) *Immersed surfaces in the modular orbifold.*
Danny Calegari, California Institute of Technology, and **Joel Louwsma***, The University of Oklahoma (1077-57-310)

1:30PM (1134) *Dynamics of the outer automorphism group on the $PSL(2,\mathbb{C})$ character variety of a 3-manifold.*
Aaron D Magid*, University of Maryland, and **Richard D Canary**, University of Michigan (1077-57-397)

2:00PM (1135) *Polynomial Pick forms for affine spheres and real projective polygons.* Preliminary report.
Michael Wolf*, Rice University, and **David Dumas**, University of Illinois at Chicago (1077-58-1138)

3:00PM (1136) *Cubic Differentials and Limits of RP^2 Structures.* Preliminary report.
John C Loftin*, Rutgers Newark, and **Michael Wolf**, Rice University (1077-53-1785)

MAA Invited Paper Session on Clever Counting or Beautiful Bijection?

1:00 PM – 4:20 PM

Organizer: **Jennifer Quinn**, University of Washington, Tacoma

1:00PM ► (1137) *Counting on Students: Combinatorial Proofs with Undergraduates.*
Arthur T. Benjamin, Harvey Mudd College (1077-AD-286)

1:30PM ► (1138) *Beautiful Bijections for Permutation Patterns.*
Lara K. Pudwell, Valparaiso University (1077-AD-1760)

2:00PM ► (1139) *A Beautiful Bijection that Counts and Does More: The Robinson-Schensted-Knuth Correspondence.*
Tom Roby, UConn/MIT (1077-AD-2904)

2:30PM ► (1140) *Beautiful Bijections and Clever Counting in Representations.*
Georgia Benkart, University of Wisconsin-Madison (1077-AD-2139)

3:00PM ► (1141) *The Benefits of Bijections.* Preliminary report.
David M. Bressoud, Macalester College (1077-AD-238)

3:30PM (1142) *Descriptive derangements for a sum of spheres.*
Bridget Eileen Tenner, DePaul University (1077-AD-1478)

4:00PM ► (1143) *A not-quite-bijective enumeration of domino tilings of Aztec diamonds.*
James G. Propp, UMass Lowell and UC Berkeley (1077-AD-345)

MAA Invited Paper Session on Decoding Geometry

1:00 PM – 3:50 PM

Organizers: **Carolyn S. Gordon**, Dartmouth College
David Webb, Dartmouth College

1:00PM (1144) *The music of triangles.*
Christopher M. Judge*, 47405, and **Luc Hillairet**, Universite de Nantes (1077-AI-862)

1:30PM (1145) *On the distribution of simple geodesics.*
Peter Buser*, Ecole Polytechnique Federale, Lausanne, and **Hugo Parlier**, University of Fribourg, Switzerland (1077-AI-2471)

2:00PM (1146) *Building Polygons from Spectral Data.*
Emily B Dryden*, Bucknell University, **Victor Guillemin**, MIT, and **Rosa Sena-Dias**, Instituto Superior Tecnico (1077-AI-2161)

2:30PM (1147) *Isospectral noncompact surfaces.* Preliminary report.
Pierre Albin, University of Illinois at Urbana-Champaign (1077-AI-1911)

3:00PM ► (1148) *A nodal domain count mystery.*
Gregory Berkolaiko, **Peter Kuchment***, Texas A&M University, and **Uzy Smilansky**, Weizmann Institute of Science and Cardiff University (1077-AI-988)

3:30PM (1149) *Distances between Riemannian Manifolds.*
Sajjad Lakzian, CUNY GC, and **Christina Sormani***, CUNY GC and Lehman College (1077-AI-1435)

MAA Minicourse #2: Part A

1:00 PM – 3:00 PM

A dynamical systems approach to the differential equations course.

Presenters: **Paul Blanchard**, Boston University
Robert Devaney, Boston University

MAA Minicourse #10: Part A

1:00 PM – 3:00 PM

Geometry and art: A liberal arts mathematics course.
Presenter: **Anneke Bart**, Saint Louis University

MAA Minicourse #9: Part A

1:00 PM – 3:00 PM

Reading original sources in Latin for the historian and mathematician.
Organizers: **Amy Shell-Gellasch**, Beloit College
Dominic Klyve, Central Washington University
Presenters: **Kim Plofker**, Union College
Stacy Langton, University of San Diego

AMS Session on Algebraic Geometry, I

1:00 PM – 2:55 PM

1:00PM (1150) *Variety of Finitely Generated k-algebra Homomorphisms.*
Jon Yaggie, University of Illinois Chicago (1077-14-2727)

1:15PM (1151) *Cyclic Breuil modules and Hopf orders in characteristic p.* Preliminary report.
Alan Koch, Agnes Scott College (1077-14-2378)

1:30PM (1152) *On the Secant Defectivity of Classically Studied Varieties.*
Jia Wan, University of Idaho (1077-14-2724)

1:45PM (1153) *Realizing Cubic Hypersurfaces in $\mathbb{P}^3$.*
Robert Edward Campbell, University of California, Irvine (1077-14-2524)

2:00PM (1154) *The Arithmetic-Geometric Mean of genus 1 with Applications to genus 2 and 3.* Preliminary report.
Eleanor S Farrington, Massachusetts Maritime Academy (1077-14-2479)

2:15PM (1155) *Stable birational equivalence and geometric Chevalley-Warning.*
Xia Liao, Florida State University (1077-14-2263)

2:30PM (1156) *Maximal rank conjecture for rational curves on hypersurfaces.*
Sara Gharahbeigi, Washington University in St Louis (1077-14-671)

2:45PM (1157) *Dolbeault dgas and L_∞-algebroids associated to subvarieties.*
Shilin Yu, Pennsylvania State University (1077-14-2004)

AMS Session on Combinatorics and Graph Theory, IV

1:00 PM – 3:55 PM

1:00PM ► (1158) *A new method for comparing chains of order statistics.* Preliminary report.
Corey M Manack, Amherst College (1077-05-2264)

1:15PM ► (1159) *Cyclic Closures of Finitely Simple Pattern Classes.*
John D Berman, Massachusetts Institute of Technology (1077-05-2257)

1:30PM (1160) *The Smith Normal Form of the Incidence Matrix of Skew Lines in $PG(3,q)$.*
Josh Ducey*, James Madison University, **Andries Brouwer**, T. U. Eindhoven, and **Peter Sin**, University of Florida (1077-05-2248)

1:45PM ► (1161) *Random Set Systems.*
William B Jamieson, East Tennessee State University (1077-05-2210)

2:00PM (1162) *Graphic Degree Sequences and Graphs with a k-factor.*
Xiaofeng Gu, West Virginia University (1077-05-2200)

2:15PM (1163) *On real number labellings and graph invertibility.*
Jeong-Ok Choi, **John P. Georges**, **David W. Mauro***, Trinity College, and **Yan Wang**, Millsaps College (1077-05-2215)

2:30PM Break.

2:45PM ► (1164) *Universal Cycles Under Equivalence Relations.*
Melinda D. Lanius*, Wellesley College, and **Andre Kuney**, Oberlin College (1077-05-2176)

3:00PM (1165) *On the Classification of Stanley Sequences.*
David S Rolnick, Massachusetts Institute of Technology (1077-05-2172)

3:15PM ► (1166) *Combinatorial Interpretations of the General Eulerian Numbers.* Preliminary report.
Tingyao Xiong*, Radford University, **Hung-ping Tsao**, Novato, CA, and **Jonathan I. Hall**, Michigan State University (1077-05-2137)

3:30PM (1167) *Cops and robbers location game.*
James Carraher*, University of Nebraska-Lincoln, **Ilkyoo Choi**, **Michelle Delcourt** and **Lawrence Erickson**, University of Illinois-Urbana Champaign (1077-05-2075)

3:45PM (1168) *Complexity of Tenacity Parameter in Networks.*
Dara Moazzami*, **Morteza Dadvand** and **Ali Moeini**, University of Tehran, School of Engineering (1077-05-364)

AMS Session on Commutative Rings and Algebras, I

1:00 PM – 3:10 PM

1:00PM (1169) *The Core of a Strongly Stable Ideal.*
Bonnie Smith, University of Kentucky (1077-13-2789)

1:15PM ► (1170) *Classifying annihilator-ideal graphs of finite commutative rings- Part I.* Preliminary report.
Amanda R. Curtis*, University of California, Santa Barbara, **Alexander J. Diesl**, Wellesley College, and **Jane C. Rieck**, University of Wisconsin- Madison (1077-13-2622)

1:30PM ► (1171) *Classifying Annihilator-Ideal Graphs for Finite Commutative Rings: Part Two.*
Amanda R Curtis, University of California, Santa Barbara, **Alexander J Diesl**, Wellesley College, and **Jane C Rieck***, University of Wisconsin, Madison (1077-13-2728)

1:45PM (1172) *Prime avoidance avoidance.* Preliminary report.
Brian Johnson, University of Nebraska - Lincoln (1077-13-2650)

2:00PM (1173) *Group Actions on Arrangement Complements.*
Daniel R Moseley, University of Oregon (1077-13-2424)

2:15PM (1174) *A Generalization of Integer-valued Polynomials Rings.*
K. Alan Loper, Ohio State University Newark, and **Nicholas J. Werner***, University of Evansville (1077-13-964)

2:30PM (1175) *On the Algebra Structure of Tor for Trivariate Monomial Ideals.* Preliminary report.
Jared L Painter, The University of Texas at Arlington (1077-13-1918)

2:45PM (1176) *Generalized Factorization in the Integers.* Preliminary report.
Alina A Florescu, University of Iowa (1077-13-861)

3:00PM ► (1177) *Normsets of almost Dedekind domains and atomicity.*
Richard Erwin Hasenauer, North Dakota State University (1077-13-536)

AMS Session on Manifolds, Cell Complexes, and Global Analysis, II

1:00 PM – 3:10 PM

1:00PM ► (1178) *The Unknotting Number of 3-Stranded Pretzel Knots.*
Eric Staron, The University of Texas at Austin (1077-57-757)

1:15PM (1179) *The finite group actions on prism manifolds.* Preliminary report.
Ryo Ohashi, King's College (1077-57-471)

1:30PM ► (1180) *Analogy between knots and primes: number fields ramified over two primes.* Preliminary report.
Moshe Cohen*, Bar-Ilan University (Israel), and **Michael Friedman**, Bar-Ilan University (1077-57-391)

1:45PM (1181) *Small volume link orbifolds.* Preliminary report.
Christopher K Atkinson* and **David Futer**, Temple University (1077-57-2615)

2:00PM ► (1182) *Analytical Properties of the Conformal Dirac Operator on the Unit Sphere.* Preliminary report.
Brett J. Pansano* and **John A. Ryan**, University of Arkansas, Fayetteville (1077-58-2141)

2:15PM (1183) *A combinatorial differential graded algebra for Legendrian knots from generating families.*
Michael Bradley Henry*, Siena College, and **Daniel R Rutherford**, University of Arkansas (1077-57-370)

2:30PM (1184) *A Lie-Algebraic Approach to the Local Index Theorem on a Flag Variety.*
Seunghun Hong, Pennsylvania State University (1077-58-2005)

2:45PM (1185) *$MU(BG_2)$, $CH(BG_2)$, and descent.*
Rebecca E Field, James Madison University (1077-58-2850)

3:00PM (1186) *Cosymplectic Metrics on Flag Manifolds and Partial Differential Equations.*
Marlio Paredes, Universidad del Turabo (1077-58-2931)

AMS Session on Real and Complex Analysis

1:00 PM – 4:10 PM

1:00PM (1187) *A Pointwise Convergence and Bessel Capacity.*
Javad Namazi, FDU (1077-26-649)

1:15PM (1188) *Some Subclasses of the Real-Valued Honorary Baire Two Functions on $\mathbb{R}^n$.* Preliminary report.
Michael J. Evans, Washington and Lee University, and **Manuel J. Sanders III***, University of South Carolina Beaufort (1077-26-2795)

1:30PM ► (1189) *Generalized Fractional Integrals, Derivatives and their Mellin's transforms.*
Udita Nalin Katugampola, Delaware State University (1077-26-957)

1:45PM (1190) *Polynomial Coefficients of Differential Operators which are Diagonal with respect to the Hermite Basis.* Preliminary report.
Tamas Forgacs, California State University Fresno, and **Andrzej Piotrowski***, University of Alaska Southeast (1077-30-2698)

2:00PM (1191) *Limit Behavior of Iterated Holomorphic Function Systems.*
Kourosh Tavakoli, City University of New York (1077-30-2312)

2:15PM (1192) *Fourier multipliers and Dirac operators.*
G Wang* and **Craig Nolder**, Florida State University (1077-30-1564)

2:30PM Break.

2:45PM (1193) *Bohr's phenomenon for analytic functions into the exterior of a compact convex body.*
R M Ali*, Universiti Sains Malaysia, and **Y Abu-Muhanna**, American University of Sharjah (1077-30-147)

3:00PM (1194) *Convolutions of Complex-Valued Harmonic Mappings.* Preliminary report.
Stacey Muir, University of Scranton (1077-30-2765)

3:15PM (1195) *On a polynomial approximation problem.*
Arthur A. Danielyan, University of South Florida (1077-30-2718)

3:30PM (1196) *Coefficient Estimates for Bi-univalent Ma-Minda Starlike and Convex Functions.*
See Keong Lee, Universiti Sains Malaysia (1077-30-276)

3:45PM (1197) *Necessary Conditions for the Existence of Higher Order Extensions of Univalent Mappings from the Disk to the Ball.* Preliminary report.
Jerry R. Muir, University of Scranton (1077-32-2683)

4:00PM ► (1198) *Multiplier sequences for simple sets of polynomials.* Preliminary report.
Tamas Forgacs, California State University, Fresno (1077-30-58)

AMS Session on Recreational Mathematics: Miscellaneous Topics

1:00 PM – 2:25 PM

1:00PM ► (1199) *On Scaling Infinite Products and their Application in Operator Decomposition.*
Wei Zhang* and **Jianzhong Wang**, Sam Houston State University (1077-00-1953)

1:15PM ► (1200) *Finding Asymmetric Drumming Rhythms.*
Andrew P Maturo* and **Nick Robbins**, Gettysburg College (1077-00-1539)

1:30PM ► (1201) *A fast finite difference method for fractional diffusion equations.* Preliminary report.
Treena Basu* and **Dr.Hong Wang**, University of South Carolina (1077-00-513)

1:45PM ► (1202) *Multisite phosphorylation with substrate sequestration can robustly generate bistability.* Preliminary report.
Kanadpriya Basu* and **Dr. Xinfeng Liu**, University of South Carolina (1077-00-512)

2:00PM (1203) *Integral Closures of number fields.*
Fidele F Ngwane, University of South Carolina, Salkehatchie, (1077-00-503)

2:15PM ► (1204) *Assessment of Enhanced College Algebra at Virginia State University in its Second Year.* Preliminary report.
Robert E. Wieman, Virginia State University (1077-97-2797)

AMS Session on Undergraduate Research, IV

1:00 PM – 3:55 PM

1:00PM ► (1205) *On 2-fold graceful labelings of graphs.*
Megan Cornett*, Indiana State University, and **Ellen Sparks**, illinois State University (1077-05-2671)

1:15PM ► (1206) *Covering Graphs, Voltage Assignments, and Hamiltonicity.*
Sarah Alexander*, Barnard College, **Matthew Hughes**, Bard College, and **Miriam Kuzbary**, The University of Texas at Dallas (1077-05-2463)

1:30PM ► (1207) *On Calculations of p-Typical Formal Group Laws.* **Eddie Santiago Beck**, University of Georgia (1077-55-2774)

1:45PM ► (1208) *Minimal Degree Parameterization for the Trefoil and Figure Eight Knots.* **Samantha Pezzimenti**, Ramapo College of New Jersey (1077-57-865)

2:00PM ► (1209) *Mean-reverting pricing models.* Preliminary report. **Jody Trapier Shipp**, George Mason University (1077-60-1206)

2:15PM (1210) *Stochastic Reduction of an SIR Model.* **Iulia Hociota*** and **Bruno D Welfert**, Arizona State University (1077-60-2105)

2:30PM Break.

2:45PM ► (1211) *Black-Scholes Model with Markov Parameters.* **Mark Goldfarb*** and **Bruno Welfert**, Arizona State University (1077-60-2152)

3:00PM (1212) *The resulting weighted ranking.* Preliminary report. **Dmitry Andreevich Sumkin**, Moscow Institute of Physics and Technology, Moscow, Russia (1077-62-2957)

3:15PM ► (1213) *Modified Chambolle Method for Speckle Image Denoising.* **Ethan Wyatt Lockhart***, North Carolina State University, **Arundhati Bagchi Misra** and **Hyeona Lim**, Mississippi State University (1077-65-2184)

3:30PM ► (1214) *Relative Efficiencies of the Maximum Partial Likelihood Estimators Under Sampling Schemes.* **Nils S Nelson***, Utah State University, and **Haimeng Zhang**, Mississippi State University (1077-62-1802)

3:45PM ► (1215) *A Proemial Disquisition of Cardinality.* **John Paul Jablonski**, Kutztown University of Pennsylvania (1077-03-336)

MAA Session on Arts and Mathematics, Together Again, III

1:00 PM – 3:35 PM

Organizer: **Douglas E. Norton**, Villanova University

1:00PM (1216) *Modular construction of knot and link patterns from simple tangles on k-uniform tessellations.* **David A Reimann**, Albion College (1077-B1-1280)

1:20PM ► (1217) *Braids, Cables, and Cells: An Interesting Intersection of Mathematics, Computer Science, and Art.* Preliminary report. **Joshua Brandon Holden**, Rose-Hulman Institute of Technology (1077-B1-2731)

1:40PM ► (1218) *Building a Better Beaded Bracelet: Transformations, Tessellations, and Tori.* **Susan Goldstine***, St. Mary's College of Maryland, and **Ellie Baker**, Lexington, MA (1077-B1-1776)

2:00PM ► (1219) *Using tiling theory to generate weaving patterns with beads.* **Gwen Laura Fisher***, beAd Infinitum, California, and **Blake Mellor**, Loyola Marymount University, Los Angeles, California (1077-B1-633)

2:20PM (1220) *A visual representation of the decomposition of the integers into prime factors.* **Margaret E. Kepner**, Washington, DC (1077-B1-2937)

2:40PM ► (1221) *The Projective Ornament of Claude Bragon.* **Susan McBurney**, Western Springs,IL (1077-B1-702)

3:00PM ► (1222) *Linear Iterative Systems and String Art.* **Samer S Habre**, Lebanese American University (1077-B1-412)

3:20PM ► (1223) *Diagrammatics: Art, Language, and Mathematics.* **Radmila Sazdanovic**, University of Pennsylvania (1077-B1-1792)

MAA Session on Projects, Demonstrations, and Activities that Engage Liberal Arts Mathematics Students, I

1:00 PM – 3:55 PM

Organizer: **Sarah Mabrouk**, Framingham State University

1:00PM (1224) *The Real Cost of Home Ownership.* **Stan Perrine**, Charleston Southern University (1077-L1-214)

1:20PM ► (1225) *Beyond Formulas: A Collaboration Between Liberal Arts Underclassmen and Senior Math Majors.* **Alissa S. Crans*** and **Robert J. Rovetti**, Loyola Marymount University (1077-L1-2272)

1:40PM ► (1226) *Try Trisecting by Bisecting.* **Theresa Jorgensen*** and **Barbara Shipman**, University of Texas at Arlington (1077-L1-1106)

2:00PM ► (1227) *Geometric Constructions in Contemporary Problem Solving.* **Jeffrey L. Poet**, Missouri Western State University (1077-L1-974)

2:20PM ► (1228) *Candy Bar Election.* **Ben Galluzzo**, Shippensburg University (1077-L1-2651)

2:40PM ► (1229) *Balancing structure and creativity in projects for liberal arts mathematics.* Preliminary report. **Reva Kasman**, Salem State University (1077-L1-560)

3:00PM (1230) *Hexiclouds: Graph Theory Meets LEGO Bricks.* **Edward W. Welsh**, Westfield State University (1077-L1-2902)

3:20PM ► (1231) *Observing the Motion of the Sun and the Moon.* **Helmer Aslaksen**, Dept. of Math./Dept. of Teacher Education, Univ. of Oslo, Norway (1077-L1-1687)

3:40PM ► (1232) *Survey It! Using Surveys to Answer Student's Questions.* **Erin Smith**, Zayed University Abu Dhabi, United Arab Emirates (1077-L1-1526)

MAA Session on Research on the Teaching and Learning of Undergraduate Mathematics, II

1:00 PM – 3:55 PM

Organizers: **Sean Larsen**, Portland State University

Stacy Brown, Pitzer College

Karen Marrongelle, Portland State University

1:00PM (1233) *Assessing Suitability of Grades and Course-Taking Patterns as Measures of Long-term Student Outcomes following Inquiry-Based Learning Experiences.* **Marina Kogan*** and **Sandra Laursen**, University of Colorado, Boulder (1077-M1-2034)

1:20PM ► (1234) *Definitions and Uses of Function Composition in Secondary and Early Collegiate Textbooks.* **Aladar K Horvath**, Michigan State University (1077-M1-2171)

1:40PM (1235) *From intuition to rigor: Calculus students' reinvention of the definition of sequence convergence.*
Michael Oehrtman, University of Northern Colorado, **Craig Swinyard***, University of Portland, **Jason Martin**, University of Central Kansas, **Catherine Hart-Weber** and **Kyeong Hah Roh**, Arizona State University

► 2:00PM (1236) *Students' Ways of Thinking about Enumerative Combinatorics Problems: Deletion and Equivalence Classes.*
Aviva Halani, Arizona State University (1077-M1-2805)

► 2:20PM (1237) *Quantitative Reasoning During Definition Formation: The Case of Absolute Value.*
Jason Martin*, University of Central Arkansas, **Michael Oehrtman**, University of Northern Colorado, **Craig Swinyard**, University of Portland, and **Beth Cory**, Sam Houston State University (1077-M1-2546)

► 2:40PM (1238) *A Controlled Study of Collaborative Learning in Intermediate Algebra.*
Claire Wyn Wladis* and **Alla Morgulis**, BMCC/CUNY (1077-M1-2580)

3:00PM (1239) *Identifying Student Difficulties in Combinatorial Proof Production.*
Nicole Engelke* and **Todd CadwalladerOlsker**, California State University, Fullerton (1077-M1-2679)

► 3:20PM (1240) *A Guided Reinvention of the Definitions of Ring, Integral Domain, and Field.* Preliminary report.
John Paul Cook, University of Oklahoma (1077-M1-2693)

► 3:40PM (1241) *Student Conceptions and Misconceptions with Order of Operations in Calculus.* Preliminary report.
Ian G. Caldwell*, **Eric Stade**, University of Colorado, Boulder, and **Hortensia Soto-Johnson**, University of Northern Colorado (1077-M1-2739)

MAA Session on Touch It, Feel It, Learn It: Tactile learning Activities in the Undergraduate Mathematics Classroom, IV

1:00 PM – 3:55 PM

Organizers: **Jessica Mikhaylov**, U.S. Military Academy
Julie Barnes, Western Carolina University

► 1:00PM (1242) *Euler Games for Differential Equations.*
Rodney X. Sturdivant, United States Military Academy (1077-O1-599)

► 1:20PM (1243) *Does the Wave Equation Really Work?*
Donald C. Armstead and **Michael A. Karls***, Ball State University (1077-O1-1862)

► 1:40PM (1244) *Demonstrations That Work in the Mathematics Classroom.*
Elton Graves, Rose-Hulman Institute of Technology (1077-O1-554)

► 2:00PM (1245) *Food for (Mathematical) Thought.*
Penelope H Dunham, Muhlenberg College (1077-O1-897)

► 2:20PM (1246) *How Many Mints Do I Have?*
Nathan Axvig, Virginia Military Institute (1077-O1-1767)

► 2:40PM (1247) *The Candy-Coated Mathematics Classroom.*
Erin Elizabeth Bancroft, Grove City College (1077-O1-2603)

► 3:00PM (1248) *Origami as Hands-on Math.*
Thomas C. Hull, Western New England University (1077-O1-2197)

3:20PM (1249) *Cookies, Sidewalk-chalk, and Office Chairs: Hands-on Activities from Calculus to Comets.*
Jessica M Mikhaylov, U.S. Military Academy, West Point (1077-O1-2669)

► 3:40PM (1250) *Using feather boas to teach students about functions in pre-calculus, calculus, and real analysis.* Preliminary report.
Julie Barnes, Western Carolina University (1077-O1-1726)

MAA Session on the Mathematics of Sudoku and Other Pencil Puzzles, II

1:00 PM – 3:35 PM

Organizers: **Laura Taalman**, James Madison University
Jason Rosenhouse, James Madison University

► 1:00PM (1251) *Arrowgrams.*
Kenneth L Price, University of Wisconsin Oshkosh (1077-H1-426)

► 1:20PM (1252) *Solitaire mancala games as pencil puzzles.* Preliminary report.
Brant Jones*, **Laura Taalman** and **Anthony Tongen**, James Madison University (1077-H1-2665)

► 1:40PM (1253) *Quantitative Analysis of Crossword Puzzle Difficulty.*
John K McSweeney, Concordia University (1077-H1-1408)

► 2:00PM (1254) *Finding closed knight's tours on annular chessboards.* Preliminary report.
Gregory P. B. Dresden, Washington & Lee University (1077-H1-148)

► 2:20PM (1255) *Radon-Kaczmarz Puzzles: CAT Scans Meet Sudoku.*
Julian F Fleron*, **Volker Ecke**, **Christine von Renesse** and **Philip K Hotchkiss**, Westfield State University (1077-H1-1603)

► 2:40PM (1256) *Mutually Orthogonal Sudoku Latin Squares.* Preliminary report.
Nate L. Coursey, Kennesaw State University (1077-H1-844)

► 3:00PM (1257) *Orthogonal Graph Colorings.*
Serge C. Ballif, Penn State University (1077-H1-850)

► 3:20PM (1258) *Magic Squares and Sudoku.*
John Lorch, Ball State University (1077-H1-505)

MAA General Contributed Paper Session: Modeling and Applications of Mathematics, I

1:00 PM – 3:40 PM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

► 1:00PM (1259) *Lagrangian Transport Patterns for Radioactive Particles after Fukushima.* Preliminary report.
Tim Lai, Arizona State University (1077-VG-2157)

► 1:15PM (1260) *Skeletons of Lagrangian Transport in Hurricane Katrina.* Preliminary report.
Chris G. Wake, Arizona State University (1077-VG-2158)

1:30PM (1261) *Linear instability in a combustion problem.*
Laura K. Gross*, Bridgewater State University, **Yi Yang**, Emory University, and **Jun Yu**, University of Vermont (1077-VG-304)

1:45PM *Study on freezing in cylindrical domain with*
► (1262) *convective cooling and energy generation.* Preliminary report.
Sushil Kumar, S. V. National Institute of Technology Surat, India (1077-VG-650)

2:00PM *A Boundary Value Problem for a Doublet.*
► (1263) **Kenneth H Luther**, Valparaiso University (1077-VG-1098)

2:15PM *A Nonparametric Expectation Maximization*
(1264) *Algorithm for Multiscale Hawkes Processes.*
Erik Lewis*, UCLA, and **George Mohler**, Santa Clara University (1077-VG-2156)

2:30PM *Laser propagation in biaxial liquid crystal polymers.*
► (1265) **Eric P Choate**, Naval Postgraduate School (1077-VG-2510)

2:45PM *Connections between bounded error parameter*
(1266) *identification and confidence ellipsoids.* Preliminary report.
Adam F Childers, Roanoke, VA (1077-VG-527)

3:00PM *Singularity of Cubic Bézier Curves and Surfaces.*
► (1267) **Edmond Nadler***, Eastern Michigan University, and **Tae-wan Kim**, Seoul National University (1077-VG-2617)

3:15PM *A Posteriori Error Analysis of Finite Element Method*
(1268) *for Linear Nonlocal Diffusion and Peridynamic Models.*
Qiang Du, Pennsylvania State University, **Lili Ju**, University of South Carolina, **Li Tian*** and **Kun Zhou**, Pennsylvania State University (1077-VG-1691)

3:30PM *Computational Sensors As Mathematical Models.*
(1269) **Emek Kose**, Saint Mary's College Of Maryland (1077-VG-2918)

SIAM Minisymposium on Sparsity in Inverse Problems and Signal Processing

1:00 PM – 3:55 PM

Organizer: **Otmar Scherzer**, University of Vienna

1:00PM *Statistical Multiscale Analysis: From Signal*
(1270) *Detection to Nanoscale Photonic Imaging.*
Axel Munk, U Goettingen and Max Planck Institute for Biophysical Chemistry (1077-62-2927)

1:30PM *A symbol-based approach to bar code decoding.*
► (1271) **Mark Iwen**, Duke University, **Fadil Santosa***, University of Minnesota, and **Rachel A Ward**, University of Texas (1077-94-2962)

2:00PM *A nonlinear sampling problem about signals with*
(1272) *finite rate of innovation.* Preliminary report.
Qiyu Sun, University of Central Florida (1077-94-1865)

2:30PM *Recent Results and Open Problems in Sparse*
(1273) *Regularisation.*
Markus Grasmair, Computational Science Center, University of Vienna (1077-49-1818)

3:00PM *Expressions of smoothness in regularization.*
(1274) **Bernd Hofmann**, Chemnitz University of Technology, Germany (1077-65-1315)

3:30PM *Hoelder Stability and Iterative Rconstruction in*
(1275) *Inverse Problems.*
Otmar Scherzer*, University of Vienna, **Maarten de Hoop** and **Lingyun Qiu**, Purdue University (1077-46-1843)

AMS Panel Discussion

1:00 PM – 2:30 PM

Summer math camps: The AMS (and mathematician's) role.

Organizers: **Irwin Kra**, SUNY at Stony Brook
Glenn Stevens, Boston University

Panelists: **Moon Duchin**, Tufts University
Glenn Stevens, Boston University
Max Warshauer, Texas State University

MAA-Young Mathematicians Network Panel Discussion

1:00 PM – 2:20 PM

Career options for undergraduate mathematics majors.

Organizers: **Nyles Breecher**, Hamline University
Raluccca Gera, Naval Postgraduate School

Panelists: **Erin Corman**, National Security Agency
Michael Dorff, Brigham Young University
Emily Kessler, Society of Actuaries

MAA Committee on Minority Participation/MAA Office of Minority Participation Panel Discussion

1:00 PM – 2:20 PM

Summer research programs.

Organizers: **William Hawkins, Jr**, MAA and University of the District of Columbia
Robert Megginson, University of Michigan

Panelists: **Min-Lin Lo**, California State University, San Bernardino
Asamoah Nkwanta, Morgan State University

The College Board/MAA Committee on Mutual Concerns Panel Discussion

1:00 PM – 2:20 PM

What can colleges and universities do to increase student success in calculus?

Organizers: **James R. Choike**, Oklahoma State University
Carl C. Cowen, Indiana University Purdue University Indianapolis

Panelists: **Alison Ahlgren**, University of Illinois, Urbana-Champaign
David M. Bressoud, Macalester College
Marilyn Carlson, Arizona State University
Bernard Madison, University of Arkansas

Summer Program for Women in Mathematics (SPWM) Reunion

1:00 PM – 4:00 PM

Organizer: **Murli M. Gupta**, George Washington University

AMS Special Session on New Perspectives in Multiplicative Number Theory (Mathematics Research Communities session), II

1:30 PM – 3:50 PM

Organizers: **Leo Goldmakher**, University of Toronto

Jonathan Kish, University of Colorado at Boulder

Micah Milinovich, University of Mississippi

Paul Pollack, University of British Columbia/Simon Fraser University

1:30PM (1276) *On the Correlation of completely multiplicative functions.*
Himadri Ganguli, Simon Fraser University (1077-11-640)

2:00PM Discussion moderated by Kannan Soundararajan

3:00PM (1277) *Resonance method for large character sums.*
Bob Hough, Stanford University (1077-11-858)

3:30PM (1278) *Elliptic Carmichael numbers.*
Carl Pomerance, Dartmouth College (1077-11-674)

MAA Poster Session on Projects Supported by the NSF Division of Undergraduate Education

2:00 PM – 4:00 PM

Organizer: **Jon Scott**, Montgomery College

2:00PM (1279) *UTMOST: Undergraduate Teaching of Mathematics with Open Software and Textbooks.*
Robert Beezer, University of Puget Sound, **Jason Grout**, Drake University, **Marja-Liisa Hassi**, University of Colorado at Boulder, **Thomas Judson***, Stephen F. Austin State University, **Kiran Kedlaya**, Massachusetts Institute of Technology, **Sandra Laursen**, University of Colorado at Boulder, and **William Stein**, University of Washington, Seattle

2:00PM (1280) *Change Agents for Teaching and Learning Statistics (CATALST).*
Joan Garfield*, **Bob delMas**, **Andy Zieffler**, University of Minnesota, **Allan Rossman**, **Beth Chance**, California Polytechnic State University, San Luis Obispo, **George Cobb**, Mount Holyoke College, and **John Holcomb**, Cleveland State University

2:00PM (1281) *Math in the City.*
Petronela Radu, **Stephen Hartke** and **Lauren Keough***, University of Nebraska-Lincoln

2:00PM (1282) *Discovery Learning Projects in Introductory Statistics.*
Brad Bailey, **Dianna Spence*** and **Sherry L Hix**, North Georgia College & State University

2:00PM (1283) *Research-Based Video for Teaching Undergraduate Proof.*
Jim Sandefur*, Georgetown University, **Connie Campbell**, Millsaps College, and **Kay Somers**, Moravian College

2:00PM (1284) *Quantitative Reasoning in the Contemporary World.*
Stuart Boersma*, Central Washington University, **Bernard L. Madison**, University of Arkansas, **Caren Diefenderfer**, Hollins University, and **Shannon Dingman**, University of Arkansas

2:00PM (1285) *Using Research to Shape Instruction and Placement in Algebra and Precalculus.*
Bernard L. Madison*, University of Arkansas, **Michael Pearson**, Mathematical Association of America, **Caren Diefenderfer**, Hollins University, and **Marilyn Carlson**, Arizona State University

2:00PM (1286) *Integrated Undergraduate Training in Mathematics and Life Sciences at NCSU.*
Hien Tran*, **Aloysius Helminck**, **James Gilliam** and **Alun Lloyd**, North Carolina State University

2:00PM (1287) *College Ready in Mathematics and Physics Partnership.*
Bernard L. Madison*, **Gay Stewart**, **Shannon Dingman**, University of Arkansas, **John Jones**, University of Arkansas at Fort Smith, and **Pete Joenks**, Springdale High School

2:00PM (1288) *Texas A&M UBM: Student Research Experience is the Key.*
May Boggess*, **Jay Walton**, **Masami Fujiwara**, Texas A&M University, **Kaibin Fu** and **Harriette Block**, Prairie View A&M University

2:00PM (1289) *REU Site: Modeling and Industrial Applied Mathematics.*
Aloysius Helminck* and **Hien Tran**, North Carolina State University

2:00PM (1290) *The Statistics Taught Using Resampling and Randomization (STURR) Project.*
Bob delMas, University of Minnesota

2:00PM (1291) *Evaluation and Assessment of Teaching and Learning About Statistics (e-ATLAS).*
Joan Garfield*, **Bob delMas** and **Andy Zieffler**, University of Minnesota

► 2:00PM (1292) *Assessing Faculty Practice and Faculty Development on Inquiry-Based Learning and Teaching in Undergraduate Mathematics.*
Sandra Laursen* and **Marina Kogan**, University of Colorado Boulder

2:00PM (1293) *The Poincare Institute: A Partnership for Mathematics Education.*
Montserrat Teixidor*, **Analucia Schliemann**, **David Carraher**, **Roger Tobin** and **Caroline J. Hagen**, Tufts University

2:00PM (1294) *Greater Birmingham Mathematics Partnership.*
John Mayer*, University of Alabama at Birmingham, **Bernadette Mullins**, Birmingham-Southern College, **Ruth Parker**, Mathematics Education Collaborative, **Ann Dominick** and **Tommy Smith**, University of Alabama at Birmingham

2:00PM (1295) *Native American-based Mathematics Materials for Integration into Undergraduate Courses.*
Charles P. Funkhouser*, **Scott A. Annin**, California State University Fullerton, and **Miles Pfahl**, Turtle Mountain Community College

2:00PM (1296) *Pathways to Calculus: Disseminating and Scaling a Professional Development Model for Algebra Through Precalculus Teaching and Learning.*
Marilyn P. Carlson*, **Wayne Raskind**, **Fabio Milner**, Arizona State University, **Michael Oehrtman**, Northern Colorado University, **Kevin Moore**, University of Georgia, and **Dawn Teuscher**, Brigham Young University

2:00PM (1297) *Empowering Student Learning in Mathematical Analysis.*
Barbara Shipman, The University of Texas at Arlington

2:00PM (1298) *MathDL Books Online.*
David Smith* and **Lang Moore**, Duke University

2:00PM (1299) *New Directions for MathDL.*
Lang Moore* and **David Smith**, Duke University

2:00PM (1300) *STEM Real World Applications of Mathematics.*
Darren Narayan* and **William Basener**, Rochester Institute of Technology

2:00PM (1301) *PREP: MAA's Professional Development Program.*
J. Michael Pearson, Mathematical Association of America, **Nancy Baxter Hastings**, Dickinson College, **Barbara Edwards**, Oregon State University, **Nathaniel Dean**, Texas State University San Marcos, **Virginia Buchanan**, Hiram College, **Mike Brilleslyper**, United States Air Force Academy, and **Jon Scott***, Montgomery College

2:00PM (1302) *Dynamic Visualization Tools for Multivariable Calculus.*
Paul Seeburger, Monroe Community College

2:00PM (1303) *Lurch, Educational Software for Writing Proofs.*
Kenneth G. Monks*, University of Scranton, and **Nathan Carter**, Bentley University

2:00PM (1304) *Flash Applets for WeBWorK Online Homework System.*
Barbara Margolius*, **Felipe Martins**, Cleveland State University, **Dan Gries**, Hopkins School, and **Yuping Wu**, Cleveland State University

2:00PM (1305) *Maplets for Calculus.*
Douglas B. Meade*, University of South Carolina, and **Philip B. Yasskin**, Texas A & M University

2:00PM (1306) *Playing Games with a Purpose: A New Approach to Teaching and Learning Statistics.*
Shonda R. Kuiper, Grinnell College, **Rodney Sturdivant***, **Billy Kaczynski**, **John Jackson** and **Kevin Cummiskey**, United States Military Academy

2:00PM (1307) *UBM-Group: Collaborations on Riverine Ecology (CORE): Investigations into species invasion and disease transmission at the interface betwwen mathematics and biology.*
James Peirce* and **Gregory Sandland**, University of Wisconsin - La Crosse

2:00PM (1308) *Texas Middle and Secondary Mathematics Project.*
Kimberly Childs, Stephen F. Austin State University

2:00PM (1309) *Texas Leadership Initiative: Mathematics Instruction Transformed (Texas LIMIT).*
Kimberly Childs*, **Deborah Pace**, **Lesa Beverly** and **Betty Alford**, Stephen F. Austin State University

2:00PM (1310) *Talented Teachers in Training for Texas (T4).*
Lesa Beverly*, **Keith Hubbard**, **Karen Embry-Jenlink** and **Dennis Gravatt**, Stephen F. Austin State University

2:00PM (1311) *Paradigms in Physics: Interactive Electromagnetism Curricular Materials.*
Tevian Dray*, **Corinne A. Manogue** and **Emily H. van Zee**, Oregon State University

2:00PM (1312) *Mathematical ACES: Algebraic Concepts for Elementary Students.*
Davida Fischman*, **Shawn McMurran**, **Joseph Jesunathadas**, California State University-San Bernardino, **Karla Wells**, Ontario Montclair Elementary School District, and **Carol Cronk**, San Bernardino Superintendent of Schools

2:00PM (1313) *Learning Discrete Mathematics and Computer Science via Primary Historical Sources.*
Jerry Lodder* and **David Pengelley**, New Mexico State University

2:00PM (1314) *Linear Algebra in New Environments (LINE).*
Draga Vidakovic*, Georgia State University, **Sergio Loch**, Grand View University, **William Martin**, North Dakota State University, and **Jeff Suzuki**, Brooklyn College

2:00PM (1315) *Careers in Mathematics.*
Michael Dorff, Brigham Young University

2:00PM (1316) *Math Images.*
Eugene Klotz*, Math Forum, and **Camilia Smith Barnes**, Sweet Briar College

2:00PM (1317) *Illustrating Graph Theory Concepts in Real World Settings.*
Joan M. Lucas* and **Rebecca Smith**, The College at Brockport, State University of New York

2:00PM (1318) *Undergraduate Research in Mathematical Biology: Modeling cellular processes from bacteria to neurons.*
George Yates*, **Jonathan Caguiat**, **Jozsi Jalics**, **Gary Walker** and **Mark Womble**, Youngstown State University

2:00PM (1319) *University Scholars in STEM.*
Leah Gold, Cleveland State University

2:00PM (1320) *Improving the Learning Environment for Underrepresented Students in Mathematics through the S-STEM Program.*
Alexandra Kurepa, North Carolina A&T State University

2:00PM (1321) *Research, Dissemination, and Faculty Development of Inquiry-Based Learning (IBL) Methods in the Teaching and Learning of Mathematics.*
Ralf Spatzier, University of Michigan

2:00PM (1322) *Distributome–An Interactive Web-based Resource for Probability Distributions.*
Kyle Siegrist*, University of Alabama in Huntsville, **Dennis Pearl**, The Ohio State University, and **Ivo Dinov**, University of California Los Angeles

2:00PM (1323) *Resources for Instructors Teaching "Elementary Mathematics for Teachers".*
Thomas H. Parker* and **Scott Baldridge**, Louisiana State University

2:00PM (1324) *Undergraduates Learning to Write Mathematics: The Math Images Project.*
K. A. Renninger*, **A. M. Phillips**, **A. Lipman** and **Gene Klotz**, Swarthmore College

2:00PM (1325) *Productive Disposition: Of What Does It Consist? The Case of Preservice Mathematics Teachers and Virtual Fieldwork: The Math Forum's Virtual Fieldwork Sequence.*
K. A. Renninger*, **M. Chin**, **D. Fan**, Swarthmore College, and **Wesley Shumar**, Drexel University

2:00PM (1326) *Discovering the Art of Mathematics.*
Julian F. Fleron*, **Volker Ecke**, **Philip K. Hotchkiss** and **Christine von Renesse**, Westfield State University

2:00PM (1327) *Introducing Statistical Techniques Through Guided Interdisciplinary Research Projects.*
Shonda Kuiper, Grinnell College

2:00PM (1328) *Math for America Boston: Teaching Scholars Program.*
Eileen Lee*, Math for America Boston, **Steve Rosenberg**, **Suzanne Chapin** and **Glenn Stevens**, Boston University

2:00PM (1329) *Focus on Mathematics: Creating Learning Cultures for High Student Achievement, A targeted Math and Science Partnership.*
Una MacDowell*, Education Development Center, Inc, **Steve Rosenberg**, **Glenn Stevens**, Boston University, **Al Cuoco**, Education Development Center, Inc, and **Wayne Harvey**, Education Development Center, Inc.

2:00PM (1330) *Resequencing Calculus.*
Mark Gruenwald* and **David Dwyer**, University of Evansville

2:00PM (1331) *Quantitative Skills in Biology through Scientific Inquiry at James Madison University.*
Brian Walton*, **Anthony Tongen**, **Nusrat Jahan** and **Reid Harris**, James Madison University

2:00PM (1332) *Project MOSAIC: Integrating Modeling, Statistics, Computation and Calculus in the Undergraduate Curriculum.*
Daniel Kaplan*, Macalester College, **Randall Pruim**, Calvin College, **Eric Marland**, Appalachian State University, and **Nicholas Horton**, Smith College

2:00PM (1333) *Biology and Mathematics in Population Studies (BioMaPS) II.*
Donald Adongo*, **K. Renee Fister**, **Terry Derting**, **Chris Mecklin**, **Claire Fuller**, **Kate He**, **Emily Croteau**, **Maeve McCarthy** and **Howard Whiteman**, Murray State University

2:00PM (1334) *DIYModeling (Do It Yourself Modeling).*
Frank Wattenberg*, **Rod Sturdivant**, **Chris Weld**, United States Military Academy, **Jim Rolf**, United States Air Force Academy, **Bill Bauldry**, Appalachian State University, **Joe Yanik** and **Betsy Yanik**, Emporia State University

2:00PM (1335) *WeBWorK: Improving Student Success in Mathematics.*
Arnold Pizer*, **Mike Gage**, **Vicki Roth**, University of Rochester, **Michael Pearson** and **John Wyatt**, Mathematical Association of America

2:00PM (1336) *The Impact of the PREP 2011 Workshops on Bioinformatics Research and Teaching Activities at Jacksonville State University.*
Monica Trifas*, **Aaron Garrett**, **Jimmy Triplett** and **Chris Murdock**, Jacksonville State University

2:00PM (1337) *An Integrative Analysis of Human Cancer: Exploiting the Synergy of Mathematical and Molecular Biological Approaches in Studying a Complex Problem.*
Jeffrey Forrester* and **Michael P. Roberts**, Dickinson College

AMS Invited Address

2:15 PM – 3:05 PM

(1338) *Invariant manifolds and dispersive Hamiltonian evolution equations.*
Wilhelm Schlag, University of Chicago (1077-35-2)

MAA/Young Mathematicians Network Panel Discussion

2:40 PM – 4:00 PM

Hit the ground running! Interview like a pro and land the job.

Organizers: **Kristine Roinestad**, Georgetown College
Nick Scoville, Ursinus College

Panelists: **David Cox**, Amherst College
Paul Dupuis, Brown University
Eric Grinberg, University of Massachusetts, Boston
Betty Mayfield, Hood College

MAA Panel Discussion

2:40 PM – 4:00 PM

Publishing with the MAA.

Organizer: **Zaven A. Karian**, Denison University

Panelists: **Donald J. Albers**, MAA
Gerald J. Bryce, Hampden-Sydney College

MAA Subcommittee on Research by Undergraduates Panel Discussion

2:40 PM – 4:00 PM

Successful and diverse models for mentoring research by undergraduates.

Organizers: **Sarah Spence Adams**, Franklin W. Olin College of Engineering
Angel R. Pineda, California State University, Fullerton

Panelists: **James Davis**, University of Richmond
Gary P. Gordon, Lafayette College
Kathryn Leonard, California State University, Channel Islands
Herbert A. Medina, Loyola Marymount University
Alison A. Motsinger-Reif, North Carolina State University
Suzanne L. Weekes, Worcester Polytechnic Institute

SIGMAA on Math Circles Demonstration for JMM Participants

3:00 PM – 4:00 PM

Come see and participate in this Math Circles experience.

Organizers: **James Tanton**, St. Mark's Institute of Mathematics
Tatiana Shubin, San Jose State University

AMS Retiring Presidential Address

3:20 PM – 4:10 PM

(1339) *Our challenges.*
George E. Andrews, Penn State University (1077-00-14)

Joint Prize Session

4:25 PM – 5:25 PM

SIGMAA on Environmental Mathematics Business Meeting

5:30 PM – 7:00 PM

Joint Prize Session Reception

5:30 PM – 6:30 PM

SIGMAA on the Philosophy of Mathematics Business Meeting and Guest Lecture

5:45 PM – 7:00 PM

5:45PM Business meeting.

6:15PM (1340) *Why is it plausible?*
Barry Mazur, Harvard University (1077-A0-44)

SIGMAA on Statistics Education Business Meeting and Reception

5:45 PM – 7:15 PM

MAA Two-Year College Reception

5:45 PM – 7:00 PM

SIGMAA on Mathematicians in Business, Industry, and Government Guest Lecture, Reception, and Business Meeting

6:00 PM – 8:45 PM

6:00PM (1341) *Rational rationing in healthcare: Observations for organ allocation.*
Sommer Gentry, U. S. Naval Academy (1077-A0-26)

7:15PM Reception.

8:00PM Business meeting.

SIGMAA on Research in Undergraduate Mathematics Education Business Meeting

6:00 PM – 7:00 PM

Young Mathematicians' Network Open Forum

7:30 PM – 8:30 PM

All meeting participants, including undergraduates and graduate students, are welcome to discuss topics and issues affecting young mathematicians.

Organizers: **Josh Laison**, Williamette University
Thomas Wakefield, Youngstown State University

Friday, January 6

Joint Meetings Registration

7:30 AM – 4:00 PM

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, I

8:00 AM – 10:50 AM

Organizers: **Bernard Brooks**, Rochester Institute of Technology
Jobby Jacob, Rochester Institute of Technology
Jacqueline Jensen, Sam Houston State University
Darren A. Narayan, Rochester Institute of Technology

8:00AM ► (1342) *The Rainbow Domination Number of a Graph.* Preliminary report.
Micaela Harris, **Ruth Haas**, **Kristina Martin***, **Shira Polster** and **Julie Woods**, Smith College (1077-05-1886)

8:30AM ► (1343) *Discrete Models with Proportional Harvesting.*
James C Cameron*, University of Texas at Austin, **Luis Diego Granera**, Yale University, **Peter Jaworski**, Central Michigan University, and **Loren Santana**, Skidmore College (1077-39-107)

9:00AM ► (1344) *On 2-fold G-designs where G has order at most 4 and edge-multiplicity 2.*
Sabrina Allen*, University of Illinois, Champaign-Urbana, **Jelsi Bolt**, Kankakee High School, IL, **Ryan C. Bunge**, Illinois State University, **Scott Burton**, Virginia Tech, and **Saad I. El-Zanati**, Illinois State University (1077-05-2666)

9:30AM ► (1345) *On Rosa-type labelings of directed graphs.*
Catherine Kruger*, Eastern Illinois University, **Saad El-Zanati**, Illinois State University, and **Jessica Klister**, University of Wisconsin La Crosse (1077-05-2812)

10:00AM ► (1346) *Higher Rectification and Polytope Numbers: The Simplex Case.* Preliminary report.
Chelsea R. Snyder* and **Christina C. Scurlock**, Grove City College (1077-05-40)

10:30AM ► (1347) *Restricted Symmetric Signed Permutations.*
Andy Hardt and **Justin M. Troyka***, Carleton College (1077-05-91)

AMS-MAA-MER Special Session on Mathematics and Education Reform, I

8:00 AM – 10:50 AM

Organizers: **William Barker**, Bowdoin College
William McCallum, University of Arizona
Bonnie Saunders, University of Illinois at Chicago

8:00AM ► (1348) *A statewide partnership to support professional development for mathematics teachers.* Preliminary report.
W James Lewis, University of Nebraska-Lincoln (1077-97-2151)

8:30AM ► (1349) *Incorporating the Common Core State Standards Integrated Secondary Curriculum in a Teacher Training Course.*
Amanda Cangelosi and **Hugo Rossi***, University of Utah (1077-97-184)

9:00AM (1350) *The Mathematical Education of Teachers II and Progressions for the Common Core State Standards for Mathematics.* Preliminary report.
Sybilla Beckmann, University of Georgia (1077-97-1542)

9:30AM ► (1351) *A Guided Tour of the Illustrative Mathematics Project.* Preliminary report.
Kristin L. Umland, University of New Mexico (1077-97-644)

10:00AM (1352) *Assessing Mathematical Habits of Mind for Teaching.*
Ryota Matsuura*, St. Olaf College, **Sarah Sword**, **Mary Beth Piecham**, Education Development Center, Inc., **Glenn Stevens**, Boston University, and **Al Cuoco**, Education Development Center, Inc. (1077-97-2827)

10:30AM ► (1353) *Transforming geometry through transformations.*
Patrick Callahan, University of California Los Angeles (1077-97-1879)

AMS-SIAM Special Session on the Mathematics of Computation: Algebra and Number Theory, I

8:00 AM – 10:50 AM

Organizers: **Jean-Marc Couveignes**, Université de Toulouse
Michael J. Mossinghoff, Davidson College
Igor E. Shparlinski, Macquarie University, Australia

8:00AM (1354) *Faster deterministic integer factorization.*
David Harvey, University of New South Wales (1077-11-881)

8:30AM ► (1355) *Algorithms for Approximately Counting Semismooth Integers.* Preliminary report.
Jonathan P Sorenson, Butler University (1077-11-405)

9:00AM (1356) *Elliptic Pseudoprimes and Elliptic Carmichael Numbers.* Preliminary report.
Joseph H. Silverman*, Brown University, and **Chantal David**, Concordia University (1077-11-173)

9:30AM ► (1357) *Wieferich primes, heuristics, and computations.* Preliminary report.
Pace P Nielsen, Brigham Young University (1077-11-48)

10:00AM (1358) *Dense product-free sets.*
Carl Pomerance, Dartmouth College (1077-11-406)

10:30AM ► (1359) *Congruence properties of the multiplicative partition function.*
Paul Pollack, University of British Columbia (1077-11-285)

AMS-AWM Special Session on Nonlinear Hyperbolic Partial Differential Equations, II

8:00 AM – 10:50 AM

Organizers: **Barbara Lee Keyfitz**, Ohio State University
Charis Tsikkou, Ohio State University

8:00AM (1360) *Transonic flow in gas dynamics.*
Dehua Wang, University of Pittsburgh (1077-35-296)

8:30AM (1361) *A system of conservation laws with no classical Riemann solution. Existence of Dafermos profiles for singular shocks.*
Barbara Lee Keyfitz and **Charis Tsikkou***, The Ohio State University (1077-35-2501)

9:00AM (1362) *Applications of Generalized Characteristics.*
Constantine M. Dafermos, Brown University (1077-35-1049)

9:30AM (1363) *Singularity Formation in Nonstrictly Hyperbolic Equations.*
Katarzyna Saxton, Loyola University, New Orleans (1077-35-2206)

10:00AM (1364) *On the transonic shocks of Euler-Poisson equations.*
Tao Luo, Georgetown University (1077-35-582)

10:30AM (1365) *Enhanced Lifespan of Smooth Solutions of a Burgers-Hilbert Equation.*
John K Hunter* and **Mihaela Ifrim**, University of California at Davis (1077-35-2769)

AMS Special Session on Advances in Mathematical Biology, I

8:00 AM – 10:50 AM

Organizers: **David Chan**, Virginia Commonwealth University
Rebecca Segal, Virginia Commonwealth University

8:00AM (1366) *Stability and bifurcations in an epidemic model with nonlinear incidence rate and varying immunity period.* Preliminary report.
Eric José Avila, Universidad Autonoma de Yucatan (1077-34-295)

8:30AM ► (1367) *Reaction-Diffusion-Delay Model for Chondrocyte/Cytokine Interactions During Typical Injury Response in Articular Cartilage.* Preliminary report.
Jason M Graham, University of Iowa (1077-92-719)

9:00AM (1368) *Dynamical behavior of a model for hormonal regulation of the menstrual cycle.*
James F Selgrade* and **Alison Margolskee**, North Carolina State University (1077-92-2359)

9:30AM (1369) *Fatal Disease and Demographic Allee Effect: Population Persistence and Extinction.*
Avner Friedman, Mathematical Bioscience Institute/ The Ohio State University, and **Abdul-Aziz Yakubu***, Howard University (1077-34-2150)

10:00AM (1370) *Attenuant and Resonant 2-Cycles in Discrete-Time 2-Species Population Models.* Preliminary report.
John E. Franke*, North Carolina State University, and **Matthew A. Morena**, University of New Hampshire (1077-92-1624)

10:30AM (1371) *On a nonlinear system of difference equations.*
M Predescu, Bentley University (1077-39-921)

AMS Special Session on Algebraic and Geometric Aspects of Integrable Systems and Random Matrices, I

8:00 AM – 10:40 AM

Organizers: **Anton Dzhamay**, University of Northern Colorado
Kenichi Maruno, University of Texas, Pan American
Virgil Pierce, University of Texas, Pan American

8:00AM (1372) *Random matrix methods for the enumeration of 3-valent maps.*
Nicholas M. Ercolani, University of Arizona, and **Virgil U. Pierce***, University of Texas – Pan American (1077-60-786)

8:30AM (1373) *The Riemann–Hilbert approach to the gap probabilities in multi-time random point processes of Airy and Pearcey type.*
Marco Bertola*, Concordia University, Montreal, and **Mattia Cafasso**, Universite' d'Angers, France (1077-60-1169)

9:00AM (1374) *β ensemble on a Jordan curve.* Preliminary report.
Seung Yeop Lee*, Caltech, and **Nikolai Makarov**, Caltech.edu (1077-60-1213)

9:30AM (1375) *A matrix model for simple Hurwitz numbers and topological recursion.*
Gaetan Borot, **Bertrand Eynard**, Service de Physique Theorique de Saclay, **Motohico Mulase**, University of California, Davis, and **Brad Safnuk***, Central Michigan University (1077-14-42)

10:00AM (1376) *Dyson's Brownian Motions and Critical Diffusions.*
Mark A Adler, Brandeis University (1077-60-2222)

AMS Special Session on Arithmetic Geometry, II

8:00 AM – 10:50 AM

Organizers: **Bo-Hae Im**, Chung-Ang University, South Korea
Jennifer Johnson-Leung, University of Idaho
Jennifer Paulhus, Grinnell College

8:00AM (1377) *Abelian surfaces with extra endomorphims.*
Reinier Broker*, Brown University, **Kristin Lauter**, Microsoft Research, and **Marco Streng**, University of Warwick (1077-14-960)

8:30AM (1378) *Automorphism groups of a family of maximal curves.*
Robert M. Guralnick, University of Southern California, **Beth Malmskog***, Wesleyan University, and **Rachel Pries**, Colorado State University (1077-11-2028)

9:00AM (1379) *Genus 2 curves with (4, 4)-split Jacobians.*
Nils Bruin and **Kevin Doerksen***, Simon Fraser University (1077-11-2125)

9:30AM (1380) *Decomposing Jacobian Varieties of Curves.* **Jennifer Paulhus**, Grinnell College (1077-11-2349)

10:00AM (1381) *On the arithmetic of the Legendre curve in a tower of function fields.* Preliminary report. **Douglas Ulmer**, Georgia Institute of Technology (1077-11-2192)

10:30AM (1382) *An arithmetic intersection formula for denominators of Igusa class polynomials.* Preliminary report. **Kristin Lauter**, Microsoft Research, and **Bianca Viray***, Brown University (1077-11-718)

AMS Special Session on Calculus of Functors and Its Applications, I

8:00 AM – 10:50 AM

Organizers: **Brian Munson**, Wellesley College
Ismar Volic, Wellesley College

8:00AM (1383) *Embedding Calculus and Topological Categories.* **Daniel Pryor**, University of Virginia (1077-55-2258)

8:30AM (1384) *Geometric representative of a* $(3d-8)$*–dimensional cycle in knot spaces.* **Kristine Pelatt**, University of Oregon (1077-55-1185)

9:00AM (1385) *New Developments in Approximation Towers of Functors.* Preliminary report. **Rosona M Eldred**, University of Illinois Urbana-Champaign (1077-55-2600)

9:30AM (1386) *The* mod 2 *homology of infinite loopspaces.* **Jason B. McCarty**, University of Virginia (1077-55-258)

10:00AM (1387) *A homotopy-theoretic view of Bott–Taubes integrals and knot spaces.* **Robin M. J. Koytcheff**, Brown University (1077-55-2329)

10:30AM (1388) *A classification of Taylor towers*. Preliminary report. **Michael Ching**, Amherst College (1077-55-1625)

AMS Special Session on Combinatorial Geometry of Polytopes, III

8:00 AM – 10:50 AM

Organizers: **Egon Schulte**, Northeastern University
Asia Ivic Weiss, York University

8:00AM (1389) *Symmetries of Equivelar Toroids.* **Asia Ivic Weiss***, York University, **Isabel Hubard**, UNAM Mexioc City, Mexico, **Alen Orbanic**, University of Ljubljana, Slovenia, and **Daniel Pellicer**, UNAM Morelia, Mexico (1077-52-614)

8:30AM (1390) *Equivelar 4-twistoids.* **Mark Mixer***, York University, **Isabel Hubard**, **Daniel Pellicer**, UNAM, and **Asia Ivic Weiss**, York University (1077-52-2512)

9:00AM (1391) *Projective Polytopes.* Preliminary report. **Javier Bracho**, UNAM (1077-52-2607)

9:30AM ► (1392) *Non-Triangulatable Polyhedra.* **B. Carrigan**, Auburn University (1077-52-1643)

10:00AM (1393) *The Law of Aboav–Weaire and its analogue in three dimensions.* **Richard Ehrenborg***, University of Kentucky, **Menachem Lazar**, Institute for Advanced Study, and **Jeremy Mason**, Lawrence Livermore National Laboratory (1077-52-866)

10:30AM (1394) *Vertex-transitive polyhedral maps and actions of discrete groups on surfaces.* **Roman Nedela**, Matej Bel University, Banska Bystrica, Slovak rep. (1077-05-852)

AMS Special Session on Control Theory and Inverse Problems for Partial Differential Equations, II

8:00 AM – 10:50 AM

Organizers: **Shitao Liu**, University of Helsinki
Ting Zhou, Massachusetts Institute of Technology

8:00AM (1395) *Carleman estimates for systems of partial differential equations.* **Matthias Eller**, Georgetown University (1077-35-2369)

8:30AM (1396) *The Calderon Problem with Partial Data.* **Gunther Uhlmann**, UC Irvine and University of Washington (1077-35-2584)

9:00AM (1397) *Schrödinger hats: cloaked amplifiers via transformation optics.* **Allan Greenleaf***, University of Rochester, **Yaroslav Kurylev**, University College London, **Matti Lassas**, University of Helsinki, **Ulf Leonhardt**, School of Physics and Astronomy, University of St. Andrews, and **Gunther Uhlmann**, University of California-Irvine (1077-35-613)

9:30AM (1398) *Recovery of a source or a sound speed with one measurement and applications.* **Plamen Stefanov***, Purdue University, and **Gunther Uhlmann**, University of Washington and UC Irvine (1077-35-615)

10:00AM (1399) *Hybrid inverse problems and internal functionals.* **Guillaume Bal**, Columbia University (1077-35-532)

10:30AM (1400) *Local Analysis of Inverse Problems: Hölder Stability and Iterative Reconstruction.* **Maarten de Hoop***, **Lingyun Qiu**, Purdue University, and **Otmar Scherzer**, University of Vienna (1077-35-1651)

AMS Special Session on Differential Algebraic Geometry and Galois Theory (in memory of Jerald Kovacic), II

8:00 AM – 10:50 AM

Organizers: **Phyllis Joan Cassidy**, Smith College and the City University of New York
Richard Churchill, Hunter College and Graduate Center at CUNY
Claude Mitschi, Université de Strasbourg, France
Michael Singer, North Carolina State University

8:00AM (1401) *Reductive connections and Ruled surfaces.* **Camilo Sanabria**, CUNY Bronx Community College (1077-34-727)

8:30AM ► (1402) *Topological Methods in Klein's Resolvent Problem.* **Yuri Burda**, University of Toronto (1077-12-932)

9:00AM (1403) *The Lie groupoid of the integers.* **Alexandru Buium**, University of New Mexico (1077-13-419)

9:30AM (1404) *Real Picard-Vessiot theory.* **Zbigniew Hajto***, Jagiellonian University, **Teresa Crespo**, Universitat de Barcelona, and **Elzbieta Sowa**, Jagiellonian University (1077-12-1171)

10:00AM (1405) *Computing the Galois Group of Linear Difference-Differential Equations.* **Ruyong Feng**, KLMM, Chinese Academy of Sciences (1077-34-541)

10:30AM ► (1406) *Solve Linear Differential Equations in terms of Hypergeometric Functions.* **Tingting Fang*** and **Mark van Hoeij**, Florida State University (1077-34-1224)

AMS Special Session on Fractal Geometry in Pure and Applied Mathematics (in memory of Benoit Mandelbrot), III

8:00 AM – 10:50 AM

Organizers: **Michael L. Lapidus**, University of California, Riverside
Erin Pearse, University of Oklahoma
Machiel van Frankenhuijsen, Utah Valley University

8:00AM (1407) *Packing dimension of images of additive Lévy processes.*
Liang Zhang, University of Utah (1077-60-1001)

8:30AM (1408) *Correlation-length bounds, and estimates for intermittent islands in parabolic SPDEs.*
Davar Khoshnevisan, University of Utah (1077-60-1461)

9:00AM (1409) *Multifractal analysis of Lévy fields.*
Arnaud Durand*, Univ. Paris-Sud, and **Stephane Jaffard**, Univ. Paris-Est (1077-60-1304)

9:30AM ► (1410) *Fractal properties of the Schramm-Loewner evolution.*
Gregory F Lawler, University of Chicago (1077-60-609)

10:00AM (1411) *On-diagonal oscillation of the heat kernels on p.c.f. self-similar fractals.*
Naotaka Kajino, University of Bielefeld (1077-60-952)

10:30AM ► (1412) *The Geometry of the Mandelbrot Set.*
Robert L. Devaney, Boston University (1077-37-1601)

AMS Special Session on Frontiers in Geomathematics, II

8:00 AM – 10:50 AM

Organizers: **Willi Freeden**, University of Kaiserslautern
Volker Michel, University of Siegen
M. Zuhair Nashed, University of Central Florida
Thomas Sonar, Technical University of Braunschweig

8:00AM (1413) *Mathematical Texture Anaylsis.*
Helmut Schaeben, Geophysics and Geoscience Informatics, TU Bergakademie Freiberg (1077-41-1819)

9:00AM (1414) *Regularization of Tomographic Inverse Problems in Geophysics.*
Volker Michel, Geomathematics Group, University of Siegen, Germany (1077-65-1069)

10:00AM (1415) *Sparse Approximation on the Sphere - A Matching Pursuit with a Kernel Based Dictionary.*
Roger Telschow, Geomathematics Group, University of Siegen (1077-41-1312)

10:30AM ► (1416) *The Regularized Functional Matching Pursuit and its Application to Inverse Ill-posed Problems in Geomathematics.*
Doreen Fischer, Geomathematics Group, University of Siegen (1077-41-1310)

AMS Special Session on Homotopy Theory, I

8:00 AM – 10:50 AM

Organizers: **Mark Behrens**, Massachusetts Institute of Technology
Mark W. Johnson, Pennsylvania State University, Altoona
Haynes R. Miller, Massachusetts Institute of Technology
James Turner, Calvin College
Donald Yau, Ohio State University

8:00AM (1417) *On the equivariant cohomology of Stiefel manifolds.* Preliminary report.
William C Kronholm, Whittier College (1077-55-56)

8:30AM (1418) *Cohomology of equivariant Grassmannians and motivic characteristic classes for quadratic bundles.*
Daniel Dugger, University of Oregon (1077-55-1920)

9:00AM (1419) *Global equivariant homotopy theory.*
Anna Marie Bohmann, Northwestern University (1077-55-1866)

9:30AM (1420) *G-spectra and equivariant commutativity.* Preliminary report.
Bertrand J Guillou*, University of Illinois - Urbana-Champaign, **J Peter May**, University of Chicago, and **Nathaniel Stapleton**, MIT (1077-55-2623)

10:00AM (1421) *A homotopical version of p-local finite groups.* Preliminary report.
Matthew J. K. Gelvin*, University of Copenhagen, and **Kári Ragnarsson**, Chicago, IL (1077-55-2305)

10:30AM (1422) *The Segal conjecture in homotopical group theory.* Preliminary report.
William G. Dwyer, Notre Dame, and **Kári Ragnarsson***, Google/AIM (1077-55-2246)

AMS Special Session on Linear Algebraic Groups: Their Arithmetic, Geometry, and Representations, II

8:00 AM – 10:50 AM

Organizers: **R. Skip Garibaldi**, Emory University
George McNinch, Tufts University

8:00AM (1423) *Graham's Variety and Perverse Sheaves on the Nilpotent Cone.*
Amber Russell, Louisiana State University (1077-22-692)

8:30AM (1424) *Nilpotent Orbit Closures in the Symplectic and Orthogonal Groups.* Preliminary report.
Ellen J Goldstein, Northwestern University (1077-14-1788)

9:00AM (1425) *Algebraic Frobenius splitting of bundles on flag varieties.* Preliminary report.
Chuck Hague, University of Delaware (1077-20-1597)

9:30AM (1426) *Equivariant Birational Properties of Algebraic Tori.* Preliminary report.
Nicole Lemire, University of Western Ontario (1077-20-2180)

10:00AM (1427) *Reduced Null Cones.*
Gerald W. Schwarz*, Brandeis University, and **Hanspeter Kraft**, University of Basel (1077-20-688)

10:30AM (1428) *On a duality for nilpotent orbits.* Preliminary report.
Eric Sommers, University of Massachusetts at Amherst (1077-17-1214)

AMS Special Session on Noncommutative Birational Geometry and Cluster Algebras, I

8:00 AM – 10:50 AM

Organizers: **Arkady Berenstein**, University of Oregon
Vladimir Retakh, Rutgers University

8:00AM (1429) *Yangians, quantum loop algebras and trigonometric connections.*
Valerio Toledano Laredo, Northeastern University, Boston, MA (1077-17-1443)

9:00AM (1430) *Yangians and quantum loop algebras.*
Sachin Gautam, Columbia University (1077-17-2633)

9:30AM (1431) *A Minimal Non-Koszul $A(\Gamma)$.*
David Nacin, Lincoln Park (1077-16-2292)

10:00AM (1432) *Noncommutative Quadratic Forms.* Preliminary report.
Padmini P Veerapen* and **Michaela Vancliff**, University of Texas, Arlington (1077-16-2846)

10:30AM (1433) *Functorial approach to differentiation algorithms for representations of partially ordered sets.*
Mark Kleiner*, Syracuse University, and **Markus Reitenbach**, Colorado Mesa University (1077-16-1476)

AMS Special Session on Progress in Free Analysis, II

8:00 AM – 10:50 AM

Organizers: **J. William Helton**, University of California, San Diego
Paul S. Muhly, University of Iowa

8:00AM (1434) *Free Inequalities.* Preliminary report.
Scott McCullough, University of Florida (1077-47-1176)

8:30AM (1435) *Noncommutative Inequalities.*
J. William Helton, UCSD La Jolla, California (1077-46-1641)

9:00AM (1436) *Noncommutative Real Ideals and an Algorithm for Computing Them.*
Christopher S Nelson, University of California, San Diego (1077-47-2006)

9:30AM (1437) *Noncommutative analytic functions.*
Dmitry Kaliuzhnyi-Verbovetskyi, Drexel University (1077-46-909)

10:00AM (1438) *Noncommutative functions: examples and key features.*
Victor Vinnikov, Ben Gurion University (1077-47-2691)

10:30AM (1439) *Dilation theory, commutant lifting and semicrossed products.*
Kenneth R. Davidson, University of Waterloo (1077-47-616)

AMS Special Session on Radon Transforms and Geometric Analysis (in honor of Sigurdur Helgason's 85th birthday), I

8:00 AM – 10:40 AM

Organizers: **Jens Christensen**, University of Maryland
Fulton Gonzalez, Tufts University
Todd Quinto, Tufts University

8:00AM (1440) *A Generalization of the Mader-Helgason Inversion Formulas for Radon Transforms.*
Yuri A. Antipov and **Boris Rubin***, Louisiana State University (1077-44-724)

8:30AM (1441) *Local injectivity of weighted Radon transforms.*
Jan Boman, Stockholm University (1077-44-715)

9:00AM (1442) *Characters of group representations and semi-classical analysis.* Preliminary report.
Victor Guillemin, Massachusetts Institute of Technology (1077-22-466)

10:00AM (1443) *Orbital Integrals, applications and problems.*
Sigurdur Helgason, MIT Cambridge MA 02139 (1077-43-916)

AMS Special Session on Recent Advances in Mathematical Biology, Ecology, and Epidemiology, I

8:00 AM – 10:50 AM

Organizers: **Sophia R. Jang**, Texas Tech University
Andrew L. Nevai, University of Central Florida
Lih-Ing W. Roeger, Texas Tech University

8:00AM (1444) *Intracellular Viral Life-cycle Induced Rich Dynamics in Tumor Virotherapy.* Preliminary report.
Jianjun Paul Tian*, College of William and Mary, **Yang Kuang**, Arizona State University, and **Hanchun Yang**, Yunnan University (1077-34-1249)

8:30AM (1445) *Extinction or Persistence of Disease in Stochastic Multi-Patch Epidemic Models.*
Glenn Lahodny Jr.* and **Linda J. S. Allen**, Texas Tech University (1077-92-1876)

9:00AM (1446) *Global Dynamics of a Cholera Model that Includes Direct and Indirect Transmission.*
Pauline van den Driessche, University of Victoria, B.C., Canada (1077-92-911)

9:30AM ► (1447) *Modeling the spread of waterborne disease: Incorporating heterogeneity in multiple transmission pathways.*
Suzanne L. Robertson, Mathematical Biosciences Institute (1077-92-1638)

10:00AM ► (1448) *Seasonality in Avian Influenza H5N1.*
Necibe Tuncer, University of Tulsa, and **Maia Martcheva***, University of Florida (1077-92-233)

10:30AM (1449) *Spatiotemporal Mutualistic Model of Mistletoes and Birds.*
Rongsong Liu, Department of Mathematics and Department of Zoology and Physiology, University of Wyoming, **Junping Shi***, College of William and Mary, **Carlos Martinez del Rio**, Department of Zoology and Physiology, University of Wyoming, and **Chuncheng Wang**, Department of Mathematics and Department of Zoology and Physiology, University of Wyoming (1077-92-1067)

AMS Special Session on Recent Trends in Graph Theory, I

8:00 AM – 10:50 AM

Organizer: **Ralucca Gera**, Naval Postgraduate School

8:00AM (1450) *Closed 3-stop distance in graphs.*
Ralucca Gera*, Naval Postgraduate School, **Linda Eroh** and **Steven Winters**, University of Wisconsin Oshkosh (1077-05-1637)

8:30AM ► (1451) *The Independence Number for the Generalized Petersen Graphs.*
Joseph Fox*, Salem State University, **Ralucca Gera** and **Pantelimon Stanica**, Naval Postgraduate School (1077-05-722)

9:00AM (1452) *Towards Vizing's Independence Number Conjecture.*
Craig Eric Larson*, Virginia Commonwealth University, **Taylor Short**, University of South Carolina, and **Bethany Turner**, N.C. State University (1077-05-2308)

9:30AM (1453) *A fractional analogue of Brook's theorem.*
Xing Peng* and **Linyuan Lu**, University of South Carolina (1077-05-611)

10:00AM *From sum optimal to max optimal graph rankings.*
► (1454) **Bonnie C. Jacob**, National Technical Institute for the Deaf at Rochester Institute of Technology, and **Jobby Jacob***, Rochester Institute of Technology (1077-05-2127)

10:30AM *Modified Linear Programming Weighting for Graph Pebbling.* Preliminary report.
► (1455) **Luke Postle**, Georgia Institute of Technology, **Dan Cranston**, Virginia Commonwealth University, and **Carl Yerger***, Davidson College (1077-05-1006)

AMS Special Session on Uniformly and Partially Hyperbolic Dynamical Systems, I

8:00 AM – 10:50 AM

Organizers: **Todd Fisher**, Brigham Young University
Boris Hasselblatt, Tufts University

8:00AM *A KAM phenomenon for volume-preserving flows.*
(1456) **Jianyu Chen***, Penn State University, **Huyi Hu**, Michigan State University, and **Yakov Pesin**, Penn State University (1077-37-1460)

8:30AM *Holder shadowing on finite intervals.*
(1457) **Sergey Tikhomirov**, Freie Universität Berlin (1077-37-678)

9:00AM *Classifying Teichmueller Disks with Completely Degenerate Kontsevich-Zorich Spectrum.*
(1458) **David Aulicino**, University of Maryland - College Park (1077-37-803)

9:30AM *Entropy of Schur-Weyl measures.*
(1459) **Sevak Mkrtchyan**, Rice University (1077-37-427)

10:00AM *Uniqueness of Equilibrium States: Constructive Techniques in a Non-Uniform, Non-Markov Setting.*
(1460) **Vaughn Climenhaga**, University of Toronto, and **Daniel J Thompson***, The Pennsylvania State University (1077-37-1329)

10:30AM *Unique equilibrium states using regular collections of times.*
(1461) **Vaughn Climenhaga***, University of Toronto, and **Daniel J Thompson**, Pennsylvania State University (1077-37-1618)

MAA Invited Paper Session on Contemporary Unsolved Problems

8:00 AM – 10:45 AM

Organizers: **Ellen Kirkman**, Wake Forest University
Jeremy Rouse, Wake Forest University

8:00AM *Partial Differential Equations: The Navier Stokes Equation.*
► (1462) **C Eugene Wayne**, Boston University (1077-AF-1011)

8:45AM *The Smooth Four Dimensional Poincare Conjecture.*
(1463) **Joel Hass**, UC Davis (1077-AF-1795)

9:30AM *Beyond Computation: The P versus NP question.*
► (1464) **Michael Sipser**, MIT (1077-AF-1281)

10:15AM *The Birch and Swinnerton-Dyer Conjecture.*
► (1465) **William Arthur Stein**, University of Washington (1077-AF-2094)

MAA Invited Paper Session on Knot Theory Untangled

8:00 AM – 10:50 AM

Organizer: **Rolland Trapp**, California State University, San Bernardino

8:00AM *Knot theory: past, present, future.*
► (1466) **Francis Bonahon**, University of Southern California (1077-AG-1741)

8:30AM *Intrinsic properties of graphs embedded in* $\mathbb{R}^3$.
► (1467) **Erica Flapan**, Pomona College (1077-AG-963)

9:00AM *Twisted Alexander Polynomials.* Preliminary report.
► (1468) **Jim Hoste**, Pitzer College (1077-AG-1971)

9:30AM *The Geometry of Knots.*
► (1469) **Jason Cantarella**, University of Georgia (1077-AG-1900)

10:00AM *4-dimensional aspects of knot theory.*
► (1470) **Tim D Cochran**, Rice University (1077-AG-2085)

10:30AM *Hyperbolic knots.*
► (1471) **Colin C Adams**, Williams College (1077-AG-776)

AMS Session on Algebraic Geometry, II

8:00 AM – 9:40 AM

8:00AM *Patch Ideals and Peterson Varieties.*
(1472) **Erik A Insko***, University of Iowa, and **Alexander Yong**, University of Illinois at Urbana-Champaign (1077-14-1989)

8:15AM *An obstruction in extending Abhyankar's results for the Jacobian conjecture.*
► (1473) **James C Price**, University of Arkansas at Fort Smith (1077-14-1631)

8:30AM *Affine fibrations and Vénéreau-type polynomials.*
(1474) **Drew Lewis**, Washington University in St. Louis (1077-14-1612)

8:45AM *Resolving Collinearity Among Four Points in the Complex Projective Plane.* Preliminary report.
(1475) **Victor I Piercey**, University of Arizona (1077-14-1430)

9:00AM *Polyhedral Methods for Space Curves and Two Dimensional Surfaces Exploiting Symmetry.*
(1476) **Danko Adrovic*** and **Jan Verschelde**, University of Illinois at Chicago (1077-14-1944)

9:15AM *Connectedness of moduli spaces of line arrangements.*
► (1477) **Fei Ye**, Bar-Ilan University (1077-14-885)

9:30AM *Asymptotic Purity for Very General Hypersurfaces of Products of Projective Spaces.*
(1478) **Michael A. Burr**, Fordham University (1077-14-1663)

AMS Session on Associative and Nonassociative Algebras and Rings: Homological Algebras and Category Theory, I

8:00 AM – 9:40 AM

8:00AM *Representations of rank two affine Hecke algebras at roots of unity.*
(1479) **Matt S Davis**, Harvey Mudd College (1077-16-2659)

8:15AM *Stable Endomorphism Rings.*
(1480) **Shannon Talbott**, The University of Iowa (1077-16-1984)

8:30AM *Deformations of an Algebra.* Preliminary report.
(1481) **Jeanette Shakalli**, Texas A&M University (1077-16-1796)

8:45AM *Twisted Nilmanifolds and Dilogarithmic OPEs.*
► (1482) **Marco A Aldi***, Brandeis University, and **Reimundo Heluani**, IMPA (1077-17-2259)

9:00AM *Delayed Koszul Duality.* Preliminary report.
(1483) **Christopher L Phan**, Bucknell University (1077-16-2186)

9:15AM *Graded Skew Clifford Algebras that are Twists of Graded Clifford Algebras.*
(1484) **Manizheh Nafari*** and **Michaela Vancliff**, University of Texas at Arlington (1077-16-1382)

9:30AM ► (1485) *Some New Results on Albert-Like Semifield Planes.* Preliminary report.
Angela M. Brown, University of Texas at Arlington (1077-17-2711)

AMS Session on Combinatorics and Graph Theory, V

8:00 AM – 10:10 AM

8:00AM ► (1486) *Transitive BLT-sets.* Preliminary report.
Eric M Nelson, Colorado State University (1077-05-1981)

8:15AM ► (1487) *Graphs with $(k \pm \epsilon)$-edge-disjoint spanning trees.*
Ping Li, West Virginia University (1077-05-1949)

8:30AM (1488) *Limits, Regularity and Removal for Relational Structures : A measure theoretic approach.*
Ashwini Aroskar* and **James Cummings**, Carnegie Mellon University (1077-05-1941)

8:45AM (1489) *Group Connectivity in Line Graphs.*
Senmei Yao, West Virginia University (1077-05-1924)

9:00AM (1490) *Edge disjoint isomorphic subgraphs in uniform hypergraphs.*
Paul Horn*, Harvard University, **Václav Koubek**, Charles University, and **Vojtěch Rödl**, Emory University (1077-05-1874)

9:15AM (1491) *Extremal Sizes of Subspace Partitions.*
Olof Heden, KTH, Sweden, **Julianne Lehmann**, Hamburg, Germany, **Esmeralda Nastase***, Xavier University, and **Papa Sissokho**, Illinois State University (1077-05-1839)

9:30AM (1492) *On 3-nets realizing a finite group in a projective plane.*
Nicola Pace, Florida Atlantic University (1077-05-2026)

9:45AM ► (1493) *On the Number of Edges in Bipartite 2-factor Isomorphic Graphs.*
Paul Wrayno, Western Kentucky University (1077-05-1869)

10:00AM ► (1494) *On Continuous Rado Numbers.*
Daniel Schaal* and **Melanie Zinter**, South Dakota State University (1077-05-2036)

AMS Session on Commutative Rings and Algebras, II

8:00 AM – 9:40 AM

8:00AM (1495) *A note on generalized Gorenstein complexes.*
Eero Hyry and **Maryam Akhavin***, University of Tampere (1077-13-804)

8:15AM (1496) *Finding generators for the vanishing ideal of a finite set of points.*
Eddy Campbell and **Jianjun Chuai***, University of New Brunswick (1077-13-583)

8:30AM ► (1497) *Cut Structures in Zero-divisor Graphs.*
M Axtell, University of St. Thomas, **N Baeth***, University of Central Missouri, and **J Stickles**, Millikin University (1077-13-535)

8:45AM (1498) *Factoring formal power series over principal ideal domains.*
Jesse Elliott, California State University, Channel Islands (1077-13-339)

9:00AM (1499) *Hilbert-Kunz multiplicities of products of ideals.* Preliminary report.
Neil Epstein*, University of Osnabrueck, and **Javid Validashti**, University of Illinois at Urbana-Champaign (1077-13-2017)

9:15AM (1500) *Integration and Primary Decomposition.*
Brian L Miller, Texas Tech University (1077-13-125)

9:30AM (1501) *Algorithms for strongly stable ideals.* Preliminary report.
Dennis Moore* and **Uwe Nagel**, University of Kentucky (1077-13-637)

AMS Session on Computer Science, Information, Control Theory, and Economics, I

8:00 AM – 10:25 AM

8:00AM ► (1502) *Price Discrepancy and Optimal Liquidation of Credit Derivatives.*
Peng Liu*, Johns Hopkins University, and **Tim Leung**, IEOR Department, Columbia University (1077-93-782)

8:15AM (1503) *Egalitarian Graph Orientations.*
Glencora Borradaile, Oregon State University, **Jennifer Iglesias**, Harvey Mudd College, **Theresa Migler**, Oregon State University, **Antonio Ochoa***, Cal Poly Pomona, **Gordon Wilfong** and **Lisa Zhang**, Bell Labs (1077-68-2919)

8:30AM (1504) *A characterization theorem for exact, unifilar hidden Markov models, and a polynomial time test for exactness.*
Nicholas F Travers* and **James P Crutchfield**, University of California, Davis (1077-68-1496)

8:45AM (1505) *Markov chains for sampling weighted permutations.*
Amanda Pascoe Streib, Georgia Institute of Technology (1077-68-973)

9:00AM ► (1506) *Subword Languages of Infinite Partial Words.*
Bob Chen*, UC San Diego, **Francine Blanchet-Sadri**, UNC Greebsboro, **Sinziana Munteanu**, **Jarret Schwartz** and **Slater Stich**, Princeton University (1077-68-2149)

9:15AM (1507) *Application of Modified Shannon Entropy.*
Brian P Kelly, Bryant University (1077-93-2836)

9:30AM (1508) *Stability Analysis for Delayed Systems with an Application.*
Shanaz Tiwari, Florida Atlantic University (1077-93-1768)

9:45AM ► (1509) *On a Geometric Packing Problem.* Preliminary report.
Bradley J. Paynter* and **Douglas R. Shier**, Clemson University (1077-90-2502)

10:00AM (1510) *Exact Controllability of Nonlinear Neutral Functional Impulsive System with Infinite Delay in Banach Spaces.*
Dimplekumar N Chalishajar, Virginia Military Institute (1077-93-1061)

10:15AM (1511) *Theoretical and Computational Issues in Control of a Thermal Fluid.*
Weiwei Hu, Interdisplinary Center for Applied Mathematics, Virginia Tech (1077-93-2360)

AMS Session on Functional Analysis and Operator Theory, II

8:00 AM – 9:55 AM

8:00AM (1512) *Topological k-graphs constructed from a topological dynamical systems and the associated C*-algebras.*
Cynthia Farthing, Creighton University, **Nura Patani***, Arizona State University, and **Paulette N. Willis**, University of Houston (1077-46-1629)

8:15AM (1513) *Some hereditary properties of vector-valued functions.* Preliminary report.
Terje Hoim*, Florida Atlantic University, and **David Robbins**, Trinity College (1077-46-1604)

8:30AM (1514) *Decomposing the C^*-algebras of groupoid extensions.*
Jonathan Henry Brown, University of Otago (1077-46-628)

8:45AM (1515) *Completely Continuous operators.* Preliminary report.
Ioana Ghenciu*, University of Wisconsin-River Falls, and **Paul W Lewis**, University of North Texas (1077-46-469)

► 9:00AM (1516) *Regularization for ill-posed parabolic evolution equations.*
Matthew A. Fury, Penn State Abington (1077-46-108)

► 9:15AM (1517) *The Aluthge Sequence of a Shift Operator.*
Kevin Rion, Bridgewater State University (1077-46-2207)

9:30AM (1518) *Aperiodicity Conditions in Topological k-Graphs.*
Sarah E. Wright, College of the Holy Cross (1077-46-226)

9:45AM (1519) *MF-traces and a lower bound for the topological free entropy dimension in unital C*-algebras.*
Weihua Li*, Columbia College Chicago, **Don Hadwin**, Univdersity of New Hampshire, **Qihui Li**, East China University of Science and Technology, and **Junhao Shen**, University of New Hampshire (1077-46-401)

AMS Session on Number Theory, Field Theory, and Polynomials, I

8:00 AM – 10:10 AM

8:00AM (1520) *Integer Embeddings of Heronian Tetrahedra.*
Susan Hammond Marshall*, Monmouth University, and **Alexander R. Perlis**, Zander Mathematics Institute (1077-11-2610)

8:15AM (1521) *The Cohen-Lenstra heuristics, roots of unity, and random matrices.* Preliminary report.
Derek Garton, University of Wisconsin, Madison (1077-11-2462)

8:30AM (1522) *A congruence modulo $\mathbb{Z}$ for values at zero of partial zeta functions for totally real cubic fields.* Preliminary report.
Barry R Smith, Lebanon Valley College, Annville, PA (1077-11-2354)

► 8:45AM (1523) *An Elliptic Curve Test for the L-Functions Ratios Conjecture.*
Ralph Morrison*, UC Berkeley, and **Steven J. Miller**, Williams College (1077-11-2242)

9:00AM (1524) *The Z-densities of the Fibonacci sequence.*
Paul Cubre* and **Jeremy Rouse**, Wake Forest University (1077-11-2205)

9:15AM (1525) *On the factorization of $f(n)$ for $f(x)$ in $\mathbb{Z}[x]$.*
Samuel S. Gross* and **Andrew F. Vincent**, University of South Carolina (1077-11-2117)

9:30AM (1526) *Counting the number of solutions to the Erdős-Straus-Schinzel equation and related problems.*
Jing-Jing Huang, The Pennsylvania State University, University Park (1077-11-1290)

► 9:45AM (1527) *Diophantine triples and quadruples.*
George W Grossman* and **Yifan Zhang**, Central Michigan University (1077-11-781)

10:00AM (1528) *The n-level density of zeroes of quadratic Dirichlet L-functions.*
Jake Levinson*, University of Michigan - Ann Arbor, and **Steven J Miller**, Williams College (1077-11-2204)

AMS Session on Undergraduate Research, V

8:00 AM – 10:25 AM

► 8:00AM (1529) *Permutations, Pattern Avoidance, and the Catalan Triangle.* Preliminary report.
Wesley K. Hough*, Hanover College, **Derek F. DeSantis**, California State University Channel Islands, **Jacob W. Ziefle**, The College of New Jersey, and **Rebecca M. Meissen**, Worcester Polytechnic Institute (1077-05-2295)

8:15AM (1530) *Numerical Methods for Optimizing Chemistry Kinetic Parameters.*
Victoria Marsh*, **Jen-Mei Chang** and **Stephen Mezyk**, California State University, Long Beach (1077-65-2777)

► 8:30AM (1531) *Image Fusion Using Gaussian Mixture Models.* Preliminary report.
Josh Koslosky, University of Minnesota, **Stacey Levine** and **Glenn Sidle***, Duquesne University (1077-68-1967)

► 8:45AM (1532) *Stability Analysis of Plate Deformation Equations Derived using the Hamiltonian Principle.*
Charles Yves Daly, CSUMS/George Mason University (1077-74-2143)

► 9:00AM (1533) *Optimizing Plasmonic Effects for a More Efficient Nanoscale Biophotovoltaic Device.*
J. E. Pina, George Mason University (1077-78-2252)

► 9:15AM (1534) *Spatial dispersion of interstellar civilizations: a site percolation model in three dimensions.*
Andrew D Hedman* and **Thomas W Hair**, Florida Gulf Coast University (1077-90-2299)

► 9:30AM (1535) *Searching for the Implied Market Utility Function.*
Aniket Anil Panjwani, George Mason University (1077-91-1832)

► 9:45AM (1536) *Sequences for Solving Puzzles and Touring Graphs.*
Tselil Schramm*, Harvey Mudd College, and **Emily Carlson**, Bard College (1077-91-2023)

► 10:00AM (1537) *Effects of Non-Independent Behavior on a Macroeconomic Model.*
Nicholas S Chaung, George Mason University (1077-91-2426)

► 10:15AM (1538) *Modern Portfolio Theory Enhanced by Manifold Learning.* Preliminary report.
Esther F. Jackson, George Mason University: CSUMS Program (1077-91-1563)

MAA Session on Modeling Across the Mathematics Curriculum, I

8:00 AM – 10:55 AM

Organizers: **Benjamin Galluzzo**, Shippensburg University
Mariah Birgen, Wartburg College
Joyati Debnath, Winona State University

8:00AM (1539) *The Volume and Surface Area of a Toy Train.*
Paul C Fonstad, Dalton State College (1077-I1-1440)

► 8:20AM (1540) *A modeling project on sensor networks.* Preliminary report.
Marian F Anton, Ripon College (1077-I1-2658)

► 8:40AM (1541) *The Optimal Placement of Range Lights.*
Michael A. Jones*, *Mathematical Reviews*, **Rabab Abi-Hanna**, Montclair State University, and **Kenneth Krott**, Altoona Area School District (1077-I1-2273)

9:00AM ► (1542) *Modeling the Gummy Bear Launcher as a Simple Computer Experiment.*
Dexter C. Whittinghill, Rowan University (1077-I1-1445)

9:20AM ► (1543) *Using Infectious Disease Models in Calculus and Differential Equations Courses.*
Alex Capaldi, Valparaiso University (1077-I1-867)

9:40AM ► (1544) *Using Mathematical Cancer Models in an Introductory Differential Equations Course.* Preliminary report.
Jana Gevertz*, The College of New Jersey, **Julie Beier** and **Keith Howard**, Mercer University (1077-I1-981)

10:00AM ► (1545) *Teaching 3D Mathematical Modeling.*
Paul R Bouthellier, University of Pittsburgh-Titusville (1077-I1-300)

10:20AM ► (1546) *Pack size vs. Prey Density in the Mexican wolf.* Preliminary report.
William Dean Stone, New Mexico Tech (1077-I1-2667)

10:40AM (1547) *Developing a Modeling Concept Inventory.*
Rebekah Isaak*, University of Minnesota, **Daniel T Kaplan**, Macalester College, **Joan Garfield** and **Andrew Zieffler**, University of Minnesota (1077-I1-780)

MAA Session on Projects, Demonstrations, and Activities that Engage Liberal Arts Mathematics Students, II

8:00 AM – 10:35 AM

Organizer: **Sarah Mabrouk**, Framingham State University

8:00AM ► (1548) *Do it together to understand it: group activities that help liberal arts students understand mathematical concepts.*
Russell D Blyth, Saint Louis University (1077-L1-1256)

8:20AM ► (1549) *"I CAN PROVE IT"– Using Proofs of the Pythagorean Theorem to Bolster Confidence for the math-anxious Liberal Arts Mathematics Students.*
Jackie A Hall, Longwood University (1077-L1-1247)

8:40AM ► (1550) *Final Project in an Elementary Cryptology Course.*
Robert Edward Lewand, Goucher College (1077-L1-442)

9:00AM ► (1551) *Open Questions in Number Theory for Liberal Arts Students: The Good, the Bad, and the Underwhelming.*
Emelie A Kenney, Siena College (1077-L1-517)

9:20AM ► (1552) *Reading, Writing and Discussing Mathematics in a Service-level Undergraduate Course.*
Daniel P. Wisniewski, DeSales University (1077-L1-282)

9:40AM (1553) *Teaching College Mathematics Using Text Messaging.*
Ricardo Sanchez, Art Institute International Minneapolis and Globe University (1077-L1-2951)

10:00AM ► (1554) *Visualizing Hyperbolic Geometry in the Liberal Arts.*
Charlotte J. Chell, Carthage College (1077-L1-2835)

10:20AM (1555) *Using a Jeopardy Game to Engage Students' Learning.*
Yun Lu, Kutztown University of PA (1077-L1-1384)

MAA Session on Topics and Techniques for Teaching Real Analysis, I

8:00 AM – 10:55 AM

Organizers: **Paul Musial**, Chicago State University
James Peterson, Benedictine College
Erik Talvila, University of the Fraser Valley
Robert Vallin, Slippery Rock University of Pennsylvania

8:00AM (1556) *Cantor's set throughout real analysis.*
Cesar E. Silva, Williams College (1077-N5-2680)

8:20AM ► (1557) *Motivating Real Analysis Students with Puzzles.*
Lynette J. Boos, Providence College (1077-N5-1707)

8:40AM ► (1558) *Communication and Learning.*
Steven George Krantz, Washington University in St. Louis (1077-N5-255)

9:00AM ► (1559) *Constructing Definitions in Undergraduate Real Analysis.*
Barbara A. Shipman, University of Texas at Arlington (1077-N5-1088)

9:20AM ► (1560) *When absolute convergence fails to imply convergence.* Preliminary report.
Robert Kantrowitz*, Hamilton College, and **Michael Schramm**, LeMoyne College (1077-N5-1078)

9:40AM ► (1561) *Some of my Suggested Topics and Techniques for the Real Analysis Course.*
Robert L Brabenec, Wheaton College (IL) (1077-N5-288)

10:00AM ► (1562) *Understanding the infinite.* Preliminary report.
Judit Kardos, The College of New Jersey (1077-N5-2237)

10:20AM ► (1563) *Analysis based on the concept of level.*
Karel Hrbacek, he City College of New York (1077-N5-2367)

10:40AM (1564) *A Proemial Proposition on Teaching Real Analysis: Instruct Via a "Strong" Modified Moore Method.*
Padraig M. McLoughlin, Kutztown University of Pennsylvania (1077-N5-1205)

MAA Session on Writing the History of the MAA, I

8:00 AM – 10:55 AM

Organizers: **Victor J. Katz**, University of the District of Columbia
Janet Beery, University of Redlands
Amy Shell-Gellasch, Beloit College

8:00AM ► (1565) *History of National Meetings.* Preliminary report.
Kenneth A Ross, University of Oregon (1077-Q1-1710)

8:20AM ► (1566) *A History of the Northeastern Section: A Work in Progress.*
J. J. Tattersall, Providence College (1077-Q1-481)

8:40AM ► (1567) *Highlights in the History of the Missouri Section.*
Leon M. Hall, Missouri S&T (1077-Q1-334)

9:00AM ► (1568) *Recovering and recapitulating the history of Project NExT.* Preliminary report.
T. Christine Stevens, Saint Louis University (1077-Q1-2032)

9:20AM ► (1569) *The Ohio Section also celebrates its centennial.*
David Kullman, Miami University, **Thomas Hern**, Bowling Green State University, and **Daniel E. Otero***, Xavier University (1077-Q1-2371)

9:40AM ► (1570) *The Kansas Section: Were We First?*
Robert W. Neufeld, McPherson College, McPherson, KS, **Elaine L. Tatham**, ETC Institute, Olathe, KS, and **Timothy W. Flood***, Pittsburg State University, Pittsburg, KS (1077-Q1-1402)

10:00AM ► (1571) *The History of SIGMAAs (Special Interest Groups of the MAA).* Preliminary report.
Steve Carlson*, Rose-Hulman Institute of Technology, and **Amy Shell-Gellasch**, Beloit College (1077-Q1-378)

10:20AM ► (1572) *Writing a History of the Iowa Section of the MAA.* Preliminary report.
Joel K. Haack*, University of Northern Iowa, and **Linda L. Haack**, Cedar Falls, IA (1077-Q1-723)

10:40AM ► (1573) *The Intermountain Section: an exceptionally brief history.* Preliminary report.
Carolyn Connell, Westminster College, Salt Lake City, Utah (1077-Q1-2590)

MAA General Contributed Paper Session: Research in Applied Mathematics, I

8:00 AM – 10:40 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:00AM ► (1574) *Inverse Modeling by Cumulative-Power-Penalized Least Squares.*
Keaton P. Quinn, Michigan State University (1077-VK-2408)

8:15AM ► (1575) *Revisiting the Basel problem.*
Marianne Dubinsky, University of Mary Washington (1077-VK-2395)

8:30AM (1576) *Comparative analysis of a few fast numerical schemes for finding positive and some sign-changing solutions to time-independent Gross-Pitaevskii type equations with general potentials.*
Yuriy Shlapak, University of Wisconsin - Marshfield/Wood County and University of Wisconsin Colleges Online (1077-VK-1803)

8:45AM ► (1577) *Searching for the Best Quadratic Approximation of a Function.*
Yajun Yang* and **Sheldon P. Gordon**, Farmingdale State College of SUNY (1077-VK-2209)

9:00AM ► (1578) *TPA: A New Method for Approximate Counting.*
Mark Huber, Claremont McKenna College, and **Sarah Schott***, Duke University (1077-VK-802)

9:15AM ► (1579) *Molecular mechanism for cardiac electrical instability in human heart disease: a predictive and multiscale computational model of "ankyrin-B syndrome.".*
Roseanne M Wolf*, **Colleen C Mitchell**, University of Iowa, **Peter Mohler** and **Thomas Hund**, The Ohio State University (1077-VK-2383)

9:30AM ► (1580) *A Markov Model for Actin Polymer Dynamics and Cell Membrane Protrusion.*
Csilla Szabo, United States Military Academy (1077-VK-2811)

9:45AM ► (1581) *The logistic gender-structured model with ephemeral pair bonds and isolation from reproduction (report on an REU project at Valparaiso University).*
Daniel Maxin*, Valparaiso University, **Ludek Berec**, Department of Biosystematics and Ecology, Institute of Entomology, Biology Centre ASCR, Czech Republic, **Michael Covello**, Loyola University Chicago, **Jill Jessee**, Simpson College, and **Matthew Zimmer**, Saint John's University (1077-VK-1216)

10:00AM (1582) *Extreme multi-stability in a chemical model system.*
Calistus Ngeh Ngonghala, National Institute for Mathematical and Biological Synthesis (NIMBioS) (1077-VK-2700)

10:15AM ► (1583) *Method to extract names of geographical features from images of maps - A theoretical case study.* Preliminary report.
Sridevi Pudipeddi*, South Central College, North Mankato, MN, and **Ravi Chityala**, Minnesota Supercomputing Institute (1077-VK-799)

10:30AM (1584) *Recovery of Fourier Transforms Using Edge Information.*
Alexander J Gutierrez, Arizona State University (1077-VK-2752)

MAA General Contributed Paper Session: Research in Number Theory

8:00 AM – 10:55 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:00AM ► (1585) *A Variation of the ElGamal Encryption Method.* Preliminary report.
Mark Wissler* and **Lavinia Ciungu**, University of Central Oklahoma (1077-VJ-2130)

8:15AM ► (1586) *Encrypting into Polynomials.* Preliminary report.
Lavinia Ciungu* and **Mark Wissler**, University of Central Oklahoma (1077-VJ-2131)

8:30AM (1587) *Explicit Plancherel Measure for PGL_2 over a p-adic field.*
Carlos De la Mora, University of Iowa (1077-VJ-2839)

8:45AM (1588) *p-adic L-functions of GL_2 automorphic representations.* Preliminary report.
Bei Zhang*, Northwestern University, and **Matthew Emerton**, University of Chicago (1077-VJ-660)

9:00AM ► (1589) *The Distribution of Generalized Ramanujan Primes.*
Nadine Amersi, University College London, **Olivia Beckwith**, Harvey Mudd College, **Steven J Miller**, Williams College, **Ryan Ronan***, The Cooper Union, and **Jonathan Sondow**, New York City, NY (1077-VJ-1449)

9:15AM (1590) *Primes of the Form $x^2 + ny^2$ and the Geometry of Convenient Numbers.*
Thomas R. Hagedorn, The College of New Jersey (1077-VJ-2605)

9:30AM ► (1591) *Gaps between summands in generalized Zeckendorf decompositions.*
Olivia Beckwith*, Harvey Mudd College, and **Steven J Miller**, Williams College (1077-VJ-1164)

9:45AM ► (1592) *Constructing Generalized Sum-Dominant Sets.*
Geoffrey S Iyer*, University of Michigan, **Oleg Lazarev**, Princeton University, and **Liyang Zhang**, Williams College (1077-VJ-946)

10:00AM ► (1593) *Evaluation of infinite products involving Fibonacci and Lucas numbers.*
Jonathan Sondow, New York, NY (1077-VJ-2416)

10:15AM ► (1594) *Sequences preserving GCD, Cyclotomic Polynomials, and Iterated Polynomials.*
Stephen Lovett, Wheaton College (IL) (1077-VJ-369)

10:30AM ► (1595) *Distribution of Missing Sums in Sumsets.*
Oleg Lazarev, Princeton University (1077-VJ-1409)

10:45AM ► (1596) *Examining the Dynamical Systems of Various Polynomials over Finite Fields Using Mathematica.*
Jonathan Weisbrod, Rowan University (1077-VJ-479)

MAA General Contributed Paper Session: Teaching Mathematics Beyond the Calculus Sequence

8:00 AM – 10:55 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:00AM ► (1597) *Numerical Method/Analysis Students Function Concept Knowledge.* **Emre Tokgoz**, University of Oklahoma (1077-VD-474)

8:15AM (1598) *Integrating factors and repeated roots of the characteristic equation.* **Howard I Dwyer**, Monmouth College, and **William R Green***, Eastern Illinois University (1077-VD-547)

8:30AM (1599) *Bridging mathematics concepts to engineering contexts: Just-in-time review modules.* Preliminary report. **Alina N. Duca***, North Carolina State University, **Dianne Raubenheimer** and **Hatice Ozturk**, NC State University, College of Engineering (1077-VD-2652)

8:45AM ► (1600) *Scaffolding for Inquiry Instruction in Mathematics.* **Mark L. Daniels**, UTeach Program Natural Scinces/ University of Texas at Austin (1077-VD-342)

9:00AM ► (1601) *An inquiry-based, writing intensive introduction to proofs course.* Preliminary report. **Carl Mummert**, Marshall University (1077-VD-1567)

9:15AM ► (1602) *Keep them guessing: teaching conjecturing in a discrete transition course.* Preliminary report. **Suzanne I Doree**, Augsburg College, Minneapolis (1077-VD-2841)

9:30AM ► (1603) *Using a capstone course to learn how to teach mathematical proofs.* **Elana Reiser**, St. Joseph's College (1077-VD-77)

9:45AM ► (1604) *Getting the Act Together.* Preliminary report. **Melvin G. Royer**, Indiana Wesleyan University (1077-VD-2519)

10:00AM (1605) *Some Strategies for Teaching a Course Based on Douglas Hofstadter's Gödel, Escher, Bach.* Preliminary report. **Stephen Andrilli**, La Salle University, Philadelphia, PA (1077-VD-444)

10:15AM ► (1606) *Developing the capstone experience at Winthrop University.* Preliminary report. **Trent Kull*** and **Heakyung Lee**, Winthrop University (1077-VD-836)

10:30AM (1607) *Moving from Theory to Practice: A Lesson Plan Activity for a History of Mathematics Course.* **Kate G McGivney**, Shippensburg University (1077-VD-2624)

10:45AM (1608) *Reading and writing assignments in a Real Analysis course.* **Bogdan Doytchinov**, Elizabethtown College (1077-VD-2790)

SIAM Minisymposium on Applied Math Outreach: Bringing Relevance to Middle and High School Math Experience

8:00 AM – 10:50 AM

Organizer: **Peter Turner**, Clarkson University

8:00AM ► (1609) *Applied Mathematics Outreach to Middle and High Schools: Opportunities and Resources.* **Peter R Turner**, Clarkson University (1077-97-303)

8:30AM ► (1610) *Scrapheap Showdown and Pi Night: Two Ways to Reach out the the Local Community.* **Erica Dakin Voolich**, Somerville Mathematics Fund (1077-97-1959)

9:00AM ► (1611) *Applied Mathematical Modeling and Research Opportunities for Middle School, High School, and Pre-Freshmen Students.* **Kathleen R Fowler**, Clarkson University (1077-97-395)

9:30AM ► (1612) *Applied Mathematics at Girls' Angle: A Math Club for Girls.* **C. Kenneth Fan**, Girls' Angle (1077-97-1094)

10:00AM ► (1613) *Trees and Soil Microbes: Activities for Bringing Life (Science) to Mathematics.* Preliminary report. **Kelly K. Sturner***, National Institute for Mathematical and Biological Synthesis, and **Suzanne Lenhart**, University of Tennessee (1077-97-978)

10:30AM (1614) *Bringing Biological Applications to the High School Mathematics Curriculum.* **Mike Martin**, Johnson County Community College (1077-92-353)

PME Council Meeting

8:00 AM – 11:00 AM

Employment Center

8:00 AM – 6:00 PM

AMS Special Session on Some Nonlinear Partial Differential Equations: Theory and Application, II

8:30 AM – 10:50 AM

Organizers: **Jerry L. Bona**, University of Illinois, Chicago
Laihan Luo, New York Institute of Technology

8:30AM ► (1615) *From Euler equation to Boussinesq system to KP equation.* **Min Chen**, Purdue University (1077-35-2223)

9:00AM (1616) *Nonlocal dissipation and the Euler Equations.* **Peter Constantin***, Princeton University, and **Vlad Vicol**, University of Chicago (1077-35-2321)

9:30AM (1617) *Initial value problem for coupled nonlinear dispersive equations.* **Jerry L. Bona**, University of Illinois at Chicago, and **Hongqiu Chen***, University of Memphis (1077-35-2628)

10:00AM (1618) *Carrier Shocks and Coherent Structures in the Nonlinear Maxwell Equation.* **Michael I. Weinstein**, Columbia University (1077-35-2813)

10:30AM (1619) *The surface quasi-geostrophic and related equations.* **Jiahong Wu**, Oklahoma State University (1077-35-1765)

AMS-MAA Grad School Fair

8:30 AM – 10:30 AM

Undergrads! Take this opportunity to meet representatives from mathematical science graduate programs.

MAA Invited Address

9:00 AM – 9:50 AM

(1620) *Sum of squares polynomials in optimization.*
Rekha R. Thomas, University of Washington
(1077-A0-6)

ASL Invited Address

9:00 AM – 9:50 AM

(1621) *The end of the inner model program: ultimate L or not ultimate L.*
W. Hugh Woodin, University of California
(1077-03-2963)

MAA Minicourse #6: Part B

9:00 AM – 11:00 AM

Getting students involved in undergraduate research.
Presenters: **Aparna Higgins**, University of Dayton
Joseph A. Gallian, University of Minnesota-Duluth

MAA Minicourse #8: Part B

9:00 AM – 11:00 AM

Preparing to serve as an outside consultant in the mathematical sciences.
Presenters: **Kyle Riley**, South Dakota School of Mines and Technology
Nancy Baxter Hastings, Dickinson College

MAA Minicourse #14: Part B

9:00 AM – 11:00 AM

Teaching introductory statistics.
Presenters: **Michael Posner**, Villanova University
Carolyn Cuff, Westminster College

MAA Session on Quantitative Literacy and Decision Making

9:00 AM – 10:15 AM

Organizers: **Eric Gaze**, Bowdoin College
Cinnamon Hillyard, University of Washington, Bothell
Semra Kilic-Bahi, Colby Sawyer College

9:00AM ► (1622) *Using MS Excel to Improve Understanding of Financial Mathematics.*
Paul Taylor, Shippensburg University
(1077-L5-930)

9:20AM ► (1623) *Complex Systems and K-16 Curricula.*
R W DeGray, Saint Joseph College, Connecticut
(1077-L5-1058)

9:40AM ► (1624) *The Financing Choices of American Consumers: The Influence of Quantitative Literacy, Cognitive Disposition and Material Values.*
Cinnamon Hillyard* and **Pete Nye**, University of Washington Bothell (1077-L5-1244)

10:00AM ► (1625) *The Financial Literacy Project at Dartmouth College: Online Classroom Resources and Modules.*
Eric C Gaze, Bowdoin College (1077-L5-2563)

MAA Professional Development Committee Panel Discussion

9:00 AM – 10:20 AM

Getting your textbook published.
Organizer: **James Hamblin**, Shippensburg University
Panelists: **Doug Ensley**, Shippensburg University
Sheldon Gordon, Farmingdale State College
Thomas W. Judson, Stephen F. Austin State University

MAA Panel Discussion

9:00 AM – 10:20 AM

Incorporation of the mathematics of climate change and sustainability into our undergraduate courses.
Organizer: **Robert E. Megginson**, University of Michigan, Ann Arbor
Panelists: **Christopher Jones**, University of North Carolina, Chapel Hill
Thomas J. Pfaff, Ithaca College
Martin E. Walter, University of Colorado, Boulder
Mary Lou Zeeman, Bowdoin College

MAA Committee on Assessment Panel Discussion

9:00 AM – 10:20 AM

Using data from the registrar's office to better understand, plan, and change your undergraduate mathematics program.
Organizer: **Jack Bookman**, Duke University
Panelists: **Mary Callahan**, Massachusetts Institute of Technology
Amy Cohen, Rutgers University
Bill Martin, North Dakota State University
Jack Bookman

Student Hospitality/Information Center

9:00 AM – 5:00 PM

AMS Special Presentation

9:30 AM – 11:00 AM

Who wants to be a mathematician—National contest.
Organizers: **Michael A. Breen**, AMS
William T. Butterworth, DePaul University

Exhibits and Book Sales

9:30 AM – 5:30 PM

ASL Invited Address

10:00 AM – 10:50 AM

(1626) *Prikry Type Forcings and Singular Combinatorics.*
Dima Sinapova, University of California at Irvine
(1077-03-159)

AMS Invited Address

10:05 AM – 10:55 AM

(1627) *The Ribe program.*
Assaf Naor, Courant Institute of Mathematical Sciences (1077-51-1)

AMS-MAA Invited Address

11:10 AM – NOON

(1628) *Apollonian packings, fractal geometry, and dynamics on hyperbolic manifolds.*
Hee Oh, Brown University

AMS Colloquium Lectures: Lecture III

1:00 PM – 1:50 PM

(1629) *Langlands program, trace formulas, and their geometrization, III.*
Edward Frenkel, University of California Berkeley (1077-14-12)

MAA Lecture for Students

1:00 PM – 1:50 PM

► (1630) *Turning theorems into plays.*
Steve Abbott, Middlebury College (1077-A0-38)

AMS Current Events Bulletin

1:00 PM – 4:45 PM

Organizer: **David Eisenbud**, University of California Berkeley

1:00PM (1631) *Assembling surfaces from random pants: mixing, matching and correcting in the proofs of the surface-subgroup and Ehrenpreis conjectures.*
Jeffrey F. Brock, Brown University (1077-51-2422)

2:00PM (1632) *The cobordism hypothesis: quantum field theory + homotopy invariance = higher algebra.*
Daniel S. Freed, University of Texas at Austin (1077-57-1075)

3:00PM ► (1633) *Dispersive equations and their role beyond PDE.*
Gigliola Staffilani, Massachusetts Institute of Technology (1077-35-769)

4:00PM (1634) *How does quantum mechanics scale?*
Umesh Vazirani, University of California, Berkeley (1077-81-1817)

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, II

1:00 PM – 5:50 PM

Organizers: **Bernard Brooks**, Rochester Institute of Technology
Jobby Jacob, Rochester Institute of Technology
Jacqueline Jensen, Sam Houston State University
Darren A Narayan, Rochester Institute of Technology

1:00PM ► (1635) *Global coordinate systems on manifolds lacking continuously moving bases.* Preliminary report.
Eileen R Martin*, University of Texas at Austin, **Ryan Hotovy**, Texas A&M University, and **Daniel Freeman**, University of Texas at Austin (1077-58-89)

1:30PM ► (1636) *Optimization of P. falciparum gametocyte sex ratios via competitive and non-competitive strategies: the evolutionary implications.*
Ha T Nguyen*, **Ryan A Warrier**, **Miranda I. Teboh-Ewungkem** and **Thomas Yuster**, Lafayette College, Easton, PA (1077-91-574)

2:00PM ► (1637) *Isoperimetry in the Plane with Density e^r.*
Luis A. Sordo Vieira*, Wayne State University, **Niralee K. Shah**, Williams College, **Miguel Fernandez**, Truman State University, and **Ping Ngai Chung**, MIT (1077-53-1109)

2:30PM (1638) *Oregon Blackberry Invasion Analyzed by Spatial Stochastic Modeling.*
Heather Johnston*, Western Oregon University, **May Boggess** and **Jay Walton**, Texas A&M University (1077-92-585)

3:00PM ► (1639) *Bounds for the Minimum Semi-Definite Rank of Circulant Graphs.* Preliminary report.
Chennah Heroor*, Massachusetts Institute of Technology, **Troy Klingler**, **Anthony Pochini**, Central Michigan University, and **Gretchen Schillemat**, Brigham Young University (1077-15-109)

3:30PM ► (1640) *A complete characterization of optimal vertex rankings of paths, cycles, and joins of graphs.*
Maxwell Bileschi*, University of Buffalo, and **Meridangela Gutierrez Jhong**, Rochester Institute of Technology (1077-05-192)

4:00PM ► (1641) *Generating Dynamic Adjustable Weighted Social Networks.*
Nakisa Nassersharif*, Syracuse University, and **Megan Sinton**, Bucknell University (1077-91-194)

4:30PM ► (1642) *Representations of Graphs modulo N.*
Ryan Held*, Rochester Institute of Technology, and **Lauren Stemler**, St. Lawrence University (1077-05-193)

5:00PM ► (1643) *On Some Multicolor Ramsey Numbers Involving $K_3 + e$ and $K_4 - e$.*
Daniel S. Shetler, Whitworth University, and **Michael Wurtz***, Northwestern University (1077-05-191)

5:30PM ► (1644) *Rank numbers of rook's graphs.*
Korinne Dobosh*, Montclair State University, and **Samuel Kennedy**, Rochester Institute of Technology (1077-05-190)

AMS-MAA-MER Special Session on Mathematics and Education Reform, II

1:00 PM – 5:40 PM

Organizers: **William Barker**, Bowdoin College
William McCallum, University of Arizona
Bonnie Saunders, University of Illinois at Chicago

1:00PM (1645) *Addressing the transition to college mathematics.*
David M. Bressoud, Macalester College (1077-97-1008)

1:30PM ► (1646) *Preparing twelfth-graders for college mathematics.*
Cathy L Seeley, Charles A. Dana Center, The University of Texas at Austin (1077-97-1488)

2:00PM ► (1647) *Listening to Students About the Transition from High School to College.* Preliminary report.
William G McCallum*, University of Arizona, and **Guadalupe Lozano-Teran**, The University of Arizona (1077-97-2939)

2:30PM ► (1648) *Factors Influencing Success in College Calculus.* Preliminary report.
Philip M. Sadler, Harvard-Smithsonian Center for Astrophysics (1077-97-2944)

3:00PM (1649) *Placement in College Mathematics.*
Bernard L Madison, University of Arkansas (1077-97-652)

3:30PM ► (1650) *Being CRAFTY in the Transition to College Mathematics.*
Daniel T Kaplan, Macalester College (1077-97-2056)

4:00PM ► (1651) *The Mathematical and Theoretical Biology Institute Community Learning Model.*
Carlos W. Castillo-Garsow, Kansas State University, **Carlos Castillo-Chavez***, Arizona State University, and **Sherry Woodley**, Math, Comp and Mod Sciences Center, Arizona State University (1077-97-2875)

4:30PM ► (1652) *Pictures of Personal Change and View of Change Needed to Enhance Transition to College Mathematics.* Preliminary report.
Brian J. Winkel, United States Military Academy, West Point (1077-97-753)

5:00PM Discussion: Panel on the *Issues of the Transition to College Mathematics* moderated by David Bressoud.

AMS-SIAM Special Session on the Mathematics of Computation: Algebra and Number Theory, II

1:00 PM – 5:50 PM

Organizers: **Jean-Marc Couveignes**, Université de Toulouse
Michael J. Mossinghoff, Davidson College
Igor E. Shparlinski, Macquarie University, Australia

1:00PM (1653) *Counting decompositions of additive polynomials.*
Mark Giesbrecht*, University of Waterloo, and **Joachim von zur Gathen**, B-IT, Universität Bonn (1077-11-939)

1:30PM (1654) *Finding a polynomial multiple that is sparse.*
Daniel S Roche, United States Naval Academy (1077-68-906)

2:00PM (1655) *An algorithm for recovering zeroes of multivariate polynomials over a prime finite field.*
Jaime Gutierrez, University of Cantabria, Santander, Spain (1077-11-542)

2:30PM (1656) *Non-abelian Cohen-Lenstra Heuristics.*
Nigel Boston, University of Wisconsin - Madison (1077-11-188)

3:00PM (1657) *Families of marked elliptic curves, with some applications.*
Noam D. Elkies, Harvard Univ. (1077-11-2569)

3:30PM (1658) *An irrationality measure for Mahler numbers.*
Michael Coons, University of Waterloo and Fields Institute (1077-11-598)

4:00PM (1659) *Identifying supersingular elliptic curves.*
Andrew V. Sutherland, Massachusetts Institute of Technology (1077-11-377)

4:30PM (1660) *Evaluating Igusa functions.*
Reinier Broker*, Brown University, and **Kristin Lauter**, Microsoft Research (1077-11-961)

5:30PM (1661) *Positive-definite quadratic forms representing all odd, positive integers.* Preliminary report.
Jeremy Rouse, Wake Forest University (1077-11-116)

AMS-AWM Special Session on Nonlinear Hyperbolic Partial Differential Equations, III

1:00 PM – 5:50 PM

Organizers: **Barbara Lee Keyfitz**, Ohio State University
Charis Tsikkou, Ohio State University

1:00PM (1662) *Self-similar solutions for the diffraction of weak shocks.*
Allen M. Tesdall*, College of Staten Island, City University of New York, and **John K. Hunter**, University of California, Davis (1077-35-1177)

1:30PM (1663) *On 2D viscous Boussinesq system on a bounded domain.*
Ronghua Pan, Georgia Institute of Technology (1077-35-2375)

2:00PM (1664) *A semi-hyperbolic region for the pressure gradient system.*
Kyungwoo Song*, Yeshiva University and Kyung Hee University, and **Yuxi Zheng**, Yeshiva University (1077-35-2678)

2:30PM (1665) *Conservation laws with prescribed eigencurves.*
Helge Kristian Jenssen, Penn State University, and **Irina A Kogan***, North Carolina State University (1077-35-204)

3:00PM ► (1666) *Some exact solutions to nonlinear hyperbolic PDE.*
Robin Young, University of Massachusetts, Amherst (1077-35-632)

3:30PM (1667) *Shock Wave Stability for Conservation Laws with Physical Viscosities.*
Tai-Ping Liu, Academia Sinica and Stanford University, and **Yanni Zeng***, University of Alabama at Birmingham (1077-35-1040)

4:00PM (1668) *Global dynamics of a diffuse interface model for solid tumor growth.*
John Lowengrub, University of California-Irvine, **Edriss S. Titi**, University of California-Irvine and the Weizmann Institute of Science, and **Kun Zhao***, University of Iowa (1077-35-228)

4:30PM ► (1669) *Vegetative Pattern Formation Model Systems: Comparison of Turing Diffusive and Differential Flow Instabilities.*
Bonni J Kealy* and **David J Wollkind**, Washington State University (1077-35-244)

5:00PM (1670) *A new result in blow-up for long-wave unstable thin film equations.*
Marina Chugunova, **Mary C. Pugh***, University of Toronto, and **Roman Taranets**, University of Nottingham (1077-35-2217)

5:30PM (1671) *Structure of solutions near sonic line for pressure gradient equation.*
T. Zhang*, Penn State University, and **Y. Zheng**, Yeshiva University (1077-35-2520)

AMS Special Session on Advances in Mathematical Biology, II

1:00 PM – 5:50 PM

Organizers: **David Chan**, Virginia Commonwealth University
Rebecca Segal, Virginia Commonwealth University

1:00PM ► (1672) *Biological dispersal strategies of Internet worms.*
David E Hiebeler, University of Maine (1077-92-1450)

1:30PM ► (1673) *Modeling and Estimation in Gene Regulatory Networks.*
Kam Dahlquist and **Ben G Fitzpatrick***, Loyola Marymount University (1077-92-1751)

2:00PM (1674) *Mathematical Model for Two Germline Stem Cells Competing for Niche Occupancy.* Preliminary report.
Jianjun Paul Tian, College of William and Mary (1077-34-1251)

2:30PM (1675) *A Low-Dimensional Model of the Innate Immune Response to Bacterial Infection.*
Lester Caudill, University of Richmond (1077-92-851)

3:00PM ► (1676) *Using a Mathematical Model to Analyze the Treatment of a Wound Infection with Oxygen Therapy.* Preliminary report.
Richard Schugart* and **Tennesse Tucker Joyce**, Western Kentucky University (1077-92-2701)

3:30PM Discussion

4:00PM (1677) *Nanoparticle Deposition in the Human Nasal Passages.*
Rebecca Segal, Virginia Commonwealth University (1077-92-1985)

4:30PM (1678) *Mechanisms for multiple activity modes of midbrain DA neurons.*
Andrew M. Oster*, Washington and Lee University, **Philippe Faure**, Université Pierre et Marie Curie, Centre National de la Recherche Scientifique, and **Boris S. Gutkin**, Group for Neural Theory, École Normale Supérieure, Centre National de la Recherche Scientifique (1077-92-918)

5:00PM (1679) *Sensory Irritation Response in Rats: Recovery and Dose-Dependence.*
Karen A Yokley, Elon University (1077-92-1535)

5:30PM ► (1680) *Development of a Quantitative Model Incorporating Key Events in a Hepatotoxic Mode of Action to Predict Tumor Incidence.*
Nicholas S. Luke*, North Carolina A&T State University, **Reeder Sams II**, National Center for Environmental Assessment, U.S. Environmental Protection Agency, **Michael J Devito**, National Toxicology Program, National Institute for Environmental Health Sciences, **Rory B Conolly** and **Hisham A. El-Masri**, Integrated Systems Toxicology Division, U.S. Environmental Protection Agency (1077-92-905)

AMS Special Session on Algebraic and Geometric Aspects of Integrable Systems and Random Matrices, II

1:00 PM – 5:50 PM

Organizers: **Anton Dzhamay**, University of Northern Colorado
Kenichi Maruno, University of Texas, Pan American
Virgil Pierce, University of Texas, Pan American

1:00PM (1681) *Integrability of random growth models.*
Alexei Borodin, MIT, Caltech (1077-60-1100)

2:00PM (1682) *Elliptic distributions on 3D Young diagrams, elliptic special functions and elliptic Painleve.* Preliminary report.
Dan Dumitru Betea, Caltech, Pasadena CA (1077-60-1255)

2:30PM (1683) *Discrete Hamiltonian structure of Schlesinger transformations.*
Anton Dzhamay, University of Northern Colorado, **Hidetaka Sakai**, University of Tokyo, and **Tomoyuki Takenawa***, Tokyo University of Marine Science and Technology (1077-39-1948)

3:00PM (1684) *Degeneration scheme of 4-dimensional Painlevé type equations.*
Hiroshi Kawakami, **Akane Nakamura** and **Hidetaka Sakai***, University of Tokyo (1077-33-1306)

4:00PM (1685) *Combinatorics of matrix refactorizations and discrete integrable systems.*
Anton Dzhamay, University of Northern Colorado (1077-35-2867)

4:30PM ► (1686) *Quantum pentagon equation, Hirota's discrete KP equation, and projective geometry over division rings.*
Adam Doliwa, University of Warmia and Mazury, Olsztyn, Poland (1077-37-464)

5:00PM (1687) *Discrete integrable systems of skew orthogonal polynomials.*
Hiroshi Miki* and **Satoshi Tsujimoto**, Graduate School of Informatics, Kyoto University (1077-33-969)

5:30PM (1688) *Discrete integrable systems arising from motions of discrete curves in the Euclidean and Minkowski planes.*
Kenichi Maruno*, The University of Texas - Pan American, **Kenji Kajiwara**, Institute of Mathematics for Industry, Kyushu University, **Jun-ichi Inoguchi**, Yamagata University, **Yasuhiro Ohta**, Department of Mathematics, Kobe University, and **Bao-Feng Feng**, The University of Texas - Pan American (1077-53-1491)

AMS Special Session on Calculus of Functors and Its Applications, II

1:00 PM – 5:50 PM

Organizers: **Brian Munson**, Wellesley College
Ismar Volic, Wellesley College

1:00PM Discussion

1:30PM (1689) *Operads and modules in embedding calculus.*
Gregory Arone*, University of Virginia, and **Victor Turchin**, Kansas State University (1077-55-1662)

2:30PM (1690) *Splitting in the rational homology and homotopy of the spaces of higher dimensional long embeddings.*
Victor Turchin*, Kansas State University, and **Gregory Arone**, University of Virginia (1077-55-886)

3:00PM (1691) *Rational homotopy theory and spaces of smooth embeddings.* Preliminary report.
Pascal Lambrechts, Université catholique de Louvain (1077-55-1654)

4:00PM (1692) *Models for Taylor towers of functors.*
Brenda Johnson*, Union College, **Kristine Bauer**, University of Calgary, **Rosona Eldred** and **Randy McCarthy**, University of Illinois at Urbana-Champaign (1077-55-2097)

4:30PM Discussion

5:30PM (1693) *Morava E-theory of the Goodwillie tower.*
Mark J Behrens, MIT (1077-55-1647)

AMS Special Session on Control Theory and Inverse Problems for Partial Differential Equations, III

1:00 PM – 5:50 PM

Organizers: **Shitao Liu**, University of Helsinki

Ting Zhou, Massachusetts Institute of Technology

1:00PM (1694) *Recent developments in inverse scattering.* Preliminary report.
Gang Bao, Michigan State University and Zhejiang University (1077-35-2373)

1:30PM (1695) *Do high frequencies contain information about low frequencies?*
Laurent Demanet, Massachusetts Institute of Technology (1077-86-2657)

2:00PM (1696) *Transient wave imaging with limited-view data.*
Vincent Jugnon*, Massachusetts Institute of Technology, **Habib Ammari**, Ecole Normale Superieure, **Hyeonbae Kang**, Inha University, **Mark Asch**, University of Picardy Jules Verne, and **Lili Guadarrama Bustos**, Ecole Superieure de Physique et Chimie Paris (1077-35-744)

2:30PM (1697) *Uniqueness for a hyperbolic inverse problem with angular control of the coefficients.*
Rakesh Rakesh, University of Delaware (1077-35-2410)

3:00PM (1698) *Enhanced Near-cloak by FSH Lining.*
Hongyu Liu, University of North Carolina (1077-35-2582)

3:30PM Discussion

4:00PM (1699) *Boundary Control Approach to Inverse Problems on Graphs.*
Sergei Avdonin, University of Alaska Fairbanks (1077-35-1501)

4:30PM (1700) *Microlocal analysis of an ultrasound operator with circular source and receiver trajectories.*
Venky P Krishnan, Tata Institute of Fundamental Research Centre for Applicable Mathematics (1077-35-1939)

5:00PM (1701) *Lipschitz stability of an inverse problem for a Schrödinger type equation.*
Lingyun Qiu*, Purdue University, **Elena Beretta**, Sapienza di Roma, and **Maarten de Hoop**, Purdue University (1077-35-925)

5:30PM (1702) *Boundary control of a beam equation with non-monotone boundary conditions.*
Irena Lasiecka, University of Virginia, **Rich Marchand**, U.S. Air Force Academy/Slippery Rock University, and **Tim McDevitt***, Elizabethtown College (1077-93-2106)

AMS Special Session on Differential Algebraic Geometry and Galois Theory (in memory of Jerald Kovacic), III

1:00 PM – 5:50 PM

Organizers: **Phyllis Joan Cassidy**, Smith College and the City University of New York
Richard Churchill, Hunter College and Graduate Center at CUNY
Claude Mitschi, Université de Strasbourg, France
Michael Singer, North Carolina State University

1:00PM (1703) *Constructive approaches to Kovacic's reduced forms of linear differential systems.*
Ainhoa Aparicio-Monforte, RISC, Linz (Austria), **Elie Compoint**, Université de Lille (France), and **Jacques-Arthur Weil***, XLIM, CNRS and Université de Limoges (France) (1077-34-831)

1:30PM (1704) *Generic Differential Galois Extensions.*
Lourdes Juan, Texas Tech University (1077-13-2280)

2:00PM (1705) *Model theory and differential algebraic geometry.*
David Marker, University of Illinois at Chicago (1077-03-507)

2:30PM (1706) *Some new techniques in differential algebraic geometry from model theory.*
Rahim N Moosa, University of Waterloo (1077-03-2035)

3:00PM (1707) *Prolongations and differentially closed fields.*
Omar Leon Sanchez, University of Waterloo. Ontario, Canada. (1077-14-792)

3:30PM ► (1708) *Tannakian formalism over fields with operators.* Preliminary report.
Moshe Kamensky, University of Notre-Dame (1077-20-1339)

4:00PM (1709) *Linear Equations in Valued D-Fields.*
Meghan Anderson, Harvard University (1077-03-1464)

4:30PM (1710) *Differential algebraic groups as superstable groups.*
James Freitag, University of Illinois at Chicago (1077-13-730)

5:00PM (1711) *Representations of reductive differential algebraic groups.*
Andrey Minchenko*, University of Western Ontario, and **Alexey Ovchinnikov**, CUNY Queens College (1077-20-1473)

5:30PM (1712) *Differential Modules over a Differential Ring.* Preliminary report.
Andy R Magid, University of Oklahoma (1077-13-537)

AMS Special Session on Enumerative and Algebraic Combinatorics, III

1:00 PM – 5:50 PM

Organizers: **Ira Gessel**, Brandeis University
Alexander Postnikov, Massachusetts Institute of Technology
Richard Stanley, Massachusetts Institute of Technology

1:00PM ► (1713) *Dismal Arithmetic.*
David Applegate, AT&T Shannon Labs, **Marc LeBrun**, Fixpoint Inc., and **Neil J. A. Sloane***, AT&T Shannon Labs (1077-11-104)

1:30PM ► (1714) *Rational Catalan Combinatorics.* Preliminary report.
Drew Armstrong, University of Miami (1077-05-1897)

2:00PM (1715) *Chromatic quasisymmetric functions and Hessenberg varieties.*
John Shareshian, Washington University, and **Michelle L Wachs***, University of Miami (1077-05-2254)

2:30PM (1716) *Recent progress on the Shuffle Conjecture: Macdonald Polynomials and Parking Functions.*
Adriano M. Garsia, University of California San Diego (1077-05-1178)

3:00PM (1717) *Vanishing Integrals for Hall-Littlewood Polynomials.*
Vidya Venkateswaran, California Institute of Technology (1077-05-372)

3:30PM (1718) *W-cells from scratch.* Preliminary report.
John R Stembridge, University of Michigan (1077-05-838)

4:00PM ► (1719) *The shape of a random affine Weyl group element, and random core partitions.*
Thomas Lam, University of Michigan (1077-05-706)

4:30PM (1720) *Torus actions, multi-partitions, and crystals.*
Steven V Sam* and **Peter Tingley**, MIT (1077-05-320)

5:00PM (1721) *A curious relation between two Markov chains.* **Tomohiro Sasamoto**, Chiba University, and **Lauren K Williams***, University of California, Berkeley (1077-05-1599)

5:30PM ► (1722) *The $1/k$ - Eulerian Polynomials.* **Carla D. Savage*** and **Gopal Viswanathan**, North Carolina State University (1077-05-1956)

AMS Special Session on Fractional, Hybrid, and Stochastic Dynamical Systems with Applications

1:00 PM – 5:50 PM

Organizers: **John Graef**, University of Tennessee at Chattanooga
Gangaram S. Ladde, University of South Florida, Tampa
Aghala S. Vatsala, University of Louisiana at Lafayette

1:00PM (1723) *Existence of solutions for fractional differential equations with anti-periodic boundary conditions.* **Mouffak Benchohra**, **Naima Hamidi**, Universite de Sidi Bel-Abbes, and **Johnny Henderson***, Baylor University (1077-34-54)

1:30PM (1724) *Positive solutions for a class of higher order boundary value problems with fractional q-derivatives.* **John R. Graef*** and **Lingju Kong**, University of Tennessee at Chattanooga (1077-34-239)

2:00PM (1725) *Fractional Inequalities Revisited.* Preliminary report. **George A Anastassiou**, University of Memphis (1077-26-359)

2:30PM (1726) *Fractional Differential Equations with Periodic Boundary Conditions. Generalized Monotone Method and Conditions for Uniqueness.* **J Diego Ramirez*** and **Aghalaya S Vatsala**, University of Louisiana at Lafayette (1077-34-578)

3:00PM (1727) *Diffusions switched by Markov chains.* Preliminary report. **Andrzej Korzeniowski**, The University of Texas at Arlington (1077-60-1064)

3:30PM (1728) *Generalized Quasilinearization Method for Nonlinear Riemann-Liouville Fractional Differential Equations.* Preliminary report. **Zachary Denton*** and **Aghalaya Vatsala**, University of Louisiana at Lafayette (1077-34-1132)

4:00PM (1729) *Stability of stochastic two-scale network delayed SIR epidemic dynamic model with temporary immunity period.* **Divine T Wanduku*** and **Gangaram S Ladde**, University of South Florida (1077-60-1376)

4:30PM (1730) *On Higher Order Stochastic differential equations.* **Jean-Claude Pedjeu*** and **G. S. Ladde**, University of South Florida (1077-60-1872)

5:00PM (1731) *Existence of multiple solutions for a class of fractional boundary value problems.* **Lingju Kong**, University of Tennessee at Chattanooga (1077-34-1873)

5:30PM (1732) *Generalized Monotone Method and Gauss Seidel Method for Caputo and Riemann Liouville Fractional Differential Systems.* Preliminary report. **Aghalaya S Vatsala***, University of Louisiana at Lafayette, and **Donna Stutson**, Xavior University of New Orleans (1077-34-1038)

AMS Special Session on Knot Theory, III

1:00 PM – 5:50 PM

Organizers: **Tim Cochran**, Rice University
Shelly Harvey, Rice University

1:00PM (1733) *Projective Representations of the Mapping Class Group coming from the Extended TQFT underlying the Kauffman Bracket.* **Charles Frohman***, **Michael Fitzpatrick**, The University of Iowa, and **Joanna Kania-Bartoszynska**, The National Science Foundation (1077-57-185)

1:30PM (1734) *Knot concordance and homology cobordism.* **Tim D Cochran**, **Bridget D Franklin**, Rice University, **Matthew Hedden**, Michigan State University, and **Peter D Horn***, Columbia University (1077-57-994)

2:00PM (1735) *On the equivalence of Legendrian and transverse knot invariants in Heegaard Floer homology.* **John A. Baldwin**, Princeton University, **David Shea Vela-Vick***, Columbia University, and **Vera Vertesi**, Massachusetts Institute of Technology (1077-57-622)

2:30PM (1736) *Obstructing concordance of related satellite operations.* **Bridget D Franklin**, Rice University (1077-57-1245)

3:00PM (1737) *Grid diagrams and the spectral sequence from Khovanov to Heegaard Floer homology.* **John A Baldwin**, Princeton University (1077-57-2413)

3:30PM (1738) *Non-triviality of knots arising from iterated infection without the use of the Tristram-Levine signature.* **Christoper William Davis**, Rice University (1077-57-1089)

4:00PM (1739) *Topologically slice knots with small fundamental group.* Preliminary report. **Prudence Heck*** and **Tim Cochran**, Rice University (1077-57-2089)

4:30PM (1740) *Classifying primitive/Seifert knots.* Preliminary report. **John Berge**, Madison, WI, **Brandy Guntel***, UT Austin, and **Sungmo Kang**, McGill University (1077-57-1421)

5:00PM (1741) *Categorification of the Jones-Wenzl projectors and applications.* **Benjamin Cooper** and **Slava Krushkal***, University of Virginia (1077-57-1627)

5:30PM (1742) *Properties of the head and tail of the colored Jones polynomial.* **Oliver Dasbach*** and **Cody Armond**, Louisiana State University (1077-57-2110)

AMS Special Session on Linear Algebraic Groups: Their Arithmetic, Geometry, and Representations, III

1:00 PM – 5:50 PM

Organizers: **R. Skip Garibaldi**, Emory University
George McNinch, Tufts University

1:00PM (1743) *Extended Quotients and Kazhdan-Lusztig Parameters.* **Paul Frank Baum**, Penn State University (1077-22-653)

1:30PM (1744) *Unexpected twists in positive depth L-packets.* Preliminary report. **Stephen DeBacker***, University of Michigan, and **Loren Spice**, Texas Christian University (1077-22-2884)

2:00PM (1745) *The Belkale-Kumar cup product.* **Sam Evens**, University of Notre Dame (1077-17-1471)

2:30PM (1746) *Representation Theory of semisimple Lie algebras in positive characteristic.* Preliminary report.
Ivan Mirkovic, U. of Massachusetts, Amherst (1077-22-1738)

3:00PM (1747) *Regular nilpotent Hessenberg varieties.*
Julianna S Tymoczko, Smith College (1077-14-2792)

3:30PM (1748) *Special nilpotent orbits and modular Lie algebra representations.* Preliminary report.
James E. Humphreys, U. Massachusetts, Amherst (1077-17-453)

4:00PM (1749) *G-Galois algebras and a Hasse principle.*
Parimala Raman*, Emory University, Atlanta, GA 30322, and **Eva Bayer-Fluckiger**, EPFL, Lausanne, Switzerland (1077-20-2439)

4:30PM (1750) *On the conjecture of Borel and Tits for abstract homomorphisms of algebraic groups.*
Igor A. Rapinchuk, Yale University (1077-20-218)

5:00PM (1751) *Degree formula for the Euler characteristic.*
Olivier Haution, University of Nottingham (1077-14-747)

5:30PM (1752) *The J-invariant and Tits indices for groups of type E_6.*
Caroline Junkins, University of Ottawa (1077-14-1010)

AMS Special Session on Progress in Free Analysis, III

1:00 PM – 5:50 PM

Organizers: **J. William Helton**, University of California, San Diego
Paul S. Muhly, University of Iowa

1:00PM (1753) *Non commutative Hardy operator algebras.*
Paul S Muhly, University of Iowa, and **Baruch Solel***, Technion, Israel Institute of Technology (1077-47-883)

1:30PM (1754) *Cuntz-Pimsner algebras for subproduct systems.*
Ami Viselter, University of Alberta (1077-46-499)

2:00PM (1755) *A survey of topological free entropy dimension.* Preliminary report.
Don Hadwin*, University of New Hampshire, **Qihui Li**, East China University of Science and Technology (Shanghai), **Weihua Li**, Columbia College (Chicago), and **Junhao Shen**, University of New Hampshire (1077-46-701)

2:30PM (1756) *Representation formulas for Hardy space functions through the Cuntz relations and new interpolation problems.*
Daniel Aron Alpay*, Ben-Gurion University, **Palle Jorgensen**, University of Iowa, **Izchak Lewkowicz**, Department of electrical engineering. Ben-Gurion University, and **Itzik Marziano**, Ben-Gurion University (1077-47-1575)

3:00PM (1757) *Characteristic functions of row contractions: unitary equivalence and coincidence.*
Vladimir Bolotnikov*, The College of William and Mary, and **Joseph A Ball**, Virginia Tech (1077-47-1968)

3:30PM (1758) *Essential normality of polynomial-generated submodules.*
Quanlei Fang*, Bronx Community College, CUNY, and **Jingbo Xia**, SUNY-Buffalo (1077-47-486)

4:00PM (1759) *Extensions of Hilbert Modules over Operator Tensor Algebras.*
Andrew K Greene, University of Iowa (1077-46-2437)

4:30PM (1760) *Second Order Even and R-diagonal Operators.* Preliminary report.
James A Mingo*, Queen's University at Kingston, and **Octavio Arizmendi**, Universität des Saarlandes (1077-46-1856)

5:00PM (1761) *Realization and interpolation theory for generalized Schur classes.* Preliminary report.
Joseph A. Ball, Virginia Tech (1077-47-200)

5:30PM (1762) *Analytic Functions from Tensors.*
Paul S. Muhly*, University of Iowa, and **Baruch Solel**, Technion (1077-46-1704)

AMS Special Session on Radon Transforms and Geometric Analysis (in honor of Sigurdur Helgason's 85th birthday), II

1:00 PM – 5:50 PM

Organizers: **Jens Christensen**, University of Maryland
Fulton Gonzalez, Tufts University
Todd Quinto, Tufts University

1:00PM (1763) *Abel-Radon transform and CR functions.*
Mark Agranovsky, Bar-Ilan University (1077-32-672)

1:30PM (1764) *Mean value theorems on symmetric spaces.*
Francois Rouviere, Universite de Nice, France (1077-22-1590)

2:00PM (1765) *The cos^{λ}-transform and intertwining operators for $SL(n, \mathbb{F})$.*
Gestur Olafsson*, Louisiana State University, and **Angela Pasquale**, University of Metz (1077-43-1085)

3:00PM (1766) *Twisted Poisson integrals on bounded symmetric domains.*
Adam Koranyi, H. H. Lehman College, CUNY (1077-22-874)

3:30PM (1767) *Radon transformation on reductive symmetric spaces: support theorems.*
Job J. Kuit, University of Copenhagen (1077-44-456)

4:00PM (1768) *Range of the Double Fibration Transform (joint work with Michael Eastwood).*
Joseph A. Wolf, University of California at Berkeley (1077-22-331)

5:00PM (1769) *The bounded hypergeometric functions associated with root systems.*
E. K. Narayanan, Indian Institute of Science, Bangalore, India, **Angela Pasquale***, Universite Paul Verlaine - Metz, France, and **Sanjoy Pusti**, University of Luxembourg (1077-33-684)

5:30PM (1770) *Paley-Wiener Theorems on R^n with respect to the spectral parameter.*
Susanna Dann*, University of Missouri, and **Gestur Olafsson**, Louisiana State University (1077-43-2720)

AMS Special Session on Rational Points on Varieties, III

1:00 PM – 5:50 PM

Organizers: **Jennifer Balakrishnan**, Massachusetts Institute of Technology
Bjorn Poonen, Massachusetts Institute of Technology
Bianca Viray, Brown University
Kirsten Wickelgren, Harvard University

1:00PM (1771) *Homotopy Obstructions to Rational Points - I.* **Tomer M. Schlank*** and **Yonatan Harpaz**, The Hebrew University of Jerusalem (1077-14-1374)

1:30PM (1772) *Homotopy Obstructions to Rational Points - II.* **Yonatan Harpaz*** and **Tomer M. Schlank**, The Hebrew University of Jerusalem (1077-14-1375)

2:00PM (1773) *Rational points and $\mathbb{A}^1$-homotopy theory.* **Aravind Asok**, University of Southern California, and **Christian Haesemeyer***, UCLA (1077-14-1226)

2:30PM (1774) *A p-adic criterion for good reduction of curves over a p-adic field.* **Adrian Iovita**, Concordia University, Montreal and Padova University, Italy (1077-14-1616)

3:00PM (1775) *The birational p-adic section conjecture -revisited.* **Florian Pop**, University of Pennsylvania (1077-08-2022)

3:30PM (1776) *Cohen-Lenstra heuristics and Random Dieudonné Modules.* **David Michael Zureick-Brown***, Emory University, **Jordan Ellenberg**, University of Wisconsin-Madison, and **Bryden Cais**, The University of Arizona (1077-11-2088)

4:00PM (1777) *Euclidean quadratic forms and ADC forms.* **Pete L. Clark**, University of Georgia (1077-11-2451)

4:30PM ► (1778) *Imaginary quadratic class numbers and Sha for congruent number curves.* Preliminary report. **Nils Bruin**, Simon Fraser University (1077-11-2012)

5:00PM (1779) *Diophantine Equations With Two Separated Variables.* **Benjamin L Weiss**, Technion (1077-12-128)

5:30PM (1780) *Extensions of a Kim and Roush Result to Algebraic Fields.* Preliminary report. **Alexandra Shlapentokh**, East Carolina University (1077-11-1325)

AMS Special Session on Recent Trends in Graph Theory, II

1:00 PM – 5:50 PM

Organizer: **Ralucca Gera**, Naval Postgraduate School

1:00PM ► (1781) *Uniquely K_r-saturated graphs.* Preliminary report. **Stephen G Hartke** and **Derrick Stolee***, University of Nebraska-Lincoln (1077-05-1584)

1:30PM ► (1782) *On Locating Sets in Graphs.* **Bryan A Phinezy**, Western Michigan University (1077-05-767)

2:00PM (1783) *Counting Kempe-equivalence classes for 3-edge-colored cubic graphs.* **Sarah-Marie Belcastro***, University of Massachusetts-Amherst and Smith College, and **Ruth Haas**, Smith College (1077-05-587)

2:30PM (1784) *On cubic non-toroidal graphs.* Preliminary report. **Stan Dziobiak***, University of Mississippi, and **Guoli Ding**, Louisiana State University (1077-05-2541)

3:00PM ► (1785) *Prime Distance Graphs.* **Joshua D Laison***, **Colin Starr**, Willamette University, and **Andrea Walker**, Sandia National Laboratory (1077-05-124)

3:30PM ► (1786) *Clawfreeness of powers of graphs.* Preliminary report. **Patrick Bahls***, University of North Carolina, Asheville, and **Nicole A. Gin**, Spring Arbor University (1077-05-45)

4:00PM ► (1787) *Parity Balanced Bipartite Graphs.* **Guven Yuceturk***, University of West Georgia, and **Dean G. Hoffman**, Auburn University (1077-05-2648)

4:30PM (1788) *Cancellation for the direct product of digraphs.* **Richard H Hammack**, Virginia Commonwealth University (1077-05-122)

5:00PM (1789) *Rainbow Matchings and the Erdos-Ko-Rado Theorem.* **David M Howard*** and **Ron Aharoni**, Technion - Israel Institute of Technology (1077-05-2297)

5:30PM (1790) *Total Detection Numbers of Graphs.* **Henry Escuadro***, Juniata College, and **Futaba Fujie-Okamoto**, University of Wisconsin - La Crosse (1077-05-2084)

AMS Special Session on Some Nonlinear Partial Differential Equations: Theory and Application, III

1:00 PM – 5:20 PM

Organizers: **Jerry L. Bona**, University of Illinois, Chicago

Laihan Luo, New York Institute of Technology

1:00PM ► (1791) *Dispersive Quantization — the Talbot Effect.* **Peter J. Olver**, University of Minnesota (1077-35-605)

1:30PM ► (1792) *On the existence of stationary solutions for some non-Fredholm integro-differential equations.* **Vitali G Vougalter**, University of Cape Town (1077-35-2063)

2:00PM (1793) *Water Waves with Discontinuous Vorticity.* **Walter A. Strauss**, Brown University (1077-76-1172)

2:30PM (1794) *On a PDE system that governs the boundary layers system for complex fluids.* **Xiaojun Wang*** and **Michael Renardy**, Virginia Tech (1077-76-1557)

3:00PM Discussion moderated by Diane Henderson

3:30PM (1795) *Some Integro-differential Equations Describing Nonlinear Evolution of Instability Waves on Shear Flows.* **Xuesong Wu**, Tianjin University, China & Imperial College London, UK (1077-76-2301)

4:00PM (1796) *Inverse energy cascade and self-organization in 2-D turbulent channel flow.* **Wanping Li*** and **Shuangxi Guo**, School of Civil Engineering and Mechanics, Huazhong University of Science and Technology, Wuhan, PR China (1077-76-683)

4:30PM (1797) *Evolution of elastic thin films with curvature regularization via minimizing movements.* **Paolo Piovano**, Carnegie Mellon University (1077-35-1747)

5:00PM ► (1798) *Well Known Equations and Not Well Known Behavior of Solutions.* Preliminary report. **Laihan Luo**, New York Institute of Technology (1077-35-463)

AMS Special Session on Uniformly and Partially Hyperbolic Dynamical Systems, II

1:00 PM – 5:40 PM

Organizers: **Todd Fisher**, Brigham Young University

Boris Hasselblatt, Tufts University

1:00PM (1799) *Partial Hyperbolicity in the Hamiltonian and geometrical context.* **Enrique Pujals**, IMPA (1077-37-764)

2:00PM (1800) *Ergodicity of the Weil Petersson geodesic flow.* **Keith Burns***, Northwestern University, **Howard Masur**, University of Chicago, and **Amie Wilkinson**, Northwestern University (1077-37-2115)

2:30PM (1801) *Isotopy class for orbits of skewed $\mathbb{R}$-covered Anosov flows.*
Thomas Barthelmé, IRMA, université de Strasbourg (1077-37-1352)

3:00PM (1802) *Partially hyperbolic actions on nilmanifolds.*
Danijela Damjanovic, Rice University (1077-37-937)

3:30PM (1803) *Mixing rates for flows.*
Michael Field, University of Houston (1077-37-1444)

4:00PM (1804) *Billiards under small twists.*
Hong-Kun Zhang, University of Massachusetts Amherst (1077-37-438)

4:30PM (1805) *A note on dynamical Borel-Cantelli lemmas for non-uniformly hyperbolic dynamical systems.*
Nicolai Haydn, University of Southern California, **Matthew Nicol***, University of Houston, **Tomas Persson**, Lunds Tekniska Hogskola, Sweden, and **Sandro Vaienti**, CPT, Luminy, France (1077-37-1419)

5:00PM (1806) *Essential coexistence of completely hyperbolic and completely non-hyperbolic behavior.*
Yakov B. Pesin, Penn State University (1077-37-540)

MAA Invited Paper Session on Semidefinite Optimization and Nonnegative Polynomials

1:00 PM – 3:45 PM

Organizers: **Rekha Thomas**, University of Washington
Greg Blekherman, Georgia Tech

1:00PM ► (1807) *Nonnegative Polynomials and Sums of Squares.*
Grigoriy Blekherman, Georgia Tech (1077-AH-2956)

1:45PM ► (1808) *Sum of Squares Optimization applied to Walking Robots and Robotic Birds.*
Russ Tedrake, Massachusetts Institute of Technology: Computer Science and Artificial Intelligence Lab (1077-AH-2831)

2:30PM ► (1809) *Computational and Algebraic Aspects of Convexity.*
Amir Ali Ahmadi, MIT (1077-AH-2925)

3:15PM ► (1810) *Graphs, Distances, and Semidefinite Programming.*
Steven J. Gortler, SEAS, Harvard University (1077-AH-900)

MAA Minicourse #3: Part B

1:00 PM – 3:00 PM

Problem-based courses for teachers, future teachers, and math majors.

Presenters: **Gail Burrill**, Michigan State University
Darryl Yong, Harvey Mudd College
Bowen Kerins, Education Development Center
James King, University of Washington

MAA Minicourse #7: Part B

1:00 PM – 3:00 PM

Study the masters: Using primary historical sources in mathematics teaching.

Presenters: **Daniel Otero**, Xavier University
David Pengelley, New Mexico State University

MAA Minicourse #11: Part B

1:00 PM – 3:00 PM

Teaching differential equations with modeling.

Presenters: **Michael Huber**, Muhlenberg College
Dan Flath, Macalester College
Tom LoFaro, Gustavus Adolphus College

AMS Session on Combinatorics and Graph Theory, VI

1:00 PM – 5:25 PM

1:00PM ► (1811) *On the Distribution of Arithmetic Sequences in the $3x+1$ Graph.* Preliminary report.
Keenan Monks, Harvard, **Ken G. Monks***, University of Scranton, **Ken M. Monks**, Colorado State University, and **Maria Monks**, UC Berkeley (1077-05-1804)

1:15PM ► (1812) *Counting Binary Normal Networks.*
Devin R Bickner, Iowa State University (1077-05-1719)

1:30PM (1813) *Improving the Computational Efficiency of the Blitzstein–Diaconis algorithm for Generating Graphs of Prescribed Degree.*
Elizabeth Moseman, NIST (1077-05-1694)

1:45PM (1814) *Combinatorial Interpretations of Quantum Elementary Characters.* Preliminary report.
Brittany C Shelton* and **Mark Skandera**, Lehigh University (1077-05-1664)

2:00PM ► (1815) *Some planar Hall completable graphs.* Preliminary report.
Sibel Ozkan, Istanbul, Turkey, and **Erik E Westlund***, Kennesaw State University (1077-05-1594)

2:15PM (1816) *The k-Fixed-Endpoint Path Partition Problem.*
Breeanne Baker* and **Garth Isaak**, Lehigh University (1077-05-1568)

2:30PM ► (1817) *Mod $(2p+1)$-orientations in graphs.*
Yanting Liang, St. Mary's College of Maryland (1077-05-1761)

2:45PM (1818) *On quasi-symmetric designs with intersection difference three.*
V. C. Mavron, **T. P. McDonough**, Institute of Mathematics and Physics, Aberystwyth, Ceredigion, UK, and **M. S. Shrikhande***, Central Michigan University (1077-05-1852)

3:00PM Break.

3:15PM ► (1819) *Split digraphs.*
M Drew LaMar, College of William and Mary (1077-05-1853)

3:30PM ► (1820) *Maximum packings of complete graphs with stars.*
Dan Roberts, Auburn University (1077-05-1457)

3:45PM ► (1821) *Generalizations of Baranyai's Theorem and Embedding Factorizations.*
Amin Bahmanian, Auburn University (1077-05-1369)

4:00PM (1822) *Conjectures and Results on Equitable Δ-Coloring of Graphs.*
Bor-Liang Chen, National Taichung Institute of Technology, Taiwan, **Ko-Wei Lih**, Academia Sinica, Taiwan, and **Chih-Hung Yen***, National Chiayi University, Taiwan (1077-05-1316)

4:15PM ► (1823) *Partial Permutations Avoiding Pairs of Patterns.*
Noah Arbesfeld, Massachusetts Institute of Technology (1077-05-1300)

4:30PM ► (1824) *Quotients of subgroup lattices of finite abelian p-groups.* Preliminary report.
Marina Dombrovskaya, Washington University in St. Louis (1077-05-1252)

4:45PM ► (1825) *A Geometric Extremal Result for Cubic Arrays.*
James E Gossell*, University of Central Missouri, and **Peter Johnson**, Auburn University (1077-05-1639)

5:00PM (1826) *A hypergraph version of a graph packing theorem by Bollobás and Eldridge.*
Peter Hamburger, Western Kentucky University, **Alexandr V. Kostochka**, University of Illinois at Urbana-Champaign, and **Christopher Stocker***, Western Kentucky University (1077-05-1945)

5:15PM (1827) *A bijective factorization of modified Macdonald polynomials.*
Nicholas A Loehr, Virginia Tech, and **Elizabeth M Niese***, Marshall University (1077-05-1513)

AMS Session on Computer Science, Information, Control Theory, and Economics, II

1:00 PM – 4:55 PM

1:00PM ► (1828) *Numerical Experiments on New Relaxation-Type Algorithms for LPs.*
Jesus A. De Loera, **Amitabh Basu** and **Mark Junod***, University of California, Davis (1077-90-1809)

1:15PM (1829) *Modeling Special Ordered Set Restrictions and Other Disjunctions using Base-2 Expansions.* Preliminary report.
Warren P Adams and **Frank M Muldoon***, Clemson University (1077-90-1418)

1:30PM (1830) *Computational Manifold Equilibrium in Dynamical Economic Models.*
Zhengyuan Gao, University of Amsterdam (1077-91-297)

1:45PM ► (1831) *A Minimax Distribution Free Approach: Joint Vendor and Buyer Model.*
Ajanta Roy, University of South Carolina, Salk, SC 29488 (1077-91-2528)

2:00PM ► (1832) *Game theory in vaccination and its application.* Preliminary report.
Yingyun Shen* and **Mike Mesterton-Gibbons**, Florida State University (1077-91-2483)

2:15PM (1833) *Identification of Systems with Structural Uncertainties using Binary Sensors.* Preliminary report.
Shaobai Kan, John Jay College of Criminal Justice, CUNY (1077-93-1291)

2:30PM (1834) *An Innovative Approach to Limiting Availibility Using Extended Semi-Markov Processes.*
Liang Hong*, Bradley University, **Jyotirmoy Sarkar**, Indiana University Purdue University Indianapolis, and **Bruno Bieth**, Modeling and Simulation, Novartis Pharma AG (1077-90-16)

2:45PM Break.

3:00PM (1835) *Strategic market games with random endowments.*
Barbara A Bennie, University of Wisconsin - La Crosse (1077-91-2382)

3:15PM (1836) *(Me) vs (Them) with the Help of Mr. Lincoln.*
Allan M. Cordish, Bethel, Ohio (1077-91-358)

3:30PM ► (1837) *Growth of one-dimensional cellular automata.*
Eric Rowland*, LaCIM, Universite du Quebec a Montreal, and **Charles Brummitt**, University of California Davis (1077-68-130)

3:45PM (1838) *Turing Machines and Quantum Computation: Building a Quantum Brain.*
Julia T Upton, Husson University (1077-68-127)

4:00PM (1839) *Strategies to Deploy Temporary Ambulatory Medical Services in Response of a Catastrophic Event.* Preliminary report.
Ahlam E.H. Tannouri*, Morgan State University, **Sam F. Tannouri**, Computer Science Department/ Morgan State University, and **Belinda Kauffman**, University of Maryland School of Medecine (1077-90-2907)

4:15PM (1840) *Communication-efficient 2-round group key establishment from pairings.*
K N Neupane* and **R Steinwandt**, Florida Atlantic University, Boca Raton, Florida (1077-94-1635)

4:30PM (1841) *Controllability of nonlocal semilinear boundary delay control systems.* Preliminary report.
Nutan Kumar Tomar* and **Suman Kumar**, Indian Institute of Technology Patna, Bihar,India (1077-93-2344)

4:45PM ► (1842) *Codes from incidence matrices and line graphs of generalized Paley graphs.* Preliminary report.
Pani Seneviratne, American University of Sharjah (1077-94-543)

AMS Session on Group Theory and Generalizations

1:00 PM – 5:40 PM

1:00PM ► (1843) *On subgroups of the Dixmier group and Calogero-Moser spaces.* Preliminary report.
Alimjon K Eshmatov, University of Arizona, Tucson (1077-20-2938)

1:15PM (1844) *Symmetry of Endomorphism Algebras - preliminary report.* Preliminary report.
Adam Anthony Allan, St. Louis University (1077-20-2820)

1:30PM ► (1845) *The probability that two elements commute in groups with small centers.* Preliminary report.
Thomas Langley, Rose-Hulman Institute of Technology (1077-20-2585)

1:45PM (1846) *Towers of IA-automorphisms.* Preliminary report.
Margaret H Dean, The City University of New York-BMCC, **Stephen Majewicz**, The City University of New York-KCC, and **Marcos Zyman***, The City University of New York-BMCC (1077-20-2573)

2:00PM (1847) *Relating the structure of a group to the module-theoretic properties of the group von Neumann algebra over the complex group ring.*
Wade Mattox, Virginia Tech (1077-20-2491)

2:15PM ► (1848) *Recent results on Cayley-Dickson loops.*
Jenya Kirshtein, University of Denver (1077-20-2154)

2:30PM ► (1849) *Monoids Defined by Second Order Recurrence Relations.* Preliminary report.
Trey Brock* and **Nicholas R Baeth**, University of Central Missouri (1077-20-2054)

2:45PM (1850) *Schur σ-groups of small prime power order.*
Michael R Bush, Smith College (1077-20-1783)

3:00PM (1851) *Hyperbolic hydra.*
Noel Brady, University of Oklahoma, **Will Dison**, Bank of England, and **Tim Riley***, Cornell (1077-20-1684)

3:15PM Break.

3:30PM (1852) *Abelian groups with partial decomposition bases.* Preliminary report.
Carol Jacoby, Jacoby Consulting, **Katrin Leistner**, University of Duisburg-Esen, Germany, **Peter Loth***, Sacred Heart University, and **Lutz Struengmann**, University of Duisburg-Essen, Germany (1077-20-1108)

3:45PM (1853) *Bounds and Asymptotics for Various Properties of Numerical Semigroups.*
Lynnelle L Ye, Stanford University (1077-20-1054)

4:00PM ► (1854) *Zero-divisor graphs with seven vertices.* Preliminary report.
Xinyun Zhu, University of Texas of the Permian Basin (1077-20-638)

4:15PM (1855) *Dirichlet-Ford Domains and Arithmetic Reflection Groups.* Preliminary report.
Grant S Lakeland, University of Texas at Austin (1077-20-446)

4:30PM (1856) *The nonabelian tensor square of nilpotent product of cyclic groups.* Preliminary report.
Arturo Magidin, University of Louisiana at Lafayette (1077-20-344)

4:45PM (1857) *Using the p-Group Generation Algorithm to Generate Extensions of D_4 by $C_2 \times C_2 \times C_{2^{n-5}}$.* Preliminary report.
Aliza A. Steurer, Dominican University (1077-20-1605)

5:00PM (1858) *On Conditions Relating to Nonsolvability.*
Michael J. J. Barry, Allegheny College (1077-20-1613)

5:15PM (1859) *Finite Groups with all Subgroups not Contained in the Frattini Subgroup Permutable.*
Joseph Kirtland, Marist College (1077-20-266)

5:30PM ► (1860) *A new distinguished form for 3-braids and its applications to the σ-order on B_3.* Preliminary report.
Emille Davie Lawrence, University of San Francisco (1077-20-259)

AMS Session on Mathematical Biology and Related Fields, III

1:00 PM – 5:10 PM

1:00PM (1861) *Reaction-diffusion replicator equation: Stability and asymptotic behavior.*
Artem S. Novozhilov*, **Vladimir P. Posvyanskii** and **Alexander S. Bratus**, Moscow State University (1077-92-829)

1:15PM ► (1862) *Mathematical Modeling of Competitive Binding on a Microarray.*
Frank H Lynch* and **Thomas Jemielita**, Occidental College (1077-92-629)

1:30PM (1863) *A Novel Baysian Change-Point (BCP) Model for Better ChIP-seq Data Analyses.* Preliminary report.
Yifan Mo*, Stony Brook University, **Will Liao**, **Haipeng Xing**, Applied Math and Statistics Department, Stony Brook University, and **Michael Zhang**, Cold Spring Harbor Laboratory (1077-92-581)

1:45PM (1864) *The Number of Multistate Nested Canalyzing Functions.*
David Murrugarra, Virginia Tech (1077-92-361)

2:00PM ► (1865) *A discrete model of iron metabolism in lung epithelial cells with fungal challenge.* Preliminary report.
John Nardini*, North Carolina State University, **Kahmya McAlpin**, Oakwood University, **Leslie Myint**, Johns Hopkins University, and **Shernita Lee**, Virginia Bioinformatics Institute (1077-92-322)

2:15PM (1866) *Estimating population growth rates for mammalian species.*
Yanthe E Pearson*, **William Fagan**, **Elise Larsen**, University of Maryland College Park, **Emma Goldberg**, University Illinois Chicago, **Heather Lynch**, Suny Stoneybrook, **Hillary Staver**, University of Maryland College Park, and **Jessica Turner**, Select (1077-92-251)

2:30PM ► (1867) *Modeling the Differences in the Development of a New Antibiotic Class versus the Development of a Next Generation Antibiotic to Combat Antimicrobial Resistance in a Hospital Setting.*
Michele L. Joyner, East Tennessee State University (1077-92-895)

2:45PM ► (1868) *Modeling thermal propagation along vein walls in endovenous laser treatment.*
William R Fuller, Ohio Northern University (1077-92-2799)

3:00PM (1869) *Tumor growth in complex, evolving geometries: A diffuse domain approach.*
Ying Chen*, University of California, Irvine, and **John S. Lowengrub**, University of California, Irvine (1077-92-2464)

3:15PM Break.

3:30PM ► (1870) *Modeling Cell Movement using the Level Set Method.* Preliminary report.
Matthew K Fox*, **Benjamin Dellaria** and **Magdalena Stolarska**, University of Saint Thomas (1077-92-2431)

3:45PM ► (1871) *Association testing in sequencing studies: Accommodating risk and protective variants.*
Abra Brisbin* and **Brooke L. Fridley**, Mayo Clinic (1077-92-245)

4:00PM (1872) *Multi-scale Model of CRISPR-induced Coevolutionary Dynamics: Diversification at the Interface of Lamarck and Darwin.* Preliminary report.
Lauren M Childs*, Georgia Institute of Technology, **Nicole Held**, Univeristy of Illinois at Urbana-Champaign, **Mark J Young**, Montana State University, **Rachel J Whitaker**, Univeristy of Illinois at Urbana-Champaign, and **Joshua S Weitz**, Georgia Institute of Technology (1077-92-241)

4:15PM ► (1873) *A Cellular Automata Model for Biofilm Growth with Surface Flow.*
Baldvin Einarsson*, Center for Complex and Nonlinear Science, University of California, Santa Barbara, **David Rodriguez** and **Ana Carpio**, Universidad Complutense de Madrid (1077-92-2514)

4:30PM (1874) *Using Optimal Control to minimize Rift Valley Fever Cases.* Preliminary report.
Donald Adongo*, **Renee Fister**, Murray State University, and **Holly Gaff**, Old Dominion University (1077-92-2218)

4:45PM ► (1875) *Modeling the Spread of a Ug99-Type Wheat Pathogen in the United States of America.*
Patrick Thomas Davis*, Central Michigan University, and **Andrew M. Ross**, Eastern Michigan University (1077-92-189)

5:00PM ► (1876) *Simple Undergraduate Mathematics to Understand Complex HIV-1 Latent Infection Dynamics.*
Naveen K. Vaidya, The University of Western Ontario (1077-92-1553)

AMS Session on Number Theory, Field Theory, and Polynomials, II

1:00 PM – 5:25 PM

1:00PM (1877) *Rational Density.* Preliminary report.
Adam C. McDougall* and **Nathan Bishop**, St. Olaf College (1077-11-1778)

1:15PM (1878) *Solutions to $xyz = 1$ and $x + y + z = k$ in Integers in Cubic Number Fields.* Preliminary report.
Helen G. Grundman*, Bryn Mawr College, and **Laura L. Hall-Seelig**, Merrimack College (1077-11-1587)

1:30PM (1879) *Integer Solutions to $xyz = 1$ and $x + y + z = k$ in Number Fields of Degree at Most Four.* Preliminary report.
Helen G. Grundman, Bryn Mawr College, and **Laura L. Hall-Seelig***, Merrimack College (1077-11-1588)

1:45PM (1880) *Robin's theorem, primes, and a new elementary reformulation of the Riemann Hypothesis.*
Geoffrey Caveney, Chicago, IL, **Jean-Louis Nicolas**, Université de Lyon; CNRS, Institut Camille Jordan, and **Jonathan Sondow***, New York, NY (1077-11-1573)

2:00PM (1881) *On the Dimension of Algebro-Geometric Trace Codes.*
Phong Le, Niagara University (1077-11-1104)

2:15PM (1882) *On positive integers n dividing the nth term of an elliptic divisibility sequence.*
Avram M. Gottschlich, Dartmouth College (1077-11-1705)

2:30PM (1883) *Computing Intersections of Abelian Varieties Associated to Modular Forms.*
Randy J Heaton, Florida State University (1077-11-1414)

2:45PM (1884) *The Inverse Galois Problem and Minimal Ramification over Function Fields.*
Meghan M De Witt, University of Central Oklahoma (1077-11-1192)

3:00PM Break.

3:15PM (1885) *Exponential Hensel Lifting.*
A Johnston, Johns Hopkins University (EP) (1077-11-1082)

3:30PM (1886) *ℓ-adic Properties of Partition Functions.*
Eva Kinoshita Belmont, Harvard University, **Sarah Trebat-Leder***, Princeton University, **Alexandra Musat**, California Institute of Technology, and **Holden Lee**, Massachusetts Institute of Technology (1077-11-1068)

3:45PM (1887) *Divisibility of Eigenforms, and computing a function of the j-invariant.*
Jeffrey Beyerl*, **Kevin James** and **Hui Xue**, Clemson University (1077-11-899)

4:00PM (1888) *Connections between discriminants and the root distribution of polynomials with rational generating functions.*
Khang D. Tran, University of Illinois at Urbana-Champaign (1077-11-687)

4:15PM (1889) *Symmetric parameterizations for quintic Eisenstein series.*
Tim Huber*, **Richard Charles** and **Andoni Mendoza**, University of Texas - Pan American (1077-11-1772)

4:30PM (1890) *Polynomial Cunningham Chains.*
Lenny Jones, Shippensburg University (1077-11-1833)

4:45PM (1891) *New Ramanujan Congruence Properties of the Restricted Partition Function $p(n, m)$ Modulo Prime Powers.*
Brandt Kronholm, Whittier College (1077-11-659)

5:00PM (1892) *The quadratic Waring-Goldbach problem and related topics.* Preliminary report.
Taiyu Li, Shandong University (1077-11-2966)

5:15PM (1893) *Congruence and Noncongruence Subgroups of $\Gamma(2)$ via Graphs on Surfaces.*
erica j. Whitaker, The Ohio State University (1077-11-626)

AMS Session on Numerical Analysis, I

1:00 PM – 4:55 PM

1:00PM (1894) *Iteratively Re-weighted Least Squares Methods for Inverse Problems with Sparsity Constraints.*
Ingrid Daubechies, Duke University, and **Sergey Voronin***, Princeton University (1077-65-1626)

1:15PM (1895) *A fast numerical solver for the unsteady Oseen problems in rotation form.*
Jia Liu, University of West Florida (1077-65-2949)

1:30PM (1896) *An Adaptive Compact Scheme for the Quenching Solution of Reaction-Diffusion Equations.*
Matthew A. Beauregard* and **Qin Sheng**, Baylor University (1077-65-2497)

1:45PM (1897) *Spectral Variational Integrators.* Preliminary report.
James Brian Hall, University of California, San Diego (1077-65-665)

2:00PM (1898) *On the construction of optimal piece-wise constant coarse spaces in algebraic multigrid method.*
James J Brannick, **Yao Chen*** and **Ludmil T Zikatanov**, Penn State University (1077-65-2705)

2:15PM (1899) *Explicit Extended Stability Time Stepping Methods.*
Katharine F Gurski, Howard University (1077-65-2804)

2:30PM (1900) *Variational Multiscale and SUPG Stabilization of Proper Orthogonal Decomposition Approximation for a Generalized Oseen Problem.*
John P Roop*, North Carolina A & T State University, **Traian Iliescu** and **Zhu Wang**, Virginia Tech (1077-65-2713)

2:45PM (1901) *A Non-linear Least Squares Estimator of Bühlmann Credibility.* Preliminary report.
Jinfeng Wei, Maryvile University of St. Louis (1077-65-2692)

3:00PM Break.

3:15PM (1902) *Perturbation theory for the approximation of stability spectra by QR methods for products of linear operators on a Hilbert space.*
M. Badawy* and **Erik S. Van Vleck**, University of Kansas (1077-65-2444)

3:30PM (1903) *Proper Orthogonal Decomposition Nonlinear Closure Models of Engineering Flows.*
Zhu Wang* and **Traian Iliescu**, Virginia Tech (1077-65-1732)

3:45PM (1904) *Immerse Finite Element Methods for Solving Parabolic Type Moving Interface Problems.*
Xu Zhang* and **Tao Lin**, Virginia Tech (1077-65-1492)

4:00PM (1905) *The Statistical Estimation of Uncertain Parameters in Elliptic PDEs.*
Hans-Werner van Wyk, Virginia Polytechnic and State University (1077-65-1465)

4:15PM (1906) *High Order Compact Reconstruction Scheme with Weighted Essentially Non-Oscillatory Limiting.*
Debojyoti Ghosh*, University of Maryland, and **James D. Baeder**, Department of Aerospace Engineering, University of Maryland (1077-65-1385)

4:30PM (1907) *Implementing the localized method of approximate particular solutions using a Schultz-Jones-Mayer algorithm.*
Guangming Yao*, Rowan University, and **Joseph Kolibal**, University of Southern Mississippi (1077-65-2230)

4:45PM (1908) *Galerkin Finite Element Approximations of an Optimal Control Problem for Elliptic PDEs with Random Input Data.*
Jangwoon Lee*, University of Mary Washington, and **Hyung-Chun Lee**, Ajou University (1077-65-1372)

AMS Session on Partial Differential Equations, I

1:00 PM – 4:25 PM

1:00PM (1909) *On theory and numerical method for computing eigen-solutions of nonlinear elliptic equation with Neumann boundary condition.* Preliminary report.
Changchun Wang, Texas A&M University (1077-35-2433)

1:15PM (1910) *Optimization Problem for Klein-Gordon Equation.*
Qinghua Luo, University of Oklahoma (1077-35-2039)

1:30PM (1911) *New Results for the Leah Cosine Function.*
Joshua Mann*, Morehouse College, and **Ronald E. Mickens**, Clark Atlanta University (1077-35-2144)

1:45PM (1912) *Fundamental differential form and boundary value problems for PDEs.*
Maxim Zyskin, UTB (1077-35-2694)

2:00PM ► (1913) *A Multi-Moment CIP Method for Hyperbolic Equations.*
Sarah King, North Carolina State University (NCSU) (1077-35-2535)

2:15PM (1914) *Nonlinear Neutral Inclusions: Assemblages of Disks and Ellipsoids.* Preliminary report.
Silvia Jiménez* and **Bogdan Vernescu**, Worcester Polytechnic Institute (1077-35-2723)

2:30PM Break.

2:45PM ► (1915) *Analysis of a 2n-th Order Differential Equation with Lidstone Boundary Conditions - The Existence of Positive Solutions.*
Tuwaner Hudson Lamar, Morehouse College (1077-35-2291)

3:00PM (1916) *On the Laplacian, and fractional Laplacian, in an Exterior Domain.*
Leonardo Kosloff* and **Tomas Schonbek**, Florida Atlantic University (1077-35-1893)

3:15PM (1917) *Blow-up of Solutions to Systems of Nonlinear Wave Equations with Interior and Boundary Sources and Damping.*
Yanqiu Guo* and **Mohammad A. Rammaha**, University of Nebraska-Lincoln (1077-35-2275)

3:30PM ► (1918) *Analysis of a Ginzburg-Landau Type Energy Model for Smectic C* Liquid Crystals with Defects.* Preliminary report.
Sean A. Colbert-Kelly* and **Daniel Phillips**, Purdue University (1077-35-2379)

3:45PM (1919) *On a Variational Approach for Water Waves.*
Danut Arama, Loyola University Chicago (1077-35-1646)

4:00PM (1920) *Global Well Posedness for a System of KDV-TYPE Equations with Quadratic Nonlinearities.* Preliminary report.
Gang Wang*, DePaul University, **Jerry L Bona**, University of Illinois at Chicago, and **Jonathan Cohen**, DePaul University (1077-35-1279)

4:15PM ► (1921) *A sixth-order compact finite difference method for Navier-Stokes in cylindrical coordinates.* Preliminary report.
Shelly M McGee, University of Findlay (1077-35-2655)

MAA Session on Developmental Mathematics Education: Helping Under-Prepared Students Transition to College-Level Mathematics

1:00 PM – 6:15 PM

Organizers: **Kimberly Presser**, Shippensburg University
J. Winston Crawley, Shippensburg University

1:00PM ► (1922) *Modularized Math Remediation: Implementation and data.*
Aaron Wong, Nevada State College (1077-C5-641)

1:20PM (1923) *Designing Developmental Mathematics for Student Success.*
Alvina J. Atkinson*, **Barry D. Biddlecomb** and **D. Natasha Brewley**, Georgia Gwinnett College (1077-C5-202)

1:40PM ► (1924) *Streamlining Basic Algebra Instruction.*
James R. Henderson, University of Pittsburgh at Titusville (1077-C5-163)

2:00PM (1925) *Factors Related to Using Algebraic Variables to Represent Quantitative Relationships.*
Susan S Gray, University of New England, **Barbara J Loud**, Regis College, and **Carole P Sokolowski***, Merrimack College (1077-C5-121)

2:20PM ► (1926) *Meeting the Needs of Under-Prepared Students.* Preliminary report.
Sarah Hutcheson Jahn* and **Robert J. Krueger**, Concordia University, St. Paul (1077-C5-1367)

2:40PM ► (1927) *What Csn We Do For Amanda?* Preliminary report.
Jesse W Byrne* and **Charlotte K Simmons**, University of Central Oklahoma (1077-C5-1411)

3:00PM ► (1928) *Developmental Mathematics: Try, Try, and Try Again.* Preliminary report.
Sarah V. Cook, Washburn University (1077-C5-2583)

3:20PM ► (1929) *Energize: Strategies to Keep Students Going and Going.*
Carla Rudder, Zayed University Abu Dhabi United Arab Emirates (1077-C5-1527)

3:40PM ► (1930) *An Integrated Media Approach to Developmental Mathematics Instruction.*
Jan O. Case* and **Jessica Bentley**, Jacksonville State University (1077-C5-1909)

4:00PM ► (1931) *An evaluation of the success of students who transition from a developmental Math Workshop into College Algebra, Trigonometry and Calculus I.* Preliminary report.
Jessica Deshler*, **Edgar Fuller**, **Betsy Kuhn**, **Doug Squire** and **Vicki Sealey**, West Virginia University (1077-C5-2673)

4:20PM ► (1932) *Digital Learning Materials: Analysis of student early preparation in College Algebra.*
Karoline Auby*, **James Sobota** and **Maighread McHugh**, University of Wisconsin-La Crosse (1077-C5-1958)

4:40PM ► (1933) *Creating Pathways to Math Success at a Liberal Arts College.* Preliminary report.
Maria Belk* and **Lauren Rose**, Bard College (1077-C5-2834)

5:00PM ► (1934) *Trying to Bridge the Gap: Outcomes and Implications of a Remedial Mathematics Intervention Program.* Preliminary report.
Karen G Santoro, Central Connecticut State University (1077-C5-2068)

5:20PM ► (1935) *The use of Pop Culture and Competition to Enhance Learning Mathematics (Survivor Math).*
Robert E. Burks, Department of Operations Research, Naval Postgraduate School (1077-C5-50)

5:40PM ► (1936) *Can Peer Coaches Improve Student Success in Developmental Mathematics Courses?*
Leonid Khazanov* and **Fred Peskoff**, Borough of Manhattan Community College/CUNY (1077-C5-630)

6:00PM ► (1937) *Experiences in Designing and Teaching Statway.* Preliminary report.
Mary R Parker, Austin Community College (1077-C5-2570)

MAA Session on Innovations in Teaching Statistics in the New Decade, I

1:00 PM – 5:15 PM

Organizers: **Andrew Zieffler**, University of Minnesota
Brian Gill, Seattle Pacific University
Nancy Boynton, SUNY Fredonia

1:00PM (1938) *Introductory Statistics with a Central Theme: "Statistical Reasoning" Courses That Interest Students.*
David G Taylor* and **Adam F Childers**, Roanoke College (1077-E5-907)

1:20PM ► (1939) *How the Analysis of Current Economic Growth, Income and Employment Can Be Used in Teaching an Introductory Statistics Course that Speaks to Students.* Preliminary report.
Alexander G. Atwood, SUNY Suffolk County Community College (1077-E5-2901)

1:40PM ► (1940) *Mathematics and the Law: How Big Should a Jury Be, and How Should It Render Its Decision?*
Jeff A Suzuki, Brooklyn College (1077-E5-72)

2:00PM ► (1941) *Read and Reflect: Making Statistics Real.*
Heather Hulett* and **Barbara Bennie**, Univ. of Wisconsin-La Crosse (1077-E5-2631)

2:20PM ► (1942) *Statistics Scrapbooks in Elementary Statistics.*
Julie Beier, Mercer University (1077-E5-1660)

2:40PM ► (1943) *Using an Online Homework System in an Introductory Statistics Course: Instructor and Student Perspectives.* Preliminary report.
Lisa Carnell, High Point University (1077-E5-1849)

3:00PM ► (1944) *Descent into 'The Abyss' of Least-Squares Linear Regression.* Preliminary report.
Charles Bergeron* and **David Clarke**, Albany College of Pharmacy and Health Sciences (1077-E5-2782)

3:20PM ► (1945) *Playing Games with a Purpose.*
Shonda Kuiper, Grinnell College (1077-E5-1653)

3:40PM ► (1946) *Playing Games with a Purpose: Initial Lessons from the Classroom.* Preliminary report.
Kevin F. Cummiskey* and **William H. Kaczynski**, United States Military Academy (1077-E5-1824)

4:00PM ► (1947) *Using R in an Undergraduate Statistics Course.*
Judith E Canner* and **Jon Detka**, California State University, Monterey Bay (1077-E5-741)

4:20PM ► (1948) *Probability Density Functions from Real-World Applications.*
Annela R Kelly, Bridgewater State University (1077-E5-2770)

4:40PM (1949) *Cutting Through the Theory: Emphasizing Statistical Thinking in Mathematical Statistics.*
Jennifer L. Green* and **Erin E. Blankenship**, University of Nebraska-Lincoln (1077-E5-2100)

5:00PM (1950) *Value and Relevance of an Engineering Statistics Course.*
Kumer Das, Lamar University, Beaumont, TX (1077-E5-2547)

MAA Session on Modeling Across the Mathematics Curriculum, II

1:00 PM – 3:15 PM

Organizers: **Benjamin Galluzzo**, Shippensburg University
Mariah Birgen, Wartburg College
Joyati Debnath, Winona State University

1:00PM ► (1951) *Why Mathematics?*
Nagaraj S Rao* and **Sanju Vaidya**, Mercy College (1077-I1-1650)

1:20PM ► (1952) *Integrating modeling into an introductory programming course.*
Sheldon Lee, Viterbo University (1077-I1-2612)

1:40PM (1953) *Learning Mathematics in the Context of Environmental Issues.*
Therese L Bennett, **Ray Mugno*** and **James Tait**, Southern CT State University (1077-I1-2500)

2:00PM ► (1954) *Social justice modeling contexts for teaching calculus and higher level math courses.*
Anand L Pardhanani, Earlham College (1077-I1-2195)

2:20PM ► (1955) *The Center for Applied Mathematics and Science at Salisbury University.* Preliminary report.
Veera Holdai, **Brian Hill**, **Steven Hetzler** and **Kathleen Shannon***, Salisbury University (1077-I1-1537)

2:40PM ► (1956) *Research Experiences for All Learners.*
Carla D Martin* and **Anthony Tongen**, James Madison University (1077-I1-1649)

3:00PM (1957) *Mathematical Thinking as a gateway to Undergraduate Research.*
Joyati Debnath, Winona State University (1077-I1-2853)

MAA Session on Research on the Teaching and Learning of Undergraduate Mathematics, III

1:00 PM – 2:55 PM

Organizers: **Sean Larsen**, Portland State University
Stacy Brown, Pitzer College
Karen Marrongelle, Portland State University

1:00PM ► (1958) *Learning mathematics from peers with different reasoning styles.* Preliminary report.
Kyeong Hah Roh, Arizona State University, **Owen Davis***, Arizona State Unniversity, and **Aviva Halani**, Arizona State University (1077-M1-2800)

1:20PM (1959) *The Role of Collective Work in Undergraduate Teaching of Mathematical Knowledge for Teaching to Future Elementary Teachers.* Preliminary report.
Wendy Aaron*, **Yvonne Lai** and **Hyman Bass**, University of Michigan (1077-M1-2829)

1:40PM ► (1960) *Examination and Analysis of Undergraduate Students' Level of Statistics Anxiety with Respect to Gender and College-year.* Preliminary report.
Soofia Malik* and **Karen Traxler**, University of Northern Colorado, Greeley, CO (1077-M1-1692)

2:00PM (1961) *Developing a research-based calculus for elementary teachers.*
Karen Keene Allen, North Carolina State University

2:20PM ► (1962) *Faculty Perspectives on the Transition to Graduate School in Mathematics.*
Sarah L. Marsh, Oklahoma Baptist University (1077-M1-1407)

2:40PM ► (1963) *Mathematics for Nonmath Majors and Mathematics Anxiety.* Preliminary report.
Moira K Devlin* and **Agnes Rash**, Saint Joseph's University (1077-M1-2507)

MAA Session on Topics and Techniques for Teaching Real Analysis, II

1:00 PM – 3:55 PM

Organizers: **Paul Musial**, Chicago State University
James Peterson, Benedictine College
Erik Talvila, University of the Fraser Valley
Robert Vallin, Slippery Rock University of Pennsylvania

1:00PM ► (1964) *Calculus: A Missed Opportunity.*
Peter A. Loeb, University of Illinois Champaign-Urbana (1077-N5-407)

1:20PM ► (1965) *The Lebesgue Integral : Motivations, advantages and Limitations.* Preliminary report.
Eddy A Kwessi, Trinity University (1077-N5-498)

1:40PM (1966) *Teaching the Lebesgue Integral with a Calculus II Prerequisite.*
William Johnston, Butler University (1077-N5-991)

2:00PM ► (1967) *A simple derivation of the trapezoidal rule for numerical integration.*
Erik Talvila*, University of the Fraser Valley, and **Matthew Wiersma**, University of Waterloo (1077-N5-662)

2:20PM ► (1968) *Undergraduate research in a Real Analysis course.* Preliminary report.
Manmohan Kaur, Benedictine University (1077-N5-2211)

2:40PM ► (1969) *Use of a "Connections Journal" in an undergraduate Real Analysis course.*
Antonia E. Cardwell, Millersville University of Pennsylvania (1077-N5-827)

3:00PM ► (1970) *Using the Banach-Mazur Game in an Undergraduate Real Analysis Class to Investigate Different Types of Infinite Sets.*
Don L Hancock, Pepperdine University (1077-N5-187)

3:20PM ► (1971) *Flows on metric spaces: ODEs, PDEs, SDEs and DDEs.*
Craig J. Calcaterra, Metropolitan State University (1077-N5-1468)

3:40PM ► (1972) *Using Illustrations to Motivate Definitions and Proofs in Real Analysis.*
Paul M. Musial, Chicago State University (1077-N5-2456)

MAA Session on Wavelets in Undergraduate Education

1:00 PM – 4:15 PM

Organizers: **Caroline Haddad**, SUNY Geneseo
Catherine Beneteau, University of South Florida
David Ruch, Metropolitan State College of Denver
Patrick Van Fleet, University of St. Thomas

1:00PM (1973) *Undergraduate Research Projects on Wavelet-Based Time Series Forecasting.*
Bruce Atwood, Beloit College, **Helmut Knaust**, The University of Texas at El Paso, **Caroline Haddad***, SUNY Geneseo, and **John Merkel**, Oglethorpe University (1077-P5-2886)

1:20PM ► (1974) *Applications of Discrete Wavelets to Stock Price Prediction.*
John C. Merkel, Oglethorpe University (1077-P5-2868)

1:40PM (1975) *Applications of Wavelets: a sophomore-level seminar course.*
Rachel J Weir, Allegheny College (1077-P5-329)

2:00PM ► (1976) *Discrete signal processing with fractal wavelets.* Preliminary report.
J. D'Andrea* and **T. Sibbett**, Westminster College of Salt Lake City (1077-P5-2808)

2:20PM ► (1977) *What Are You Hiding? Steganography Using Wavelets.*
Jeff Zeitler, SUNY Geneseo (1077-P5-1875)

2:40PM ► (1978) *Smartphone Sensors and Wavelets.*
Edward F Aboufadel*, **Nathan Marculis**, Grand Valley State University, and **SaraJane Parsons**, Indiana University of Pennsylvania (1077-P5-901)

3:00PM ► (1979) *Facial Detection and Recognition Using the Haar Transform in Static Images.*
Joseph Michael Gonzalez, University of South Florida (1077-P5-772)

3:20PM ► (1980) *Some Ideas for Undergraduate Projects Involving Periodic Wavelets.*
Kenneth R. Hoover*, California State University, Stanislaus, and **Brody Dylan Johnson**, Saint Louis University (1077-P5-2611)

3:40PM ► (1981) *Investigation of Second Generation Wavelets.*
Karleigh Cameron, **Michael Gustin***, **John Holden** and **Stacy Siereveld**, Central Michigan University (1077-P5-101)

4:00PM ► (1982) *Smoke Detection in Stationary Video Using Wavelets.* Preliminary report.
Helmut Knaust, The University of Texas at El Paso (1077-P5-2893)

MAA Session on the Mathematics of Sustainability

1:00 PM – 2:55 PM

Organizers: **Elton Graves**, Rose-Hulman Institute of Technology
Peter Otto, Willamette University

1:00PM ► (1983) *A Mathematics Course for Majors in Sustainable Living at the Level of Intermediate Algebra.*
M. Anne Dow, Maharishi University of Management (1077-H5-2830)

1:20PM ► (1984) *Embodied Energy, Energy Return on Investment, and Sustainability.*
Ben Fusaro, Florida State University (1077-H5-2896)

1:40PM ► (1985) *Nineteen Years Teaching Environmental Numeracy and Logic: Mathematics for the Environment.* Preliminary report.
Martin E. Walter, University of Colorado, Boulder (1077-H5-696)

2:00PM (1986) *Sustainability Project for Calculus I.*
Peter T Otto, Willamette University (1077-H5-2138)

2:20PM (1987) *Preventing the tragedy of the commons through punishment of over-consumers and encouragement of under-consumers.*
Irina Kareva, **Benjamin Morin**, Arizona State University, and **Georgy Karev***, NCBI, NIH (1077-H5-2000)

2:40PM ► (1988) *What's for Dinner: Linear Analysis of Nutritional Data and an Application to Community Health.* **Michael Ian Friedrich** and **Halcyon Annette Garrett***, University of North Carolina Asheville (1077-H5-2455)

MAA Session on the Philosophy of Mathematics and Mathematical Practice

1:00 PM – 4:55 PM

Organizers: **Dan Sloughter**, Furman University
Bonnie Gold, Monmouth University

1:00PM ► (1989) *The Consequences of Drawing Necessary Conclusions.* Preliminary report. **Daniel C. Sloughter**, Furman University (1077-K1-1196)

1:30PM ► (1990) *Thought in Mathematical Practice.* **Thomas Drucker**, University of Wisconsin–Whitewater (1077-K1-383)

2:00PM ► (1991) *Beyond Practicality: George Berkeley and the Need for Philosophical Integration in Mathematics.* **Joshua B. Wilkerson**, Texas A&M University (1077-K1-85)

2:30PM ► (1992) *Philosophy (but not philosophers) of mathematics does influence mathematical practice.* Preliminary report. **Bonnie Gold**, Monmouth University (1077-K1-2002)

3:00PM (1993) *Epistemological Culture and Mathematics.* Preliminary report. **Sarah-Marie Belcastro**, University of Massachusetts-Amherst / Smith College (1077-K1-1287)

3:30PM ► (1994) *How Do I (We) Know Mathematics.* **Ruggero Ferro**, UniversitÃ di Verona, Italia (1077-K1-904)

4:00PM ► (1995) *Formal mathematical proof and mathematical practice: a new skeptical problem.* Preliminary report. **Jeff Buechner**, Rutgers University-Newark and Saul Kripke Center, CUNY Graduate Center (1077-K1-800)

4:30PM ► (1996) *CDEG: Computerized Diagrammatic Euclidean Geometry.* **Nathaniel G. Miller**, University of Northern Colorado (1077-K1-1744)

MAA General Contributed Paper Session: Modeling and Applications of Mathematics, II

1:00 PM – 5:40 PM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

1:00PM ► (1997) *Modeling Wrist Oscillations Using Perturbation Methods.* Preliminary report. **Joe Latulippe***, Norwich University, and **Randy Sierra**, Cal Poly Pomona (1077-VG-1951)

1:15PM ► (1998) *Development of an Ozone Inhalation Model.* Preliminary report. **Andrew Kirby***, University of Wisconsin-Madison, **Analise Rodenberg**, Lewis & Clark College, **Andrew Bernstein**, University of Maryland College Park, and **Adrian McLean**, Fayetteville State University (1077-VG-1195)

1:30PM ► (1999) *Modeling Articular Cartilage Regeneration: A Phenomenological Approach.* Preliminary report. **Janine M. Haugh**, University of North Carolina at Asheville (1077-VG-2815)

1:45PM ► (2000) *Estimating the stiffness of healthy arteries via multi-dimensional secant method.* **Kun Gou**, Texas A&M University (1077-VG-1208)

2:00PM (2001) *The Mechanical Stability of Growing Arteries.* **Rebecca M Vandiver**, St. Olaf College (1077-VG-2241)

2:15PM ► (2002) *Non-Newtonian Effects on the Blood Pressure Drop in Atherosclerotic Right Coronary Arteries.* **Biyue Liu**, Monmouth University (1077-VG-689)

2:30PM (2003) *The effect of thrombin activatable fibrinolysis inhibitor (TAFI) in a multiscale mathematical model of fibrinolysis.* **Brittany E. Bannish***, **James P. Keener** and **Aaron L. Fogelson**, University of Utah (1077-VG-1131)

2:45PM (2004) *Methods for Reducing and Transforming Agent-Based Models into Polynomial Dynamical Systems.* **Franziska Hinkelmann**, **Matt Oremland**, Virginia Bioinformatics Institute, **Hussein Al-Asadi**, University of Michigan, **Atsya Kumano**, Colorado College, **Laurel Ohm***, St. Olaf College, **Alice Toms**, North Carolina State University, and **Reinhard Laubenbacher**, Virginia Bioinformatics Institute (1077-VG-473)

3:00PM (2005) *A three-dimensional mathematical and computational model of necrotizing enterocolitis.* Preliminary report. **Jared Barber***, **Mark Tronzo**, University of Pittsburgh, **Gilles Clermont**, Center for Inflam. and Reg. Modeling, McGowan Institute and Dept for Crit. Care Medicine, University of Pittsburgh, **Yoram Vodovotz**, Department of Surgery, University of Pittsburgh and Center for Inflam. and Reg. Modeling, McGowan Institute, and **Ivan Yotov**, University of Pittsburgh (1077-VG-1722)

3:15PM ► (2006) *Stochastic Modeling of Ribosomal Frameshifting.* **Brenae L. Bailey**, University of Arizona (1077-VG-1039)

3:30PM (2007) *A mathematical model of drug resistance with infection by health care workers.* **Avner Friedman**, Mathematical Biosciences Institute/ The Ohio State University, **Najat Ziyadi***, Morgan State University, and **Khalid Boushaba**, Johns Hopkins University (1077-VG-1455)

3:45PM ► (2008) *An improved mathematical model for dose-response of anticancer drug combinations at fixed schedule.* **Ardith El-Kareh**, University of Arizona, **Leslie Jones***, University of Tampa, and **Timothy Secomb**, University of Arizona (1077-VG-2082)

4:00PM ► (2009) *Cannibals and Mosquitos: Using a predator-prey epidemic model to search for a Dengue fever reservoir.* Preliminary report. **Lee R Gibson***, Indiana University - Southeast, and **Mary E Bradley**, University of Louisville (1077-VG-2661)

4:15PM (2010) *Inferring gang affiliation for violent events with incomplete data.* **Rachel Anne Hegemann***, **Erik Lewis** and **Andrea L. Bertozzi**, University of California, Los Angeles (1077-VG-2162)

4:30PM (2011) *A Mathematical Investigation of the Financial Performance of Movie Sequels.* **Ron Buckmire***, **Jacob Ortega-Gingrich**, Occidental College, and **David Edwards**, University of Delaware (1077-VG-1799)

4:45PM (2012) *Exploration of Stable Distributions.*
Catherine Rose O'Doherty, University of Mary Washington (1077-VG-1988)

5:00PM (2013) *Learning in three multi-player auctions.*
Delong Meng, Massachusetts Institutute of Technology (1077-VG-806)

5:15PM (2014) *Markov and Itō Representations of Option Price Models.* Preliminary report.
Kevin Coltin, Arizona State University (1077-VG-947)

5:30PM (2015) *Point process models for order arrival rates in order book dynamics.* Preliminary report.
He Huang, Florida State University (1077-VG-1558)

MAA General Contributed Paper Session: Research in Applied Mathematics, II

1:00 PM – 2:40 PM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

1:00PM (2016) *Intermittency and chaos near Hopf bifurcation with broken $O(2) \times O(2)$ symmetry.*
Yang Zou*, **Gerhard Dangelmayr** and **Iuliana Oprea**, Colorado State University (1077-VK-1683)

1:15PM (2017) *Modeling wave velocity and frequency spectra in low-temperature, compressed LJ lattices: HPC simulations, mathematical theory and applications to acoustic metrics.* Preliminary report.
Stephen H. Harnish, Bluffton University (1077-VK-2924)

1:30PM (2018) *Effective Acceleration of Gravity due to the Expanding Universe.*
Christopher Robert Frye* and **Costas Efthimiou**, University of Central Florida (1077-VK-2637)

1:45PM (2019) *Memory Effects for the Heat Conductivity of Random Suspensions of Spheres.*
Abhinandan Chowdhury, Delaware State University (1077-VK-2095)

2:00PM (2020) *The $(1+N)$-vortex problem: a study of inviscid and weakly viscous vortex relative equilibria.*
Anna M. Barry*, **Glen R. Hall** and **C. Eugene Wayne**, Boston University (1077-VK-1366)

2:15PM (2021) *The Dynamic Programming Equation for a Deterministic Optimal Control Problem.*
Jesus A. Pascal* and **Betsi J. Tirado**, American University of Afghanistan (1077-VK-2290)

2:30PM (2022) *Trajectory Controllability of Nonlinear Integro-differential System.*
Dimplekumar N. Chalishajar* and **Heena D. Chalishajar**, Virginia Military Institute (1077-VK-1060)

SIAM Minisymposium on Applied, Computational, and Discrete Mathematics at National Laboratories and Federal Research Agencies

1:00 PM – 6:25 PM

Organizers: **Zuhair Nasheed**
Luminita Vese, University of California Los Angeles

1:00PM (2023) *Non Standard Parabolic Equations and Image Reconstruction.* Preliminary report.
Alfred S. Carasso, NIST (1077-35-1644)

1:30PM (2024) *Splitting algorithms for nonconvex, matrix optimization.*
Rick Chartrand, Los Alamos National Laboratory (1077-49-2113)

2:00PM (2025) *Scalable Stochastic Programming for Optimization Under Uncertainty of Energy Systems.*
Mihai Anitescu*, **Cosmin Petra**, Argonne National Laboratory, **Miles Lubin**, University of Chicago, and **Victor Zavala**, Argonne National Laboratory (1077-90-1204)

2:30PM (2026) *Simulation-Based Optimization and Uncertainty Quantification Methods and Software at Sandia National Labs.*
Patricia D. Hough, Sandia National Laboratories (1077-68-1657)

3:00PM (2027) *Nonlinear Solvers in Large-Scale Computational Science: Challenges and Opportunities.*
Lois Curfman McInnes, Argonne National Laboratory (1077-35-2309)

3:30PM (2028) *Discrete Event Execution and Reversibility: Challenges in the Path to Asynchrony for Massively Parallel Computing.* Preliminary report.
Kalyan S Perumalla, Oak Ridge National Laboratory (1077-94-2457)

4:00PM (2029) *Constructing Interactive 3D Visualizations for the NIST Digital Library of Mathematical Functions.*
Bonita V. Saunders, National Institute of Standards and Technology (1077-33-1721)

4:30PM (2030) *Optimization-based Approaches to Singular Value and Eigenvalue Problems.*
Christopher G. Baker, Oak Ridge National Laboratory (1077-65-2066)

5:00PM (2031) *Scalable Methods for Characterizing and Generating Large Graphs.*
Ali Pinar*, **Seshadhri Comandur** and **Tammy Kolda**, Sandia National Laboratories (1077-68-1611)

5:30PM (2032) *Allele specific compatibility of interactions underlying yeast DNA repair phenotypes.* Preliminary report.
Yang Huang* and **Teresa M Przytycka**, National Center for Biotechnology Information, NLM/NIH (1077-92-2515)

6:00PM (2033) *Spreadsheets, Big Tables, and the Algebra of Associative Arrays.*
Jeremy Kepner, MIT Lincoln Laboratory (1077-05-1447)

NAM Granville-Brown-Haynes Session of Presentations by Recent Doctoral Recipients in the Mathematical Sciences

1:00 PM – 4:20 PM

1:00PM (2034) *On the Arithmetic and Geometry of Quaternion Algebras: a new spectral correspondence for Maass waveforms.*
Terrence R Blackman, Medgar Evers College, CUNY (1077-11-880)

1:30PM (2035) *Character sums and hyperelliptic curves associated with subsets of finite fields with square order.*
Lois Simon, Howard University (1077-11-1516)

2:00PM (2036) *Elements of Tensor Products of Ultrafilters on $\mathbb{N}$.* Preliminary report.
Vitaly Bergelson, Ohio State University, **Neil Hindman**, Howard University, and **Kendall Williams***, United States Military Academy (1077-22-1974)

2:30PM (2037) *Deriving Optimal Composite Scores: Relating Observational/Longitudinal Data with a Primary Endpoint.*
Rhonda D Ellis*, Norfolk State University, and **Chris Gennings**, Virginia Commonewealth Universty (1077-62-2037)

3:00PM (2038) *Bicircular Matroids with Circuits of at Most Two Sizes.*
Torina Deachune Lewis*, Bethune-Cookman University, **Talmage James Reid** and **Laura Sheppardson**, The University of Mississippi, Oxford (1077-05-2060)

3:30PM (2039) *Computationally Tractable Stochastic Integer Programming Models for Air Traffic Flow Management.*
Charles N Glover* and **Michael O Ball**, University of Maryland (1077-90-2182)

4:00PM (2040) *Mathematics You Won't Sleep on.*
Dennis A. Dean II, Boston (1077-92-2576)

MAA Committee on Two-Year Colleges Panel Discussion

1:00 PM – 2:20 PM

A new look at math for the non-STEM students.

Organizer: **Joanne Peeples**, El Paso Community College

Moderator: **Bruce Yoshiwara**, Los Angeles Pierce College

Panelists: **Kris Bishop**, University of Texas, Austin

Karon Klipple, Carnegie Foundation

Jane Muhich, Carnegie Foundation

AMS Special Session on Climate Modeling and Geophysical Fluid Dynamics, III

1:30 PM – 4:20 PM

Organizers: **Qingshan Chen**, Florida State University

Nathan Glatt-Holtz, Indiana University

Mickael Chekroun, University of California, Los Angeles

1:30PM (2041) *Energy Balance Climate Models with Bio-Feedback.*
Georg Hetzer, Auburn University (1077-35-734)

2:00PM (2042) *Well-posedness results for a nonlinear Stokes problem arising in Glaciology.*
Qingshan Chen, **Max Gunzburger** and **Mauro Perego***, Florida State University (1077-35-2855)

2:30PM (2043) *On the Global Well-posedness of a Simplified Reduced Rayleigh-Bénard Convection Model.*
Chongsheng Cao, Florida international University, **Aseel Farhat***, University of California, Irvine, and **Edriss S. Titi**, University of California, Irvine & The Weizmann Institute of Science, Israel (1077-76-1250)

3:00PM ► (2044) *Lie group analysis - a microscope of physical and engineering sciences.*
Ranis N Ibragimov, University of Texas at Brownsville (1077-35-712)

3:30PM ► (2045) *A Generalization of Contour Advection with Surgery for Three Dimensional Flows.* Preliminary report.
Zachary M Harrison* and **Peter Derek Bradshaw**, Arizona State University (1077-VG-2061)

4:00PM ► (2046) *A new staggering approach towards shallow water simulations.* Preliminary report.
Qingshan Chen*, Los Alamos National Laboratory, **Max Gunzburger**, Florida State University, and **Todd Ringler**, Los Alamos National Laboratory (1077-65-2219)

ASL Invited Address

2:15 PM – 3:05 PM

(2047) *Structures associated with real closed fields and real closed exponential fields.*
Julia F. Knight, University of Notre Dame (1077-03-155)

Rocky Mountain Mathematics Consortium Board of Directors Meeting

2:15 PM – 4:00 PM

MAA Presentations by Teaching Award Winners

2:30 PM – 3:50 PM

Organizers: **Barbara Faires**, Westminster College

Paul Zorn, Saint Olaf College

2:30PM ► (2048) *Unexpected Adventures and Undergraduate Research.*
Cindy Wyels, CSU Channel Islands (1077-A0-2744)

3:00PM ► (2049) *Teaching, Mentoring, and Advising Undergraduate Research: Lessons Learned On the Streets.*
Susan Loepp, Williams College (1077-A0-1847)

3:30PM ► (2050) *Learning to teach and teaching to learn.* Preliminary report.
Matthew E DeLong, Taylor University (1077-A0-2872)

AMS Committee on Science Policy Panel Discussion

2:30 PM – 4:00 PM

The changing landscape of research funding.

Speakers: **Subra Suresh**, National Science Foundation

MAA/Park City Mathematics Institute Panel Discussion

2:40 PM – 4:00 PM

Engaging secondary teachers in doing mathematics.

Organizer: **Gail Burrill**, Michigan State University

Panelists: **Brian Hopkins**, St. Peters College

James King, University of Washington

Brynja Kohler, Utah State University

Roger Knobel, University of Texas Pan American

Glenn Stevens, Boston University

ASL Invited Address

3:15 PM – 4:05 PM

(2051) *Randomness and ergodic theory.*
Johanna N.Y. Franklin, University of Connecticut (1077-03-153)

MAA Session on the History of Mathematics and Its Uses in the Classroom, I

3:20 PM – 5:35 PM

Organizer: **Amy Shell-Gellasch**, Beloit College

3:20PM (2052) *Newton Estimates the Natural Logarithm of 2: A History Lesson for Calculus II.* Preliminary report.
Martin E. Flashman, Humboldt State University (1077-E1-707)

3:40PM (2053) *Torricelli and Robinson play Gabriel's Trumpet.* Preliminary report.
Maureen T. Carroll*, **Steven Dougherty**, University of Scranton, and **David Perkins**, Luzerne County Community College (1077-E1-2390)

4:00PM (2054) *Bringing Sixteenth Century Mathematics into the Twenty-First Century Calculus Classroom.* Preliminary report.
Duane K Farnsworth, Clarion University of Pennsylvania (1077-E1-2668)

4:20PM (2055) *Google Books and the Long Tail of Mathematics.*
Scott B. Guthery, Docent Press (1077-E1-1174)

4:40PM (2056) *Astronomical Instruments Between Theory and Practice.*
Toke L Knudsen, SUNY Oneonta (1077-E1-592)

5:00PM (2057) *Euler's "Letters to a German Princess": Translation and Betrayal.*
Dominic W Klyve, Central Washington University (1077-E1-2271)

5:20PM (2058) *James Hamblin Smith's Euclid.*
Charles F. Rocca, Western Connecticut State University (1077-E1-2935)

MAA Minicourse #5: Part B

3:30 PM – 5:30 PM

Dance and mathematics.

Presenters: **Leon Harkleroad**, Bowdoin College
Karl Schaffer, De Anza College

MAA Minicourse #12: Part B

3:30 PM – 5:30 PM

Using randomization methods to build conceptual understanding of statistical inference.

Presenters: **Robin Lock**, St. Lawrence University
Patti Frazer Lock, St. Lawrence University
Kari F. Lock, Harvard University/Duke University
Eric F. Lock, University of North Carolina
Dennis F. Lock, Iowa State University

MAA Undergraduate Poster Session

3:30 PM – 5:30 PM

Organizer: **Joyati Debnath**, Winona State University

ASL Contributed Paper Session, I

4:15 PM – 6:15 PM

4:15PM (2059) *Martin's Maximum and Tower Forcing.*
Sean Cox, Universität Münster

4:40PM (2060) *Approximable functions and strong reducibilities.*
Jennifer Chubb Reimann*, University of San Francisco/Pennsylvania State University, and **Russell Miller**, Queens College and the Graduate Center, City University of New York

5:05PM (2061) *Reverse mathematics and dichotomy.*
Jeffry Hirst*, **François Dorais** and **Paul Shafer**, Appalachian State University

5:30PM (2062) *Complexity in the degrees of unsolvability of mass problems.*
Paul Shafer, Appalachian State University

5:55PM (2063) *The distance function on a computable graph.*
Wesley Calvert*, Southern Illinois University, **Jennifer Chubb**, Penn State University, and **Russell Miller**, Queens College and the Graduate Center, City University of New York

AMS Congressional Fellowship Session

4:30 PM – 6:30 PM

Organizer: **Samuel M. Rankin III**, American Mathematical Society

AMS-MAA-SIAM Special Event

4:30 PM – 6:00 PM

Forum for community input on the proposed NSF Division of Mathematical Sciences name change.

SIGMAA on Mathematics Instruction Using the Web Business Meeting, Reception, and Guest Lecture

5:00 PM – 6:15 PM

5:30PM (2064) *Examples of how mobile/Web technologies can impact how, when, where, what, and why students learn.*
Frank Wattenberg, U. S. Military Academy (1077-A0-49)

SIGMAA on Quantitative Literacy Business Meeting

5:00 PM – 6:00 PM

MAA Actuarial Science Panel Discussion

5:00 PM – 7:00 PM

Actuarial Science: Career milestones and choices.

Organizers: **Patrick Brewer**, Lebanon Valley College
Robert Buck, Slippery Rock University
Bettye Anne Case, Florida State University
Kevin Charlwood, Washburn University
Steve Paris, Florida State University

Moderators: **Bettye Anne Case**
Robert Buck

MAA Special Presentation: Poetry Reading

5:00 PM – 7:00 PM

All mathematical poets and those interested in mathematical poetry are invited.

Organizers: **JoAnne Growney**, Silver Spring, Maryland
Mark Huber, Claremont McKenna College

Gizem Karaali, Pomona College

Reception in Honor of Retiring MAA Executive Director Tina Straley

5:00 PM – 6:30 PM

SIGMAA on Mathematical and Computational Biology Business Meeting and Guest Lecture

6:00 PM – 7:45 PM

6:00PM Reception and business meeting.

7:00PM (2065) *Epidemiology of influenza strains: Competition, prediction, and associated mortality.*
Edward Goldstein, Harvard School of Public Health (1077-A0-46)

MAA Dramatic Presentation

6:00 PM – 7:00 PM

Mathematically Bent Theater.
Presenter: **Colin Adams**, Mobiusbandaid Theater Company

AMS Mathematical Reviews Reception

6:00 PM – 7:00 PM

NAM Cox-Talbot Address

7:30 PM – 8:15 PM

► (2066) *Creating Mathematical Scientists Among the Underrepresented.*
Sylvia T Bozeman, Spelman College (1077-00-434)

MAA-Project NExT Reception

8:30 PM – 10:00 PM

All Project NExT Fellows, consultants, and other friends of Project NExT are invited.
Organizers: **Judith Covington**, Louisiana State University, Shreveport
Joseph A. Gallian, University of Minnesota-Duluth
Aparna W. Higgins, University of Dayton
P. Gavin LaRose, University of Michigan

Saturday, January 7

MAA Minority Chairs Breakfast

7:00 AM – 10:00 AM

Joint Meetings Registration

7:30 AM – 2:00 PM

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, III

8:00 AM – 10:50 AM

Organizers: **Bernard Brooks**, Rochester Institute of Technology
Jobby Jacob, Rochester Institute of Technology
Jacqueline Jensen, Sam Houston State University
Darren A Narayan, Rochester Institute of Technology

8:00AM ► (2067) *Geometry of Surfaces with Density.*
Miguel A. Fernandez*, Truman State University, **Ping Ngai Chung**, MIT, **Niralee K. Shah**, Wiliams College, and **Luis A. Sordo Vieira**, Wayne State University (1077-51-1580)

8:30AM (2068) *A Survey of the Feasibility of Similarity Measures for use in Rigid Registration.*
John A.W.B. Costanzo* and **Nathan D. Cahill**, Rochester Institute of Technology (1077-65-2775)

9:00AM ► (2069) *Identification of Certain Parameters in Fourth Order Boundary Value Problems.*
Andrew N Zemke* and **Akhtar Khan**, Rochester Institute of Technology (1077-65-1405)

9:30AM ► (2070) *Differences of multiple Fibonacci numbers.*
Hannah Alpert, MIT (1077-11-1733)

10:00AM ► (2071) *A Tropical Proof of the Brill-Noether Theorem.*
Filip Cools, Katholieke Universiteit Leuven, **Jan Draisma**, Technische Universiteit Eindhoven, **Sam Payne**, Yale University, and **Elina Robeva***, Harvard University (1077-05-2803)

10:30AM ► (2072) *Gromov's knot distortion.*
John V Pardon, Stanford University (1077-53-2900)

AMS-MAA-MER Special Session on Mathematics and Education Reform, III

8:00 AM – 10:50 AM

Organizers: **William Barker**, Bowdoin College
William McCallum, University of Arizona
Bonnie Saunders, University of Illinois at Chicago

8:00AM ► (2073) *Math Anxiety: From Teacher to Student.*
Sian L. Beilock, Chicago, IL (1077-97-762)

8:30AM ► (2074) *Gender Differences in Mathematics: Facts from Recent Data.*
Janet E. Mertz*, University of Wisconsin – Madison, and **Jonathan M. Kane**, Univesity of Wisconsin – Whitewater (1077-97-1282)

9:00AM ► (2075) *Girls' Angle: A Math Club for Girls.*
C. Kenneth Fan, Girls' Angle (1077-97-1095)

9:30AM ► (2076) *Progress and Persistent Barriers for Women in Advanced Mathematics.*
Patricia Hale, Cal Poly Pomona (1077-97-1688)

10:00AM (2077) *Is STEM Still Just a Man's World? Awards and Prizes for Research in Disciplinary Societies Go Mainly to Men, Despite Growth in Women's Participation.*
Alice B. Popejoy* and **Phoebe S. Leboy**, Association for Women in Science (AWIS) (1077-00-1439)

10:30AM ► (2078) *Discussion: Participation of Girls and Women in Mathematics.* Preliminary report.
Cathy Kessel*, Berkeley, CA, **Bonnie Saunders**, University of Illinois at Chicago, **Maura Mast**, University of Massachusetts Boston, and **Tanya Leise**, Amherst College (1077-97-2493)

AMS-SIAM Special Session on the Mathematics of Computation: Algebra and Number Theory, III

8:00 AM – 10:50 AM

Organizers: **Jean-Marc Couveignes**, Université de Toulouse
Michael J. Mossinghoff, Davidson College
Igor E. Shparlinski, Macquarie University, Australia

8:00AM (2079) *Interesting families of algebraic curves.* **T. Shaska***, Oakland University, **L. Beshaj** and **V. Hoxha**, Research Institute of Science and Technology (1077-14-175)

8:30AM ► (2080) *An Application of Quasi-Inverse Rings.* **Harlan Kadish**, Texas A&M University (1077-13-409)

9:00AM (2081) *Lattice Cryptography and Pseudorandomness.* **Daniele Micciancio**, UCSD (1077-68-2091)

9:30AM (2082) *The Entropic Discriminant.* **Raman Sanyal**, Freie Universitat Berlin, **Bernd Sturmfels***, UC Berkeley, and **Cynthia Vinzant**, University of Michigan (1077-14-35)

10:00AM (2083) *On the computation of Galois Belyi maps.* **John Voight**, University of Vermont (1077-11-177)

10:30AM (2084) *Number Fields Unramified Away From 2.* **John W Jones**, Arizona State University (1077-11-182)

AMS Special Session on Algebraic and Geometric Aspects of Integrable Systems and Random Matrices, III

8:00 AM – 10:40 AM

Organizers: **Anton Dzhamay**, University of Northern Colorado
Kenichi Maruno, University of Texas, Pan American
Virgil Pierce, University of Texas, Pan American

8:00AM (2085) *Integrable n-field model on a triangular domain.* **Maxim Zyskin**, University of Texas, Brownsville (1077-35-2599)

8:30AM (2086) *Bilinearization of the Degasperis-Procesi equation.* **Baofeng Feng***, **Kenichi Maruno**, The University of Texas-Pan American, and **Yasuhiro Ohta**, Kobe University (1077-35-2568)

9:00AM (2087) *Coupled Maxwell-Bloch equations with inhomogeneous broadening for a 3-level system.* Preliminary report. **Mark J. Ablowitz**, CU Boulder, **Sarbarish Chakravarty**, Univ of Colorado at Colorado Springs, and **Barbara Prinari***, Univ of Colorado at Colorado Springs and Dept of Physics - Univ of Salento (Italy) (1077-35-1110)

9:30AM (2088) *On the Q4-elliptic Painleve equation and rational elliptic surfaces.* **Adrian Stefan Carstea**, Institute of Physics and Nuclear Engineering, P.O.Box, MG-6, Magurele, Bucharest, Romania (1077-39-1070)

10:00AM (2089) *Calogero-Moser curves and the geometry of the moduli space of curves.* **Samuel Grushevsky**, Stony Brook University (1077-14-654)

AMS Special Session on Arithmetic Geometry, III

8:00 AM – 10:50 AM

Organizers: **Bo-Hae Im**, Chung-Ang University, South Korea
Jennifer Johnson-Leung, University of Idaho
Jennifer Paulhus, Grinnell College

8:00AM (2090) *Simple Cubic Function Fields.* **Pieter Rozenhart**, University of Calgary, and **Jonathan Webster***, Bates College (1077-11-1566)

8:30AM (2091) *Conjugacy classes in GSp_4 and an application to the enumeration of abelian surfaces.* Preliminary report. **Cassie L Williams**, Colorado State University (1077-11-216)

9:00AM (2092) *Cyclic p-Extensions of $\mathbb{Z}_p$-Fields.* **Jordan Schettler**, University of Arizona (1077-11-1059)

9:30AM (2093) *Arithmetic Torelli maps for cubic surfaces and threefolds.* Preliminary report. **Jeffrey D Achter**, Colorado State University (1077-14-1246)

10:00AM (2094) *Rigid cohomology for algebraic stacks.* **David Zureick-Brown**, Emory University (1077-11-1861)

10:30AM (2095) *Far beyond Newton polygons.* **Joseph Rabinoff**, Harvard University (1077-14-1858)

AMS Special Session on Control of Biological and Physical Systems, I

8:00 AM – 10:50 AM

Organizers: **Wandi Ding**, Middle Tennessee State University
Volodymyr Hrynkiv, University of Houston-Downtown
Suzanne Lenhart, University of Tennessee, Knoxville, and NIMBioS

8:00AM ► (2096) *Reducing HIV Epidemic by Education and Treating it Using Optimal Control.* Preliminary report. **Hem Raj Joshi**, Xavier University, Cincinnati, OH (1077-49-2824)

8:30AM (2097) *Bang-bang Optimal Control of Continuous Time Species Augmentation.* **Erin N Bodine***, Rhodes College, and **Suzanne Lenhart**, University of Tennessee, Knoxville (1077-92-1716)

9:00AM (2098) *Long time behavior of Flow-Structure interactions arising in modeling of subsonic and supersonic flows of gas.* Preliminary report. **Irena M. Lasiecka*** and **Justin Webster**, University of Virginia (1077-35-664)

9:30AM (2099) *Linear and non-linear boundary stabilization in $L_2 \times H^{-1}$ of the system of dynamic elasticity with Dirichlet Boundary dissipation: a direct approach.* Preliminary report. **Jing Zhang*** and **Roberto Triggiani**, University of Virginia (1077-35-697)

10:00AM ► (2100) *A Local Approach for an Inverse Problem on a Semi-Axis.* **John V Matthews*** and **Boris Belinskiy**, University of Tennessee at Chattanooga (1077-35-826)

10:30AM (2101) *Determining Physical Parameters for a Neuronal Cable Model Defined on a Tree Graph.* **Sergei Avdonin***, University of Alaska Fairbanks, and **Jonathan Bell**, UMBC (1077-35-1808)

AMS Special Session on Fractal Geometry in Pure and Applied Mathematics (in memory of Benoit Mandelbrot), IV

8:00 AM – 10:50 AM

Organizers: **Michael L. Lapidus**, University of California, Riverside
Erin Pearse, University of Oklahoma
Machiel van Frankenhuijsen, Utah Valley University

8:00AM (2102) *Intersection property of fractals via Schmidt games.* **Ryan Broderick**, **Lior Fishman**, **Dmitry Kleinbock***, **Asaf Reich**, Brandeis University, and **Barak Weiss**, Ben Gurion University (1077-11-1050)

8:30AM (2103) *Hitting Probabilities and Packing Dimensions of the Random Covering Sets.* Preliminary report. **Bing Li**, South China University of Technology, **Narn-Rueih Shieh**, National Taiwan University, and **Yimin Xiao***, Michigan State University (1077-60-1556)

9:00AM ► (2104) *Lipschitz Equivalence of Cantor Sets.* **Yang Wang**, Michigan State University (1077-26-2606)

9:30AM (2105) *Exponential spectra in $L^2(\mu)$.* Preliminary report. **Xing-Gang He**, Central China Normal University, **Chun-Kit Lai** and **Ka-Sing Lau***, The Chinese University of Hong Kong (1077-46-1750)

10:00AM ► (2106) *Fractals and hyperbolicity.* Preliminary report. **Vadim Kaimanovich**, University of Ottawa (1077-37-2630)

10:30AM (2107) *Self-similar fractals as boundaries of networks.* **Erin P.J. Pearse**, University of Oklahoma (1077-60-2960)

AMS Special Session on Frontiers in Geomathematics, III

8:00 AM – 10:50 AM

Organizers: **Willi Freeden**, University of Kaiserslautern
Volker Michel, University of Siegen
M. Zuhair Nashed, University of Central Florida
Thomas Sonar, Technical University of Braunschweig

8:00AM (2108) *Multiscale simulations for Richards' equation in high-contrast media and applications.* **Yalchin Efendiev**, **Juan Galvis**, **Seul ki Kang*** and **Raytcho Lazarov**, Texas A&M University (1077-65-1770)

8:30AM (2109) *Stress field simulations in geothermal reservoirs.* Preliminary report. **Matthias Augustin**, University of Kaiserslautern (1077-74-1305)

9:00AM (2110) *Recent trends in Multi-parameter Regularization.* **Sergei Pereverzev**, Johann Radon Institute, Austrian Academy of Sciences (1077-65-1506)

10:00AM (2111) *Methods for the treatment of indirect noisy data.* **Bernd Hofmann**, Chemnitz University of Technology, Germany (1077-65-1314)

10:30AM (2112) *Maximum likelihood regularization of some inverse problems.* Preliminary report. **Paul P. B. Eggermont**, Food and Resource Economics, University of Delaware (1077-86-2173)

AMS Special Session on Homotopy Theory, II

8:00 AM – 10:50 AM

Organizers: **Mark Behrens**, Massachusetts Institute of Technology
Mark W. Johnson, Pennsylvania State University, Altoona
Haynes R. Miller, Massachusetts Institute of Technology
James Turner, Calvin College
Donald Yau, Ohio State University

8:00AM (2113) *Model structures for higher categories.* **Ricardo Andrade**, Stanford University (1077-55-1745)

8:30AM (2114) *Dendroidal sets and symmetric monoidal infinity categories.* Preliminary report. **Samuel Baruch Isaacson**, The University of Texas at Austin (1077-55-2269)

9:00AM (2115) *Categories of Modules and their Deformations.* **Romie Banerjee**, Tata Institute of Fundamental Research (1077-18-1908)

9:30AM (2116) *Weak n-categories are sheaves on $d \leq n$-manifolds.* Preliminary report. **David Hector Ayala**, Harvard University (1077-55-1274)

10:00AM (2117) *Manifolds, Higher Categories and Topological Field Theories.* **Nick Rozenblyum**, Northwestern University (1077-55-1490)

10:30AM (2118) *On the uniqueness of the homotopy theory of higher categories.* **Christopher J. Schommer-Pries**, Massachusetts Institute of Technology (1077-55-1982)

AMS Special Session on Mathematical Theory of Control of Quantum Systems, I

8:00 AM – 10:50 AM

Organizers: **Francesca Albertini**, University of Padua
Domenico D'Alessandro, Iowa State University
Raffaele Romano, University of Trieste
Francesco Ticozzi, University of Padua

8:00AM ► (2119) *Quantum Circuits at Nash Equilibrium.* **Faisal Shah Khan*** and **Simon J. D. Phoenix**, Khalifa University (1077-81-745)

8:30AM (2120) *Engineering Pointer States in Open Quantum Systems.* **Lorenza Viola**, Dartmouth College (1077-93-1544)

9:00AM (2121) *Encoded weak quantum Zeno effect for quantum computation and control.* **Gerardo A. Paz-Silva**, University of Southern California, **Ali T. Rezakhani**, Sharif University of Technology, Tehran, **Jason M. Dominy*** and **Daniel A. Lidar**, University of Southern California (1077-93-2078)

9:30AM (2122) *Stabilization of stochastic quantum dynamics via open and closed loop control.* **Francesco Ticozzi**, University of Padova and Dartmouth College (1077-93-619)

10:00AM (2123) *Real-time feedback control of a mesoscopic superposition.* **Kurt Jacobs***, **Justin Finn** and **Sai Vinjanampathy**, University of Massachusetts at Boston (1077-00-270)

10:30AM (2124) *Convergence of quantum random walks with decoherence.*
Sheng Xiong*, Edward Waters College, **Shimao Fan**, Temple University, **Zhiyong Feng**, Philadelphia, PA, and **Wei-Shih Yang**, Temple University (1077-81-1273)

AMS Special Session on Matrices and Graphs, I

8:00 AM – 10:50 AM

Organizers: **Leslie Hogben**, Iowa State University and American Institute of Mathematics
Bryan L. Shader, University of Wyoming

8:00AM (2125) *Zero Forcing Number and Maximum Nullity of Subdivided Graphs.*
Michael Young*, **Leslie Hogben**, Iowa State University, **My Huynh**, Arizona State University, **Kirill Lazebnik**, State University of New York at Geneseo, **Anna Cepek**, Bethany Lutheran College, **Travis Peters**, Iowa State University, and **Minerva Catral**, Xavier University (1077-05-1837)

8:30AM ► (2126) *The Inverse Inertia Problem for Graphs.*
Wayne Barrett, Provo (1077-15-2757)

9:00AM ► (2127) *Computing inertia sets of graphs using variations of zero forcing.* Preliminary report.
Jason Grout*, Drake University, **Steve Butler**, Iowa State University, and **Tracy Hall**, Provo, UT (1077-05-2621)

9:30AM (2128) *Refined Inertia of Sign Pattern Matrices.* Preliminary report.
Pauline van den Driessche, University of Victoria, B.C., Canada (1077-15-908)

10:00AM (2129) *The minimum semidefinite rank of the Heawood graph is 10.*
Louis Deaett, Quinnipiac University (1077-15-2809)

10:30AM (2130) *Unordered multiplicity lists of a class of binary trees.*
In-Jae Kim*, Minnesota State University, Mankato, and **Bryan L Shader**, University of Wyoming (1077-15-496)

AMS Special Session on My Favorite Graph Theory Conjectures, I

8:00 AM – 10:50 AM

Organizers: **Ralucca Gera**, Naval Postgraduate School
Craig Larson, Virginia Commonwealth University

8:00AM ► (2131) *On the nature of mathematical conjecture.*
Neil Robertson, Ohio State University, Columbus, and King Abdulahziz University, Jeddah, Saudi Arabia (1077-05-2361)

8:30AM ► (2132) *Powers of Strong Digraphs.*
Ping Zhang, Western Michigan University (1077-05-1217)

9:00AM (2133) *My Favorite Graph Coloring and Domination Conjectures.*
Stephen T. Hedetniemi, Clemson University (1077-05-1740)

9:30AM ► (2134) *The Δ^2 Conjecture for Graph Labellings with Separation Conditions.*
Jerrold R. Griggs, University of South Carolina (1077-05-1128)

10:00AM (2135) *Two Conjectures Involving Diameter and Total Domination in Graphs.*
Teresa W. Haynes, East Tennessee State University (1077-05-2226)

10:30AM ► (2136) *Some History on the Reconstruction Conjecture.* Preliminary report.
Allen J. Schwenk, Western Michigan University (1077-05-2021)

AMS Special Session on Noncommutative Birational Geometry and Cluster Algebras, II

8:00 AM – 10:50 AM

Organizers: **Arkady Berenstein**, University of Oregon
Vladimir Retakh, Rutgers University

8:00AM (2137) *Triangular bases in acyclic quantum cluster algebras.* Preliminary report.
Andrei Zelevinsky, Northeastern University (1077-13-1577)

9:00AM (2138) *Cluster structures on quantum coordinate ring.* Preliminary report.
Christof Geiss*, Universidad Nacional Autonoma de Mexico, **Bernard Leclerc**, Universite de Caen, and **Jan Schroeer**, University of Bonn (1077-16-2239)

10:00AM (2139) *Quantum Caldero-Chapoton Type Cluster Characters.*
Dylan Charles Rupel, University of Oregon (1077-81-2525)

10:30AM (2140) *Proof of a positivity conjecture by M. Kontsevich.*
Kyungyong Lee*, Wayne State University, and **Ralf Schiffler**, University of Connecticut (1077-05-1477)

AMS Special Session on Operator Theory on Analytic Function Spaces, I

8:00 AM – 10:50 AM

Organizers: **Robert F. Allen**, University of Wisconsin, La Crosse
Katherine C. Heller, North Central College
Matthew A. Pons, North Central College

8:00AM (2141) *Compact differences of composition operators in several variables.*
Katherine Heller, North Central College, **Barbara D. MacCluer***, University of Virginia, and **Rachel J. Weir**, Allegheny College (1077-47-1359)

8:30AM (2142) *Commutators of composition operators with adjoints of composition operators on weighted Bergman spaces.*
Sivaram K. Narayan, Central Michigan University (1077-47-380)

9:00AM (2143) *Closed-Range Composition Operators on Dirichlet type spaces.* Preliminary report.
Maria Tjani, University of Arkansas (1077-47-2314)

9:30AM (2144) *Boundedness and compactness of composition operators on Segal-Bargmann spaces.* Preliminary report.
Trieu L. Le, University of Toledo (1077-47-2190)

10:00AM (2145) *Weighted reproducing kernels and the Bergman space.*
Brent J Carswell and **Rachel J Weir***, Allegheny College (1077-30-328)

10:30AM (2146) *Norm of the multiplication operators from H^∞ to the Bloch Space of a bounded symmetric domain.*
Flavia Colonna*, George Mason University, **Glenn R. Easley**, System Planning Corporation, Arlington, Virginia, and **David Singman**, George Mason University (1077-47-1313)

AMS Special Session on Radon Transforms and Geometric Analysis (in honor of Sigurdur Helgason's 85th birthday), III

8:00 AM – 10:40 AM

Organizers: **Jens Christensen**, University of Maryland
Fulton Gonzalez, Tufts University
Todd Quinto, Tufts University

8:00AM (2147) *Splines for Radon transform on compact Lie groups with application to $SO(3)$.* **Swanhild Bernstein**, **Svend Ebert**, TU Bergakademie Freiberg, Institute of Applied Analysis, and **Isaac Z. Pesenson***, Temple University (1077-58-1102)

8:30AM (2148) *Schroedinger equation on certain compact symmetric spaces.* **Tomoyuki Kakehi**, Okayama University (1077-58-1528)

9:00AM (2149) *Counting lattice points on homogeneous spaces.* **Henrik Schlichtkrull**, University of Copenhagen (1077-22-1929)

10:00AM (2150) *Special geometries arising from some special symmetric spaces.* Preliminary report. **Robert J. Stanton***, Ohio State Univ., and **Marcus J. Slupinski**, Univ. Strasbourg (1077-22-2459)

AMS Special Session on Reaction Diffusion Equations and Applications, II

8:00 AM – 10:50 AM

Organizers: **Jerome Goddard II**, Auburn University Montgomery
Junping Shi, College of William and Mary
Ratnasingham Shivaji, University of North Carolina Greensboro

8:00AM (2151) *Existence of Positive Solutions For a Class of Semipositone Systems with Exponential Growth in R^2.* **Maya Chhetri***, UNC Greensboro, and **Petr Girg**, University of West Bohemia, Czech Republic (1077-35-2243)

8:30AM (2152) *Pattern Formation For Reaction Diffusion Systems On Arbitrary Surfaces.* **Necibe Tuncer**, University of Tulsa (1077-35-1927)

9:00AM (2153) *Two-Species Competition Model with Nonlocal Dispersal.* **Georg Hetzer***, Auburn University, **Tung Nguyen**, University of Illinois Springfield, and **Wenxian Shen**, Auburn University (1077-35-733)

9:30AM (2154) *Eigenvalue-curves and nonlinear boundary conditions for nonlinear elliptic equations.* **N. Mavinga**, Swarthmore College, and **M. N. Nkashama***, University of Alabama at Birmingham (1077-35-2255)

10:00AM (2155) *On the Variational Characterization of the Fucik Spectrum.* Preliminary report. **Stephen Robinson***, Wake Forest University, and **Pavel Drabek**, University of West Bohemia, Plzen, Czech. Rep. (1077-35-940)

10:30AM (2156) *Population models with diffusion, strong Allee effect, and nonlinear boundary conditions.* **Jerome Goddard II***, Auburn University Montgomery, **E. Lee**, Pusan National University, and **R. Shivaji**, University of North Carolina Greensboro (1077-35-420)

AMS Special Session on Recent Advances in Mathematical Biology, Ecology, and Epidemiology, II

8:00 AM – 10:50 AM

Organizers: **Sophia R. Jang**, Texas Tech University
Andrew L. Nevai, University of Central Florida
Lih-Ing W. Roeger, Texas Tech University

8:00AM (2157) *A Refuge-mediated Apparent Competition Model.* **Lih-Ing Wu Roeger***, Texas Tech University, and **Sze-Bi Hsu**, National Tsing Hua University, Taiwan (1077-92-1257)

8:30AM (2158) *Qualitative Assessment of the Roles of an Imperfect Vaccine and Pap Cytology Screening on the Transmission Dynamics of Human Papillomavirus.* **M. T. Malik***, Departments of Mathematics and Community Health Sciences, University of Manitoba, **J. Reimer**, Mathematical Institute, University of Oxford, Oxford, UK, **A. B. Gumel**, University of Manitoba, **E H Elbasha**, Merck Research Laboratories, North Wales, PA, USA, and **S. M. Mahmud**, Winnipeg Regional Health Authority, Winnipeg, Manitoba (1077-92-332)

9:00AM (2159) *Dispersal in heterogeneous landscape.* **Yuan Lou**, Ohio State University (1077-92-497)

9:30AM (2160) *Species abundance distributions in a stochastic niche model.* **Rosalyn C Rael***, Pacific Ecoinformatics and Computational Ecology Lab, **Annette Ostling**, University of Michigan, **Trevor Bedford**, University of Edinburgh, and **Rafael D'Andrea**, University of Michigan (1077-92-2845)

10:00AM ► (2161) *Climate-driven dynamics of seasonal influenza in the tropical regions.* Preliminary report. **Maria C.A. Leite***, University of Toledo, **Xiamgming Xiao**, Deartment of Botany and Microbiology, University of Oklahoma, and **Meijun Zhu**, University of Oklahoma (1077-34-603)

10:30AM (2162) *Persistence and Competitive Exclusion for a Nonautonomous Multi-Strain SIR Epidemic Model with Nonlinear Host Mortality.* Preliminary report. **Azmy S. Ackleh*** and **Paul Salceanu**, University of Louisiana at Lafayette (1077-92-1269)

AMS Special Session on Tensor Categories and Representation Theory, I

8:00 AM – 10:50 AM

Organizers: **Deepak Naidu**, Northern Illinois University
Dmitri Nikshych, University of New Hampshire

8:00AM ► (2163) *On the algebra of a class of finite-dimensional objects which accounts for some invariants of* 1-1 *tangles, knots, and links.* Preliminary report. **David E. Radford**, University of Illinois at Chicago (1077-16-1188)

8:30AM (2164) 3*-Dimensional Topology and Finite Tensor Categories.* **Noah Snyder***, Columbia University, **Christopher Douglas**, Oxford University, and **Christopher Schommer-Pries**, MIT (1077-17-390)

9:00AM (2165) *On an equivalence of categories of relative Yetter-Drinfeld modules.* **Istvan Heckenberger**, Philipps University Marburg (1077-81-984)

9:30AM (2166) *Ideals in Deligne's $\underline{Rep}(GL_\delta)$.*
Jonny Comes, Lewis and Clark College (1077-18-1607)

10:00AM (2167) *Forms of tensor categories over arbitrary fields.*
Pavel Etingof*, MIT, and **Shlomo Gelaki**, Technion (1077-18-447)

10:30AM (2168) *On Symmetric Tensor Categories.*
Shlomo Gelaki, Technion - I.I.T, Haifa, Israel (1077-16-1326)

AMS Special Session on Theory and Applications of Stochastic Differential and Partial Differential Equations, II

8:00 AM – 9:50 AM

Organizers: **Edward Allen**, Texas Tech University
Mahmoud Anabtawi, American University of Sharjah
Armando Arciniega, University of Texas at San Antonio
Gangaram S. Ladde, University of South Florida
Sivapragasam Sathananthan, Tennessee State University

8:00AM (2169) *Static and Dynamic Features of Liquid Crystal Films.*
Lei Z. Cheng, Purdue University (1077-35-938)

8:30AM (2170) *Derivation of system of SDEs for simple phylogenetic tree.*
Ummugul Bulut* and **Edward Allen**, Texas Tech University (1077-92-2189)

9:00AM (2171) *Existence of solutions for financial models with transaction costs and stochastic volatility.*
Indranil SenGupta, University of Texas- El Paso (1077-35-170)

9:30AM (2172) *Shooting Methods for Numerical Solution of Linear and Nonlinear Stochastic Boundary Value Problems.*
Armando Arciniega*, The Universtity of Texas at San Antonio, and **Edward Allen**, Texas Tech University (1077-60-1842)

AMS Special Session on Uniformly and Partially Hyperbolic Dynamical Systems, III

8:00 AM – 10:40 AM

Organizers: **Todd Fisher**, Brigham Young University
Boris Hasselblatt, Tufts University

8:00AM (2173) *Invariant Sets of Hyperbolic Toral Automorphisms.*
Skyler C Simmons, Brigham Young University (1077-37-1330)

8:30AM (2174) *Anosov diffeomorphisms constructed from $\pi_k(\mathrm{Diff}(\mathbf{S^n}))$.*
Tom Farrell and **Andrey Gogolev***, SUNY Binghamton (1077-37-944)

9:00AM (2175) *Local rigidity for Anosov automorphisms.*
Andrey Gogolev, Binghamton University, **Boris Kalinin*** and **Victoria Sadovskaya**, University of South Alabama (1077-37-1189)

9:30AM (2176) *Cohomology of $GL(2,\mathbb{R})$-valued cocycles over hyperbolic systems.*
Victoria Sadovskaya, University of South Alabama (1077-37-1258)

10:00AM (2177) *Actions of higher rank abelian groups: from measure rigidity to arithmeticity to topology.*
Anatole Katok, Pennsylvania State University (1077-37-2555)

AMS Session on Associative and Nonassociative Algebras and Rings: Homological Algebras and Category Theory, II

8:00 AM – 10:10 AM

8:00AM (2178) *Cartan Type Lie Superalgebra $\widetilde{S}(n)$ over a Field of Positive Characteristic.*
Qiang Mu, Harbin Normal University, China (1077-17-1576)

8:15AM (2179) *Equivalent Condition of Primitivity for Semifields.*
linlin Chen* and **Minerva Cordero**, University of Texas at Arlington (1077-17-1432)

8:30AM (2180) *Equivalence Classes of Subquotients of Pseudodifferential Operator Modules on the Line.* Preliminary report.
Jeannette Mun Larsen, University of North Texas (1077-17-1762)

8:45AM (2181) *Maximal weights and multiplicities of certain $\widehat{sl}(n)$-modules.*
Rebecca L. Jayne*, Washington College, and **Kailash C. Misra**, North Carolina State University (1077-17-63)

9:00AM (2182) *Ring maps, derived categories, and the Bousfield Lattice.*
Luke Wolcott, University of Washington (1077-18-893)

9:15AM ► (2183) *Coherence of canonically-defined natural transformations in the derived category of ℓ-adic sheaves.*
Ryan Cohen Reich, UCLA (1077-18-2289)

9:30AM (2184) *The stable derived category of a polynomial ring in two variables modulo the quadratic forms.* Preliminary report.
Daniel A. Bravo Vivallo, University of Southern Maine (1077-18-1623)

9:45AM (2185) *The projective stable derived category of a ring.* Preliminary report.
James Gillespie, Ramapo College (1077-18-1656)

10:00AM (2186) *Finite generation of the cohomology of quotients of a PBW algebra.*
Piyush Ravindra Shroff, Texas A&M University (1077-18-1052)

AMS Session on Combinatorics and Graph Theory, VII

8:00 AM – 10:25 AM

8:00AM ► (2187) *Log-concavity of the Partition Function.* Preliminary report.
Janine E. Janoski*, **Neil J. Calkin**, **Brian Bowers**, Clemson University, **Kerry Gannon**, Nazareth College, **Katie Jones**, University of Kentucky, and **Anna Kirkpatrick**, University of South Carolina (1077-05-914)

8:15AM ► (2188) *Minimum Clique Number, Chromatic Number, and Ramsey Numbers.*
Gaku Liu, Princeton University (1077-05-1042)

8:30AM ► (2189) *3-shuffles of permutations.* Preliminary report.
Camillia Smith Barnes, Sweet Briar College (1077-05-1126)

8:45AM (2190) *Codes of compositions.*
John T. Hird*, **Naihuan Jing** and **Ernest Stitzinger**, North Carolina State University (1077-05-989)

9:00AM ► (2191) *Parallel Double Rule Application in Signed Graphs.*
Margaret Meyerhofer, Carnegie Mellon University (1077-05-967)

9:15AM (2192) *Combination of ordered trees associated with nonnegative integer sequences.*
Hana Kim*, **Gi-Sang Cheon**, Sungkyunkwan University, and **L. W. Shapiro**, Howard University (1077-05-1811)

9:30AM ► (2193) *h-vectors of small matroid complexes.*
Jesus A DeLoera, **Yvonne Kemper** and **Steven Klee***, UC Davis (1077-05-997)

9:45AM ► (2194) *Subtraction-Division Games, Patterns, and Self-similarity.*
Elizabeth J. Kupin, Rutgers University (1077-05-913)

10:00AM (2195) *Part Products of Random S-Restricted Compositions.*
Caroline Shapcott, Drexel University (1077-05-754)

10:15AM (2196) *Restricted rooted non-separable planar maps.* Preliminary report.
Sergey Kitaev, University of Strathclyde, Department of Computer and Information Sciences, **Pavel Salimov**, Sobolev Institute of Mathematics SB RAS, **Christopher Clark Severs**, Arizona State University, and **Henning Arnor Ulfarsson***, Reykjavik University, School of Computer Science (1077-05-1823)

AMS Session on Geometry and Differential Geometry, II

8:00 AM – 9:40 AM

8:00AM ► (2197) *Ford Circles and Spheres.* Preliminary report.
Sam Northshield, SUNY-Plattsburgh (1077-51-2722)

8:15AM (2198) *The Kähler-Ricci flow, the Mabuchi metric, and the existence of Kähler-Einstein metrics.*
Donovan C. McFeron, Ramapo College of New Jersey (1077-53-149)

8:30AM ► (2199) *Curve Matching via Discrete Invariants.* Preliminary report.
Susan B Crook, North Carolina State University (1077-53-2155)

8:45AM (2200) *Metric Fibrations from Simply Connected Rank - One Projective Spaces.* Preliminary report.
Richard H. Escobales,Jr., Canisius College (1077-53-1365)

9:00AM ► (2201) *Rectifying Viviani curves.* Preliminary report.
Scott J Simmons, Drury University (1077-53-1756)

9:15AM (2202) *A Model Category Structure on Smooth Spaces.*
Dan Christensen and **Enxin Wu***, the University of Western Ontario (1077-53-2470)

9:30AM (2203) *An example of a wild geometric structure.* Preliminary report.
Stanislav Dubrovskiy*, MSRI, and **Mikhail Shubin**, Northeastern University (1077-53-2596)

AMS Session on Mathematical Logic, and Ordered and General Algebraic Structures

8:00 AM – 9:40 AM

8:00AM ► (2204) *A logical analysis of the Monty Hall problem.*
Allen L. Mann, Colgate University (1077-03-1980)

8:15AM ► (2205) *Beatty Sequences and Exponential Complexity Issues.* Preliminary report.
Iraj Kalantari and **Mojtaba Moniri***, Western Illinois University (1077-03-2911)

8:30AM (2206) *Nilpotence in Groups with Bounded Chains of Centralizers.*
Paul Baginski*, Smith College, and **Tuna Altinel**, Universite Lyon 1 (1077-03-2750)

8:45AM ► (2207) *Finding Factors of Factor Rings over the Eisenstein Integers.* Preliminary report.
Valmir Bucaj, Texas Lutheran University (1077-08-382)

9:00AM (2208) *The Order Dimension and Coloring of Planar Point Sets.*
Jonathan E Beagley, George Mason University (1077-06-1035)

9:15AM ► (2209) *A new description of the Bruhat-Chevalley order on Gauss-Jordan elements in the Renner monoid.* Preliminary report.
Ryan K Therkelsen, Bellarmine University (1077-06-1800)

9:30AM (2210) *The Algebraic Lattice of Algebraic Closure Operators.*
Martha Lee Hollist Kilpack, Binghamton University (1077-06-1934)

AMS Session on Number Theory, Field Theory, and Polynomials, III

8:00 AM – 9:40 AM

8:00AM (2211) *Dihedral p-adic fields.*
Chad Awtrey, Elon University (1077-11-1766)

8:15AM (2212) *Selectivity in Quaternion Algebras.*
Benjamin Linowitz, Dartmouth College (1077-11-533)

8:30AM (2213) *Symbolic evaluation of log-sine integrals in polylogarithmic terms.*
Jonathan M. Borwein, University of Newcastle, NSW Australia, and **Armin Straub***, Tulane University (1077-11-487)

8:45AM (2214) *Almost Universal Inhomogeneous Quadratic Forms.*
Anna R Haensch, Wesleyan University (1077-11-132)

9:00AM (2215) *A Set of Quadratic Equations For Factoring or Primality Determination of odd 6*n + or -1 Type Odd Integers.*
L J Balasundaram, Cambridge, Massachusetts (1077-11-96)

9:15AM (2216) *Asymptotics for polynomials from integer partitions.*
Robert P Boyer, Drexel University (1077-11-1970)

9:30AM (2217) *Making imprimitive characters behave primitively.*
Ryan C Daileda*, Trinity University, and **Nathan C Jones**, University of Mississippi (1077-11-2476)

AMS Session on Partial Differential Equations, II

8:00 AM – 9:55 AM

8:00AM (2218) *Slow Drift and Fast Asynchronous Oscillatory Instabilities of Spike Patterns in a One-Dimensional Singularly Perturbed Brusselator Model.*
Justin C Tzou*, Northwestern University, **Yana Nec** and **Michael J Ward**, University of British Columbia (1077-35-1151)

8:15AM (2219) *Mixed Boundary Value Problem for Quasilinear Elliptic Equations.* Preliminary report.
Chunquan Tang* and **Gary M. Lieberman**, Iowa State University (1077-35-1081)

8:30AM (2220) *Schur Complements and Block Preconditioners for Coupled Diffusion Systems.* Preliminary report.
Geoffrey Robert Wienefeld Dillon, Texas Tech University (1077-35-2421)

8:45AM (2221) *The 2D Boussinesq equations with partial viscous dissipation.*
Dhanapati Adhikari*, Marywood Univeersity, and **Jiahong Wu**, Oklahoma State University (1077-35-2232)

9:00AM (2222) *The Nonlinear Klein-Gordon Equation and Average Variational Principle.*
Lokenath Debnath, The University of Texas - Pan American (1077-35-927)

9:15AM ► (2223) *Extended fifth-order KdV type equations.*
Netra P Khanal, The University of Tampa (1077-35-882)

9:30AM (2224) *Nonlinear multi-integrable couplings with Hamiltonian structures.*
Wen-Xiu Ma, University of South Florida (1077-35-604)

9:45AM (2225) *Hölder continuity of a bounded weak solution of generalized parabolic $p-$Laplacian type equations.* Preliminary report.
Sukjung Hwang* and **Gary Lieberman**, Iowa State University (1077-35-106)

MAA Session on Trends in Teaching Mathematics Online, I

8:00 AM – 10:55 AM

Organizer: **Michael B. Scott**, California State University, Monterey Bay

8:00AM ► (2226) *Implications for learning transition level mathematics using a distance delivery model.* Preliminary report.
Ronald L Merritt, Athens State University (1077-O5-94)

8:20AM ► (2227) *An Analysis of 4 College Algebra Classes With or Without Computer Software Support.*
Bonnie L. Oppenheimer, Mississippi University for Women (1077-O5-195)

8:40AM ► (2228) *On Synchronous Distance Teaching in a Mathematics MS Program.* Preliminary report.
Kuiyuan Li*, **Raid Amin** and **Josphat Uvah**, University of West Florida (1077-O5-231)

9:00AM ► (2229) *Students' Attitude Toward Assessment of on-Line Learning of College Algebra and Intermediate Algebra.*
A. S. Elkhader, Northern State University (1077-O5-350)

9:20AM ► (2230) *Exploring the Effect of Using Technology on the online Learning of Algebra.*
Bashar Zogheib, American University of Kuwait (1077-O5-1167)

9:40AM ► (2231) *Expanding Redesign Success.* Preliminary report.
Elizabeth A Eagle, University of North Carolina at Charlotte, NC (UNCC) (1077-O5-2122)

10:00AM ► (2232) *Teaching a General Education Math Course Online with Discussion boards and a Screencast system.*
James Baglama, University of Rhode Island (1077-O5-2044)

10:20AM ► (2233) *On WeBWork: how to Design a Model Course that is Concise and Complete?* Preliminary report.
Shumei C Richman, Columbia, SC (1077-O5-1914)

10:40AM (2234) *Online PREP Workshops: The experience of teaching online professional development courses in mathematics.*
Mike May, Saint Louis University (1077-O5-1221)

MAA Session on the History of Mathematics and Its Uses in the Classroom, II

8:00 AM – 10:55 AM

Organizer: **Amy Shell-Gellasch**, Beloit College

8:00AM ► (2235) *The History of Irrational and Transcendental Numbers; Classroom Benefits.*
Charlie L Smith, Park University (1077-E1-2677)

8:20AM ► (2236) *A President, A. Partridge, and Practical Mathematics.* Preliminary report.
Dick Jardine, Keene State College (1077-E1-2008)

8:40AM ► (2237) *Exploring Prime Numbers in Classes with Preservice and Inservice Teachers.*
Jim Fulmer* and **Tom McMillan**, University of Arkansas at Little Rock (1077-E1-1053)

9:00AM ► (2238) *Mayan Geometry in the Classroom.* Preliminary report.
Cynthia J. Woodburn, Pittsburg State University (1077-E1-441)

9:20AM ► (2239) *When a Number System Loses Uniqueness: The Case of the Maya.* Preliminary report.
Amy Shell-Gellasch*, Beloit College, Beloit WI, and **Pedro Freitas**, FCUL Universidade de Lisboa (1077-E1-562)

9:40AM ► (2240) *Could they have known it generalized? could they? Giving credit where credit probably due.* Preliminary report.
Steven R Benson, Lesley University (1077-E1-2233)

10:00AM ► (2241) *Putting Mathematics Education Controversies in Historical Context.*
H. Smith Risser, Montana Tech (1077-E1-2108)

10:20AM ► (2242) *Number theory à la Sophie Germain: a course of guided discovery from her research manuscripts on Fermat's Last Theorem.*
David J. Pengelley, New Mexico State University (1077-E1-627)

10:40AM ► (2243) *A Partial Examination of the Evolution of Structural Design.*
Patricia Williams* and **Elizabeth C. Rogers**, Piedmont College (1077-E1-2857)

MAA Session on the Mathematical Preparation of Teachers: The Impact of the Common Core State Standards Initiative, I

8:00 AM – 10:55 AM

Organizers: **Kenneth C. Millett**, University of California, Santa Barbara
Elizabeth Burroughs, Montana State University
Holly Peters Hirst, Appalachian State University
William McCallum, The University of Arizona

8:00AM ► (2244) *Aligning the Self-Efficacy to Teach Statistics (SETS) Instrument to the Common Core State Standards for Mathematics.*
Leigh M. Harrell Williams*, Virginia Tech, **Teri J. Murphy**, Norhtern Kentucky University, **M. Alejandra Sorto**, Texas State University - San Marcos, **Rebecca L. Pierce**, Ball State University, and **Lawrence M. Lesser**, The University of Texas at El Paso (1077-F5-979)

8:20AM (2245) *Uncovering and Discovering: CCSS Mathematical Process Standards in a Mathematics Course for Middle School Teachers.*
Teresa D Magnus*, Rivier College, Nashua NH, and **Ann Gaffney**, River College and Londonderry Middle School (1077-F5-222)

8:40AM ► (2246) *Using Video Excerpts from Authentic Mathematics Classrooms to Demonstrate the Mathematical Practices at Various Grade Levels.* Preliminary report.
Taliesin Sutton* and **Nicole Kersting**, University of Arizona (1077-F5-2914)

9:00AM ► (2247) *Using Experience from the Past to Move Forward to the Common Core State Standards.*
Elizabeth C. Rogers, Piedmont College (1077-F5-2908)

9:20AM ► (2248) *Advanced Teacher Capacity in Mathematics and the Common Core.*
Gregory D Foley, Ohio University (1077-F5-2643)

9:40AM ► (2249) *Enhancing the content knowledge of pre-service secondary mathematics teachers: Understanding connections.*
Yating Liu, The Ohio State University (1077-F5-2087)

10:00AM (2250) *Inquiry-Based Courses at UAB for Prospective Elementary and Middle School Teachers Modeling the Standards for Mathematical Practice.*
Tommy Smith*, **John C Mayer** and **Donna Ware**, University of Alabama at Birmingham (1077-F5-2050)

10:20AM (2251) *Developing Teachers' Flexibility in Geometry: Addressing the CCSS Mathematics Objectives.*
Tanya Berezovski, St. Joseph's University, Philadelphia, PA (1077-F5-859)

10:40AM (2252) *Updating the CBMS report on the mathematical education of teachers and the Common Core.*
William McCallum, The University of Arizona (1077-F5-2955)

MAA General Contributed Paper Session: Assorted Topics, I

8:00 AM – 10:55 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:00AM ► (2253) *Investigations of the Riemann Hypothesis - Three Independent Confirmations.*
Donald Leigh Hitzl*, Lockheed-Martin Advanced Technology Center, and **Frank Zele**, Lockheed-Martin Solar and Astrophysics Laboratory (1077-VL-22)

8:15AM (2254) *Exposed and strongly exposed points in symmetric spaces of measurable operators.*
Malgorzata M Czerwinska, University of Mississippi (1077-VL-2545)

8:30AM (2255) *Apriori bounds and maximum principles for some higher order nonlinear pdes.*
Anita Mareno, Penn State Harrisburg (1077-VL-392)

8:45AM ► (2256) *"Resistance" is Futile: Understanding the Effect of Resistance in Physical Systems.*
Perry Y.C. Lee, Kutztown University of Pennsylvania (1077-VL-1892)

9:00AM ► (2257) *What Does the Normality Test Indicate About the Coverage Probability of the One Sample t-based Confidence Interval?* Preliminary report.
Daniel J. Ghezzi, King's College, Wilkes-Barre, Pa. (1077-VL-1997)

9:15AM ► (2258) *Modeling Examination scores with the Wakeby Distribution.*
Bernard Beecher, Bmcc/CUNY-The City University of New York (1077-VL-1947)

9:30AM ► (2259) *Jensen's Inequality Versus Algebra in Finding the Exact Maximum.*
Mohammad K Azarian, University of Evansville (1077-VL-610)

9:45AM (2260) *Asymptotic Behavior of some Strodt Polynomials.*
Timothy B. Flowers, Indiana University of Pennsylvania (1077-VL-2411)

10:00AM ► (2261) *Wilf's conjecture.*
Tewodros Amdeberhan, Tulane University, **Valerio De Angelis***, Xavier University of Louisiana, and **Victor Moll**, Tulane University (1077-VL-2526)

10:15AM ► (2262) *The Algebraic Thinking Project and the Encyclopedia of Algebraic Thinking.* Preliminary report.
Steve Rhine and **Colin Starr***, Willamette University (1077-VL-2001)

10:30AM ► (2263) *Using Screen Capture Video to Aid Instruction.*
Pat Kiihne, Illinois College (1077-VL-942)

10:45AM ► (2264) *Communication: The Success to Online Courses.* Preliminary report.
Edward D. Smith, Pima Community College (1077-VL-2921)

MAA General Contributed Paper Session: Assorted Topics, II

8:00 AM – 10:55 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:00AM (2265) *Into the deep end of the mathematical pool: some preliminary experiences teaching with IBL.*
Kayla Bradley Dwelle*, Ouachita Baptist University, and **Ruth A. Enoch**, Arkansas Tech University (1077-VL-1930)

8:15AM ► (2266) *Contradictions in the Common Core State Standards: Problems and a possible solution.*
Patricia Baggett*, New Mexico State University, and **Andrzej Ehrenfeucht**, University of Colorado at Boulder (1077-VL-347)

8:30AM ► (2267) *Mathematics Teacher Preparation in Shanghai for Grades 1-9.*
Hong Yuan*, The City University of New York, and **Xinsheng Lu**, Shanghai Normal University (1077-VL-2389)

8:45AM ► (2268) *Hua Loo-keng's Movement of Popularizing Mathematics and Quantitative Literacy (1958 to 1985).*
Jean W. Richard* and **Hong Yuan**, BMCC CUNY The City University of New York (1077-VL-2557)

9:00AM ► (2269) *Status, Interaction, and Undergraduate Mathematics in Nigeria: A VLP Experience.*
Martha Byrne, University of New Mexico (1077-VL-346)

9:15AM (2270) *Perceptions of Turkish High School Mathematics Teachers Regarding the 2005 Curricular Changes and Their Effects on Mathematical Proficiency and University Entrance Exam Preparation.* Preliminary report.
S Nihan Er, Ohio University (1077-VL-2859)

9:30AM ► (2271) *Native American-based Mathematics Materials for Undergraduate Courses.* Preliminary report.
Charles Peter Funkhouser*, **Scott A. Annin**, California State University Fullerton, and **Miles Pfahl**, Turtle Mountain Community College, Belcourt, ND (1077-VL-2826)

9:45AM ► (2272) *Project SOAR: Providing Low-Income, First-Generation, Underrepresented STEM Students Comprehensive Support for Success.*
Heather A Bullen, **Kristi L Haik** and **Gail Mackin***, Northern Kentucky University (1077-VL-492)

10:00AM ► (2273) *Recruitment and Retention of First Generation Mathematics Majors.*
Elizabeth K. Mauch, Bloomsburg University of Pennsylvania (1077-VL-500)

10:15AM ► (2274) *"Leading Disadvantaged Students to Success in Mathematics" —- A midterm report of our S-STEM funded project.* Preliminary report.
Zhanbo Yang*, **F G Wukovits**, **A. Daniel** and **J. Beltrami**, University of the Incarnate Word (1077-VL-639)

10:30AM ► (2275) *Mentoring and Networking Mathematics and Science Majors in Applying Mathematics.* Preliminary report.
Frederick A. Adkins* and **Yu-Ju Kuo**, Indiana University of Pennsylvania (1077-VL-2895)

10:45AM (2276) *Mentoring Junior Faculty: A Formula for Success.*
Jenna P. Carpenter, Louisiana Tech University (1077-VL-982)

MAA General Contributed Paper Session: Research in Algebra and Topology

8:00 AM – 10:55 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:00AM ► (2277) *Finite Type Knot Invariants.* Preliminary report.
Lena Folwaczny, Univesity of Illinois, Chicago (1077-VJ-2832)

8:15AM ► (2278) *The Coefficient Space of Polynomial Knots.*
Lee Stemkoski, Adelphi University (1077-VJ-2199)

8:30AM ► (2279) *Adding Complexity to Playing Tic-Tac-Toe.* Preliminary report.
Mary J Riegel, University of Montana (1077-VJ-2664)

8:45AM (2280) *On global invariants of fibrations of smooth complete intersections.*
James A Fullwood, Florida State University (1077-VJ-2579)

9:00AM (2281) *Regular Graded Skew Clifford Algebras of Low Global Dimension.*
Manizheh Nafari, University of Texas at Arlington (1077-VJ-2505)

9:15AM (2282) *Global Weyl modules for twisted loop algebras.*
Nathaniael J Manning*, University of California, Riverside, **Ghislain Fourier**, Mathematisches Institut, Universität zu Köln, Germany, and **Prasad Senesi**, The Catholic University of America (1077-VJ-2133)

9:30AM (2283) *BGG reciprocity for the current algebra of* $\mathfrak{sl}_2$.
Matthew L. Bennett*, **Nathaniael J. Manning** and **Vyjayanthi Chari**, University of California, Riverside (1077-VJ-2118)

9:45AM (2284) *On Fourier-Mukai type functors.* Preliminary report.
Alice Rizzardo, Columbia University (1077-VJ-2247)

10:00AM (2285) *Improving the Consistency Strength of Reflection at* $\aleph_{\omega+1}$.
Zachary Paul Faubion, University of California, Irvine (1077-VJ-2838)

10:15AM ► (2286) *Compactness properties of the second uncountable cardinal.*
Sean D. Cox, University of Münster (1077-VJ-2762)

10:30AM ► (2287) *Creating Separation in Topological Spaces.*
Jay R. Stine, Misericordia University (1077-VJ-552)

10:45AM (2288) *Lusternik–Schnirelmann Category and the connectivity of* X.
Nicholas A Scoville, Ursinus College (1077-VJ-2933)

MAA General Contributed Paper Session: Research in Graph Theory and Combinatorics

8:00 AM – 10:55 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:00AM (2289) *On the Limiting Distribution of Eigenvalues of Large Random d-Regular Graphs with Weighted Edges.*
Michael Cap Khoury*, University of Michigan – Ann Arbor, and **Steven J Miller**, Williams College (1077-VJ-636)

8:15AM (2290) *Necessary Spectral Conditions for 2-coloring Regular 3-uniform Hypergraphs.*
Franklin H.J. Kenter, University of California, San Diego (1077-VJ-2586)

8:30AM (2291) *Cops and Robber on the hypercube.* Preliminary report.
David Offner, Westminster College (1077-VJ-2398)

8:45AM (2292) *Randomly Altering Graphs via Vertex Switching.*
Jacob Hughes, University of California - San Diego (1077-VJ-2236)

9:00AM ► (2293) *Virus Dynamics in Star Graphs.*
Alexander Greaves-Tunnell*, Williams College, **Thealexa Becker**, Smith College, **Aryeh Kontorovich**, Ben Gurion University, **Steven Miller**, Williams College, **Pradeep Ravikumar**, University of Texas, Austin, and **Karen Shen**, Stanford University (1077-VJ-2175)

9:15AM ► (2294) *The Firefighter Problem for Directed Grids.*
Daniel P. Biebighauser, Concordia College, Moorhead, MN (1077-VJ-1695)

9:30AM ► (2295) *Total Efficient Domination in Cayley Graphs.* Preliminary report.
Keegan C. Gary*, **Mari Castle** and **Joe DeMaio**, Kennesaw State University (1077-VJ-924)

9:45AM (2296) *The Characteristic Polynomial for Bi-Rooted Trees.*
Steven J. Tedford, Misericordia University, Dallas PA. (1077-VJ-553)

10:00AM ► (2297) *Combinatorial Interpretations of Congruences for the spt-function.*
George E Andrews, Pennsylvania State University, **Frank G Garvan**, University of Florida, and **Jie L. Liang***, University of Central Florida (1077-VJ-2404)

10:15AM ► (2298) *Counting the Number of Invalid Reductions of Fractions - How "Weird" are "Weird" Fractions?*
Ryan Stuffelbeam, Transylvania University (1077-VJ-2384)

10:30AM ► (2299) *How Many Unique 4 by 4 Natural Magic Squares are There?* Preliminary report.
Peter Staab* and **Jared Weed**, Fitchburg State University (1077-VJ-2337)

10:45AM (2300) *Thompson's Group and the Four Color Theorem.*
Garry S. Bowlin, SUNY Oneonta (1077-VJ-2096)

SIAM Minisymposium on Recent Advances in Fluid Dynamics and Turbulence Models

8:00 AM – 10:55 AM

Organizer: **Edriss Titi**, University of California Irvine

8:00AM (2301) *On the wellposedness of the Navier-Stokes-Maxwell system.*
Slim Ibrahim*, University of Victoria, BC, Canada, and **Nader Masmoudi**, Courant Institute, New York University (1077-35-1835)

8:30AM (2302) *Global solutions for the Euler-Maxwell equation.* **Pierre M Germain**, Courant Institute, New York University. (1077-35-1529)

9:00AM (2303) *Nonlinear Maximum Principle for Dissipative Nonlocal Operators and Applications: SQG.* **Peter Constantin***, Princeton University, and **Vlad Vicol**, The University of Chicago (1077-35-2324)

9:30AM (2304) *Global wellposedness of 2D anisotropic Boussinesq equations.* **Chongsheng Cao***, Florida International University, and **Jiahong Wu**, Oklahoma State University (1077-35-1904)

10:00AM (2305) *Ensemble Dynamics and Bred Vectors.* **Anna L Mazzucato**, Pennsylvania State University (1077-37-1552)

10:30AM ► (2306) *Pressure Beneath a Stokes Wave.* **Walter A Strauss**, Brown University (1077-76-1170)

MAA General Contributed Paper Session: Assorted Topics, III

8:15 AM – 10:55 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:15AM ► (2307) *A Student Inspired Capstone Experience.* Preliminary report. **Elyn Rykken**, Muhlenberg College (1077-VL-2695)

8:30AM ► (2308) *Creating a Meaningful Mock Classroom Experience for Pre-Service Secondary Teachers.* Preliminary report. **Becky E Hall**, Western Connecticut State University (1077-VL-2278)

8:45AM ► (2309) *How I Taught A Course About The History Of Mathematics For The First Time.* **Ricardo Enrique Rojas**, Northern State University, Aberdeen, South Dakota. (1077-VL-1668)

9:00AM ► (2310) *An Overview of Numeral Systems.* Preliminary report. **Walter S. Sizer**, Minnesota State University Moorhead (1077-VL-340)

9:15AM ► (2311) *Red, White, and Blue: Pythagorean Triples in Undergraduate Mathematics Teaching.* Preliminary report. **Homer W. Austin***, Salisbury University, and **Jathan W. Austin**, University of Delaware (1077-VL-1377)

9:30AM ► (2312) *Deciphering a Message Using the Vigenère Square.* Preliminary report. **Bill Linderman**, King College (1077-VL-1724)

9:45AM ► (2313) *Benjamin Franklin's Magic.* Preliminary report. **Rebecca Garcia**, Sam Houston State University (1077-VL-2879)

10:00AM ► (2314) *Combinatorial Proofs of Fibonacci Identities by Means of the Path Graph.* Preliminary report. **John T. Jacobson**, Kennesaw State University (1077-VL-842)

10:15AM ► (2315) *Domination and Independence on the Triangular Honeycomb Chessboard.* Preliminary report. **Hong Lien T. Tran**, Kennesaw State University (1077-VL-846)

10:30AM ► (2316) *Tiling Deficient Chessboards with n-Polyominoes.* **Kristina J Woodside**, Washington and Jefferson College (1077-VL-2396)

10:45AM ► (2317) *Counting Liars and Truth-tellers: Binomial Identities through Logic Puzzles.* **Oscar Levin**, University of Northern Colorado (1077-VL-2402)

AWM Workshop

8:25 AM – 4:30 PM

This session has several parts that will be listed separately by time in this program. All presentations are open to all JMM participants.

AMS Special Session on Geometric Invariants of Groups and Related Topics, I

8:30 AM – 10:50 AM

Organizers: **Nic Koban**, University of Maine, Farmington
Peter N. Wong, Bates College

8:30AM (2318) *$\mathbb{Z}G$-modules over $CAT(0)$ spaces. Preliminary report.* **Ross Geoghegan**, Binghamton University (SUNY) (1077-20-1173)

9:00AM (2319) *Σ^1 for Semi-Direct Products Acting on Locally Finite Trees.* **Keith M Jones**, Trinity College, Hartford CT (1077-20-995)

9:30AM (2320) *Novikov homology of right-angled Artin groups.* **Dirk Schuetz**, Durham University (1077-20-1907)

10:00AM (2321) *Boundary of a CAT(0) 2-Complex.* Preliminary report. **Yulan Qing**, Tufts University (1077-54-617)

10:30AM (2322) *Geometric and homological finiteness in free abelian covers.* **Alexander I. Suciu**, Northeastern University (1077-20-1180)

AMS Special Session on Nonlinear Analysis of Partial Differential Equation Models in Biology and Chemical Physics, I

8:30 AM – 10:50 AM

Organizers: **Zhonghai Ding**, University of Nevada, Las Vegas
Zhaosheng Feng, University of Texas-Pan American

8:30AM (2323) *A Simple Model for Arterial Blood Flow.* Preliminary report. **Jerry L. Bona**, University of Illinois at Chicago (1077-92-2128)

9:00AM (2324) *Initial-boundary value problem for coupled nonlinear dispersive equations.* Preliminary report. **Jerry L. Bona**, University of Illinois at Chicago, and **Hongqiu Chen***, University of Memphis (1077-35-2619)

9:30AM (2325) *Modeling spatial spread of infectious diseases with a fixed latent period in a spatially continuous domain.* **Jing Li***, Pennsylvania State University, and **Xingfu Zou**, University of Western Ontario (1077-35-2848)

10:00AM (2326) *Financial models used in biology.* **Indranil SenGupta*** and **Maria C. Mariani**, University of Texas- El Paso (1077-35-171)

10:30AM ► (2327) *Existence and stability of steady states of the microtubule formation in three states.* Preliminary report. **Shantia Yarahmadian**, Mississippi State University (1077-35-2120)

MAA Invited Paper Session on Applications of Dynamical Systems

8:30 AM – 10:50 AM

Organizer: **Gene Wayne**, Boston University

8:30AM (2328) *Chaos, Complex Dynamics, and Undergraduate Research Projects.*
Robert L. Devaney, Boston University (1077-AB-103)

9:00AM (2329) *Patterns of Oscillation in Network Systems.*
Martin Golubitsky, Mathematical Biosciences Institute, Ohio State (1077-AB-557)

9:30AM ► (2330) *A Dynamical Systems Approach to Paleoclimate Models.* Preliminary report.
Richard McGehee, University of Minnesota, Minneapolis, Minnesota (1077-AB-1019)

10:00AM ► (2331) *Lagrangian Dynamics and the incorporation of data into ocean models.*
Christopher K R T Jones, University of North Carolina at Chapel Hill (1077-AB-2388)

10:30AM ► (2332) *Snakes and ladders.*
Bjorn Sandstede, Brown University (1077-AB-1739)

MAA General Contributed Paper Session: History and Philosophy of Mathematics

8:30 AM – 9:55 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

8:30AM ► (2333) *Raising Awareness of the History of Mathematics in High School Curriculum.*
Leslie Bolinger-Horton*, Quinsigamond Community College, and **Regina M. Panasuk**, University of Massachusetts Lowell (1077-VF-375)

8:45AM ► (2334) *History of Computation as a Professional Development Course for Middle School Teachers.* Preliminary report.
Todd H. Moore, **Andrew G. Bennett*** and **Carlos W. Castillo-Garsow**, Kansas State University (1077-VF-2076)

9:00AM (2335) *Using the History of Women in Mathematics to Address Gender Equity and Prepare Future Teachers.*
Jacqueline M. Dewar*, **Lily S. Khadjavi** and **Alissa S. Crans**, Loyola Marymount University (1077-VF-2181)

9:15AM ► (2336) *Mathematical Thinking: Can we ever agree on a definition? A conceptual meta-analysis.* Preliminary report.
Sean F Argyle, Kent State University (1077-VF-1263)

9:30AM ► (2337) *Geometric constructions using a finite compass and a finite straightedge.*
David S Richeson, Dickinson College (1077-VF-2530)

9:45AM ► (2338) *Best Web sites for the history of mathematics.* Preliminary report.
Paul R. Bialek, Trinity International University (1077-VF-2626)

AWM Workshop: Research Presentations by Recent Ph.D.s

8:30 AM – 10:20 AM

Organizers: **Alissa Crans**, Loyola Marymount University
Rachelle DeCoste, Wheaton College
Kirsten Eisentraeger, Pennsylvania State University
Susan Williams, University of South Alabama

8:30AM (2339) *On Legendrian Graphs.*
Danielle O'Donnol, Smith College, and **Elena Pavelescu***, Occidental College (1077-57-263)

9:00AM (2340) *Springer's representation via sl(3) webs.*
Heather M. Russell*, University of Southern California, **Julianna S. Tymoczko**, University of Iowa, and **Matthew Housley**, BYU (1077-57-240)

9:30AM (2341) *Categorification of the polynomial ring.*
Radmila Sazdanovic*, University of Pennsylvania, and **Mikhail Khovanov**, Columbia University (1077-18-212)

10:00AM (2342) *Promotion and rowmotion.*
Jessica Striker* and **Nathan Williams**, University of Minnesota (1077-05-256)

AMS Committee on Education Panel Discussion

8:30 AM – 10:00 AM

Models for engaging undergraduate students in research.

Organizers: **David Damiano**, College of the Holy Cross
Steven J. Miller, Williams College

Moderator: **David Damiano**

Panelists: **Dean M. Evasius**, National Science Foundation
Joe Gallian, University of Minnesota Duluth
Steven Miller
Ivelisse Rubio, University of Puerto Rico, Rio Piedras

MAA Session on Motivating Statistical and Quantitative Learning through Social Engagement

8:40 AM – 10:55 AM

Organizers: **Brian Gill**, Seattle Pacific University
Eric Gaze, Bowdoin College
Andrew Zieffler, University of Minnesota
Stuart Boersma, Central Washington University

8:40AM ► (2343) *Mathematics for a Just World: Teaching Quantitative Literacy Through Social Justice Issues and Service Learning.*
Bonnie J Shulman, Bates College, Lewiston, ME (1077-J1-143)

9:00AM ► (2344) *Quantitative Literacy in a First-Year Seminar Course.* Preliminary report.
Maria G Fung, Worcester State University (1077-J1-1973)

9:20AM (2345) *Service Learning Project in a First-Year Seminar.* Preliminary report.
Zeynep Teymuroglu, Rollins College (1077-J1-768)

9:40AM ► (2346) *Service-Learning Projects and Activities that Engage Liberal Arts Mathematics Students: Implementation and Assessments.*
Morteza Shafii-Mousavi* and **Paul Kochanowski**, Indiana University South Bend (1077-J1-169)

10:00AM ► (2347) *Quantitative Reasoning and Informed Citizenship: Building Students' Awareness of Social Issues.*
Alicia Sevilla* and **Kay Somers**, Moravian College (1077-J1-2467)

10:20AM ► (2348) *Math Trails in Undergraduate Mathematics.*
Mike Daven and **Lee Fothergill***, Mount Saint Mary College (1077-J1-161)

10:40AM ► (2349) *How Does Acceptance of Lesbian and Gay Men Spread in a Social Network?*
Angela Vierling-Claassen*, Lesley University, and **Dorea Vierling-Claassen**, Brown University (1077-J1-784)

AMS Invited Address

9:00 AM – 9:50 AM

(2350) *Beyond q: Special functions on elliptic curves.*
Eric Rains, California Institute of Technology (1077-33-9)

ASL Invited Address

9:00 AM – 9:50 AM

(2351) *Set Theory and Infinitary Model Theory.*
John Baldwin, University of Illinois at Chicago (1077-03-152)

MAA Minicourse #4: Part B

9:00 AM – 11:00 AM

Elementary mathematics in architecture.
Presenter: **Alexander J. Hahn**, University of Notre Dame

MAA Minicourse #13: Part B

9:00 AM – 11:00 AM

Interactive applets for calculus and differential equations.
Presenter: **Haynes Miller**, Massachusetts Institute of Technology

MAA Minicourse #1: Part B

9:00 AM – 11:00 AM

Mathematics and backgammon.
Presenters: **Arthur Benjamin**, Harvey Mudd College
Robert Koca, Community College of Baltimore County

SIGMAA on Math Circles Demonstration for JMM Participants, Teachers, and other Mathematical Enthusiasts

9:00 AM – 9:50 AM

Come learn about and participate in this Math Circles experience.
Organizers: **James Tanton**, St. Mark's Institute of Mathematics
Tatiana Shubin, San Jose State University

NAM Panel Discussion

9:00 AM – 9:50 AM

Title to be announced.

Student Hospitality/Information Center

9:00 AM – 2:00 PM

Exhibits and Book Sales

9:00 AM – NOON

Employment Center

9:00 AM – NOON

MAA General Contributed Paper Session: Assorted Topics, IV

10:00 AM – 10:40 AM

Organizers: **Jennifer Beineke**, Western New England College
Lynette Boos, Providence College
Aliza Steurer, Dominican University

10:00AM ► (2352) *Matrices with Equal Power Property.* Preliminary report.
Wasin So, San Jose State University (1077-VL-531)

10:15AM ► (2353) *What can a right triangle look like?*
Steven Schlicker, Grand Valley State University (1077-VL-1348)

10:30AM ► (2354) *The Braikenridge-Maclaurin Construction.* Preliminary report.
Salvatore Giunta, Adelphi University (1077-VL-2185)

ASL Contributed Paper Session, II

10:00 AM – 10:45 AM

10:00AM (2355) *Forking in VC-minimal theories.*
Sarah Cotter* and **Sergei Starchenko**, University of Notre Dame

10:25AM (2356) *Indiscernible sequences and simplicity.*
Donald Brower, University of Notre Dame

SIGMAA on Math Circles Demonstration for Undergraduate Students

10:00 AM – 11:00 AM

Come learn about and participate in this Math Circles experience.
Organizers: **James Tanton**, St. Mark's Institute of Mathematics
Tatiana Shubin, San Jose State University

NAM Business Meeting

10:00 AM – 10:50 AM

MAA Invited Address

10:05 AM – 10:55 AM

(2357) *Mathematical challenges in climate and sustainability.*
Mary Lou Zeeman, Bowdoin College (1077-A0-7)

AWM Workshop: Poster Session with Presentations from Women Graduate Students

10:30 AM – 11:00 AM

10:30AM ► (2358) *An alternative approach to hyperbolic structures on link complements.* **Morwen Thistlethwaite** and **Anastasiia Tsvietkova***, University of Tennessee, Knoxville (1077-57-134)

10:30AM (2359) *Hilbert Functions and Graded Betti Numbers of Arithmetically Gorenstein Points on General Surfaces in* $\mathbb{P}^3$. Preliminary report. **Megan Patnott**, University of Notre Dame (1077-14-197)

10:30AM (2360) *On the Unimodality of Pure O-Sequences.* Preliminary report. **Bernadette M Boyle**, University of Notre Dame (1077-13-205)

10:30AM ► (2361) *Reflection groups: Comparing length and codimension.* **Briana Foster-Greenwood**, University of North Texas (1077-05-211)

10:30AM (2362) *The von Kármán theory for incompressible elastic shells.* **Hui Li**, University of Minnesota (1077-74-230)

10:30AM (2363) *Sum-list-coloring and sc-greedy graphs.* Preliminary report. **Michelle A. Lastrina**, Iowa State University (1077-05-232)

10:30AM (2364) *Splittings of Non-Finitely Generated Groups.* **Robin M. Lassonde**, University of Michigan (1077-20-249)

10:30AM (2365) *Equivalence and Duality for Rank-Metric and Matrix Codes.* **Katherine Morrison**, University of Nebraska – Lincoln (1077-94-257)

10:30AM ► (2366) *Extending the analysis of the Blum medial axis to multiple regions.* **Ellen K Gasparovic**, University of North Carolina at Chapel Hill (1077-54-261)

10:30AM (2367) *Tracking Control and Robustness Analysis for PVTOL Aircraft under Bounded Feedbacks.* **Aleksandra Gruszka***, **Michael Malisoff**, Louisiana State University, and **Frederic Mazenc**, Team INRIA DISCO, CNRS-Supelec (1077-93-306)

10:30AM (2368) *Uniqueness and multiplicity results for classes of infinite positone problems.* **Eunkyung Ko**, Mississippi State University (1077-35-307)

10:30AM (2369) *The topology of restricted partition posets.* **Richard Ehrenborg** and **JiYoon Jung***, University of Kentucky (1077-05-308)

MAA Business Meeting

11:10 AM – 11:40 AM

Chair: **Paul Zorn**, Saint Olaf College

AMS Business Meeting

11:45 AM – 12:15 PM

NAM Claytor-Woodard Lecture

1:00 PM – 1:50 PM

(2370) *Profinite (Continuous) Equivariant Higher Algebraic K-theory for the Action of Algebraic Groups.* **Aderemi Oluyomi Kuku**, Grambling State University (1077-19-884)

AMS-MAA-SIAM Special Session on Research in Mathematics by Undergraduates and Students in Post-Baccalaureate Programs, IV

1:00 PM – 5:50 PM

Organizers: **Bernard Brooks**, Rochester Institute of Technology
Jobby Jacob, Rochester Institute of Technology
Jacqueline Jensen, Sam Houston State University
Darren A Narayan, Rochester Institute of Technology

1:00PM ► (2371) *The Role of Dynamic Representations in Development of Algebraic Concepts.* Preliminary report. **Marie Nicole Ermete***, **Natasha Dawn Brackett** and **Karli Nicole Powell**, Central Michigan University (1077-97-102)

1:30PM ► (2372) *Trigonometric Interpolation for Numerical Solution of Differential Equations.* **Oksana Bihun**, **Austin Bren***, **Michael Dyrud** and **Kristin Heysse**, Concordia College, MN (1077-65-105)

2:00PM ► (2373) *Folded ribbon knots in the plane.* Preliminary report. **Eleanor Conley***, **Emily Meehan**, **Elizabeth Denne** and **Rebecca Terry**, Smith College (1077-51-1889)

2:30PM ► (2374) *The Life and Death of a Geodesic.* Preliminary report. **Arielle McCoy***, **Cal Hotchkiss**, **Alison Pryor**, **Kirin Khan** and **James Henle**, Smith College (1077-51-1891)

3:00PM ► (2375) *Mathematical Modeling and Analysis of a Nonlinear Large Deformation Plate Model with Applications to Micro Air Vehicles.* Preliminary report. **James Cameron***, **Charles Daly** and **Padmanabhan Seshaiyer**, George Mason University (1077-35-1902)

3:30PM ► (2376) *Statistical functional equations in the plane.* **Mary Michael Forrester**, Sewanee: The University of the South (1077-39-1087)

4:00PM ► (2377) *Constructing the Moduli Space of* 2|2*-Dimensional Complex Associative Algebras.* **Josh Frinak**, University of Wisconsin-Eau Claire (1077-00-2734)

4:30PM ► (2378) *Optimal Harvesting Models for Fishery Populations.* Preliminary report. **Corinne Alexandra Wentworth***, St. Mary's College of Maryland, **Jay Walton** and **Masami Fujiwara**, Texas A&M University (1077-92-348)

5:00PM ► (2379) *A Family of Multidimensional Continued Fraction Stern Sequences.* Preliminary report. **Krishna Dasaratha**, Harvard University, **Laure Flapan**, Yale University, **Chansoo Lee**, Williams College, **Cornelia Mihaila**, Wellesley College, **Nicholas Neumann-Chun**, Williams College, **Sarah Peluse**, University of Chicago, Lake Forest College, **Matthew Stoffregen***, University of Pittsburgh, and **Thomas Garrity**, Williams College (1077-05-2543)

5:30PM ► (2380) *A Generalized Family of Multidimensional Continued Fractions and its Correspondence to Existing Algorithms.* Preliminary report. **Krishna Dasaratha**, Harvard University, **Laure Flapan**, Yale University, **Chansoo Lee***, Williams College, **Cornelia Mihailia**, Wesley College, **Nicholas G Neumann-Chun**, Williams College, **Sarah Peluse**, Lake Forest College, **Matt Stoffregen**, University of Pittsburgh, and **Thomas A Garrity**, Williams College (1077-11-2469)

AMS Special Session on Advanced Investigations on Applied Optimization and Multiple Fractional Programming

1:00 PM – 5:50 PM

Organizers: **Ram U. Verma**, Texas A&M University
Alexander J. Zaslavski, Technion, Israel

1:00PM (2381) *The $\epsilon-$Optimality conditions for Multiobjective Fractional Programming Problems.* **R. N. Mohapatra***, University of Central Florida, Orlando, Florida, and **Ram U Verma**, Teaxs A & M University, Kingsville, Texas (1077-49-223)

1:30PM (2382) *Stochastic differential equations on Banach spaces and optimization of supports of measures induced.* **Nasir U. Ahmed**, University of Ottawa (1077-93-62)

2:00PM (2383) *Finding moment-matching cubature formulas using optimization techniques, with applications in stochastic optimization.* **Sanjay Mehrotra** and **David Papp***, Northwestern University, Department of Industrial Engineering and Management Sciences (1077-65-1472)

2:30PM (2384) *Subdifferentials of Supremum Lipschitzian Functions and Its Applications to Nonsmooth Semi-infinite and Infinite Programs.* **Boris Mordukhovich** and **Nghia Tran***, Wayne State University (1077-49-221)

3:00PM (2385) *Quantum Games & Quaternionic Strategies.* **Aden Omar Ahmed**, Texas A&M University - Kingsville (1077-49-323)

3:30PM (2386) *Higher-Order Necessary Conditions in Nonsmooth Set Constrained Optimization.* **Elena Constantin**, University of Pittsburgh-Johnstown (1077-49-178)

4:00PM (2387) *The Smallest Intersecting Ball Problem and the Smallest Enclosing Ball Problem: Numerical Implementation.* **Mau Nam Nguyen*** and **Cristina Villalobos**, University of Texas-Pan American (1077-90-1718)

► 4:30PM (2388) *Metric subregularity for composite-convex generalized equations in Banach spaces.* Preliminary report. **Xiyin Zheng**, Yunnan University, P.R. China, and **Wei Ouyang***, Wayne State University (1077-49-448)

5:00PM (2389) *Convergence of a proximal point method and of a projected subgradient method in the presence of computational errors in Hilbert spaces.* **Alexander J. Zaslavski**, The Technion - Israel Institute of Technology (1077-49-278)

5:30PM (2390) *The Weak Optimality Conditions for Multiple Objective Fractional Programming Based on Generalized Invexity of Higher Order.* **Ram U Verma**, Texas A&M University (1077-90-623)

AMS Special Session on Algebraic and Geometric Aspects of Integrable Systems and Random Matrices, IV

1:00 PM – 5:40 PM

Organizers: **Anton Dzhamay**, University of Northern Colorado
Kenichi Maruno, University of Texas, Pan American
Virgil Pierce, University of Texas, Pan American

1:00PM (2391) *Asymptotics of rational Painleve II solutions.* **Robert J. Buckingham***, University of Cincinnati, and **Peter D. Miller**, University of Michigan, Ann Arbor (1077-34-1262)

1:30PM (2392) *On the Modified Nonlinear Schrödinger Equation in the Semiclassical Limit.* **Peter D. Miller**, University of Michigan (1077-35-1187)

2:30PM (2393) *Prym-Tyurin classes and tau-functions.* **Dmitry Korotkin**, Concordia University (1077-51-315)

3:30PM (2394) *Higher genus Weierstrass sigma-function.* **Dmitry Korotkin**, Concordia University, and **Vasilisa Shramchenko***, University of Sherbrooke (1077-33-1046)

4:00PM (2395) *Real Grassmannian and KP solitons.* **Yuji Kodama**, Ohio State University (1077-35-1458)

5:00PM (2396) *Sigma function and random matrices.* **Emma Previato**, Boston University (1077-33-1428)

AMS Special Session on Control of Biological and Physical Systems, II

1:00 PM – 5:50 PM

Organizers: **Wandi Ding**, Middle Tennessee State University
Volodymyr Hrynkiv, University of Houston-Downtown
Suzanne Lenhart, University of Tennessee, Knoxville, and NIMBioS

1:00PM (2397) *Tracking and Robustness Analysis for UAVs with Bounded Feedbacks.* **Aleksandra Gruszka***, **Michael Malisoff**, Louisiana State University, and **Frederic Mazenc**, Team INRIA DISCO (1077-93-1855)

1:30PM (2398) *Optimal Control of Advection Direction on Reaction-Diffusion Population Models.* **Heather Finotti**, **Suzanne Lenhart** and **Tuoc Van Phan***, University of Tennessee (1077-35-987)

2:00PM (2399) *Optimal control of a biharmonic obstacle problem.* **David R. Adams**, University of Kentucky, **Volodymyr Hrynkiv***, University of Houston-Downtown, and **Suzanne Lenhart**, University of Tennessee-Knoxville (1077-49-2081)

► 2:30PM (2400) *Mosquito Management in the face of Natural Selection.* Preliminary report. **Folashade B. Agusto***, Austin Peay State Univeristy, **Sharon Bewick**, National Institute for Mathematical and Biological Synthesis, and **Rana D Parshad**, Center for Turbulence Research, Stanford University, (1077-92-2287)

► 3:00PM (2401) *Influence of Model Structure on Control of a Cholera Epidemic.* Preliminary report. **Elsa N Schaefer**, Marymount University (1077-93-2069)

3:30PM (2402) *Optimal Control Applied to Native-Invasive Species Competition via a PDE Model.* **Wandi Ding***, Middle Tennessee State University, **Volodymyr Hrynkiv**, University of Houston - Downtown, and **Xiaoyu Mu**, University of Tennessee - Knoxville (1077-49-341)

4:00PM (2403) *Modelling effective transmission strategies and control of the world's most successful parasite.* **Matthew D Turner**, University of Tennessee Knoxville (1077-92-1919)

4:30PM ► (2404) *Optimal Control of a Harvesting Problem Modeled by Integrodifference Equations.*
Peng Zhong*, Department of Ecology, Evolution, and Natural Resources, Rutgers University, and **Suzanne Lenhart**, University of Tennessee, Knoxville (1077-92-1781)

5:00PM ► (2405) *A Vegetative Pattern Formation Aridity Classification Scheme Along a Rainfall Gradient: An Example of Desertification Control.*
Bonni J Kealy* and **David J Wollkind**, Washington State University (1077-92-146)

5:30PM (2406) *Hopf and backward bifurcations in a new model for the dynamics of malaria transmission.*
Calistus Ngeh Ngonghala, National Institute for Mathematical and Biological Synthesis (NIMBioS) (1077-92-2663)

AMS Special Session on Fractal Geometry in Pure and Applied Mathematics (in memory of Benoit Mandelbrot), V

1:00 PM – 5:50 PM

Organizers: **Michael L. Lapidus**, University of California, Riverside
Erin Pearse, University of Oklahoma
Machiel van Frankenhuijsen, Utah Valley University

1:00PM ► (2407) *Derivatives on Fractals.* Preliminary report.
Alexander Teplyaev, University of Connecticut (1077-58-2822)

1:30PM ► (2408) *Vector equations on fractals.*
Michael Hinz*, University of Connecticut and FSU Jena, and **Alexander Teplyaev**, University of Connecticut (1077-35-1885)

2:00PM (2409) *Factorization of the spectral zeta function of differential operators on fractals.*
Nishu Lal* and **Michel Lapidus**, University of California, Riverside (1077-28-2420)

2:30PM ► (2410) *Casimir effect on higher dimensional Laakso spaces.* Preliminary report.
Robert Kesler and **Benjamin Steinhurst***, Cornell University (1077-81-1963)

3:00PM ► (2411) *Constructing invariant Laplacians on Julia sets.* Preliminary report.
Robert S. Strichartz, Cornell University (1077-28-1531)

3:30PM ► (2412) *Buried Points in Rational Julia Sets Have Full Geometric and Dynamical Measure.*
Clinton P Curry, Huntingdon College, **John C Mayer***, University of Alabama at Birmingham, and **E. D. Tymchatyn**, University of Saskatchewan (1077-37-2675)

4:00PM (2413) *Statistical mechanics and quantum field theory on fractal structures.*
Eric Akkermans, Physics Department, Technion Israel Institute of Technology (1077-81-785)

4:30PM (2414) *Number Theoretic Solutions to a Certain Nonlinear Cauchy Problem with Optimized Constraints.*
Michael Anthony Maroun, University of California, Riverside (1077-33-2768)

5:00PM (2415) *Spectral zeta function and quantum statistical mechanics on Sierpinski carpets.*
Joe P Chen, Cornell University (1077-82-708)

5:30PM (2416) *Properties of compatible sequences of periodic orbits of prefractal approximations of the Koch snowflake fractal billiard.*
Robert G. Niemeyer* and **Michel L. Lapidus**, University of California, Riverside (1077-37-1115)

AMS Special Session on Frontiers in Geomathematics, IV

1:00 PM – 5:50 PM

Organizers: **Willi Freeden**, University of Kaiserslautern
Volker Michel, University of Siegen
M. Zuhair Nashed, University of Central Florida
Thomas Sonar, Technical University of Braunschweig

1:00PM (2417) *Multiscale data sampling and function extension for data analysis and processing of large high dimensional data.*
Amit Bernanis, Tel Aviv University, **Amir Averbuch***, School of Computer Science, Tel Aviv University, and **Ronald Raphel Coifman**, Yale University (1077-42-1602)

1:30PM (2418) *Mathematical challenges arising from earth-space observation: mixed integer linear model, measurement-based perturbation theory and data assimilation for ill-posed problems.*
Peiliang Xu, Kyoto University (1077-86-1504)

2:30PM (2419) *Fast Multipole Accelerated Solution of the Oblique Boundary Value Problem.*
Martin Gutting, University of Kaiserslautern, Germany (1077-31-1921)

3:00PM (2420) *Real Earth Based Geopotential Determination.* Preliminary report.
Elena Kotevska, University St. Kliment Ohridski-Bitola (1077-31-2427)

3:30PM ► (2421) *Differentiation Tools in Geoscience Computation.*
A A Abokhodair, King Fahd University of Petroleum and Minerals (1077-86-2435)

4:00PM ► (2422) *Data Assimilation for Dynamical Systems.*
Humberto C. Godinez, Los Alamos National Laboratory (1077-93-2730)

4:30PM ► (2423) *Inverse and Moment Problems in Geosciences - Revisited.*
M. Zuhair Nashed, University of Central Florida (1077-86-2871)

5:30PM Discussion

AMS Special Session on Global Dynamics of Rational Difference Equations with Applications

1:00 PM – 5:50 PM

Organizers: **Mustafa R. S. Kulenovic**, University of Rhode Island
Gerasimos Ladas, University of Rhode Island
Orlando Merino, University of Rhode Island

1:00PM (2424) *Number Theoretic Properties of Difference Equations Associated to Hénon Maps.* Preliminary report.
Joseph H. Silverman, Brown University (1077-37-174)

1:30PM (2425) *Patterns of boundedness for systems of rational difference equations.*
Gerry Ladas, University of Rhode Island (1077-39-1633)

2:00PM (2426) *Systems of rational difference equations from population dynamics and global dynamics on the boundary of the positive cone.* Preliminary report.
Jim M. Cushing, University of Arizona (1077-39-1925)

2:30PM ► (2427) *Constant Proportion Harvest Policy, Predator Saturation and Mating Limitation Induced Allee Effects In Pacific Halibut and Atlantic Cod Fisheries.* **Abdul-Aziz Yakubu*** and **Nianpeng Li**, Howard University (1077-92-2159)

3:00PM ► (2428) *Chaos in expansive rank-type equations.* Preliminary report. **Timothy Sauer**, George Mason University (1077-39-1999)

3:30PM ► (2429) *Attractivity and Global Stability for Linearizable Difference Equations.* **M. R. S. Kulenovic*** and **Ed Janowski**, University of Rhode Island (1077-39-1161)

4:00PM ► (2430) *When does local stability imply global stability in planar competition models?* **Saber N Elaydi***, Trinity University, and **Rafael Luis**, Tecnical University of Lisbon (1077-39-1237)

4:30PM (2431) *On the Dynamics of some Competitive Rational Systems in the Plane.* **Gabriel Lugo** and **Frank J. Palladino***, University of Rhode Island (1077-39-975)

5:00PM ► (2432) *Spectral parameter power series for Sturm-Liouville problems on time scales.* Preliminary report. **Lynn Erbe**, **Raziye Mert** and **Allan Peterson***, University of Nebraska-Lincoln (1077-39-788)

5:30PM (2433) *Representations and Ostrowski type inequalities on Time scales.* Preliminary report. **George A Anastassiou**, University of Memphis (1077-39-360)

AMS Special Session on Homotopy Theory, III

1:00 PM – 5:50 PM

Organizers: **Mark Behrens**, Massachusetts Institute of Technology
Mark W. Johnson, Pennsylvania State University, Altoona
Haynes R. Miller, Massachusetts Institute of Technology
James Turner, Calvin College
Donald Yau, Ohio State University

1:00PM (2434) *A general bar-cobar duality.* Preliminary report. **André Joyal*** and **Matthieu Anel**, UQAM, Montréal (1077-18-2785)

1:30PM (2435) *Localization and completion with respect to topological Quillen homology.* **John E Harper**, University of Western Ontario (1077-55-1672)

2:00PM (2436) *Cell complexes and inductive definitions.* **Michael A Shulman**, University of California, San Diego (1077-55-875)

2:30PM (2437) *Non-realizable 2-stage Π-algebras.* **Martin Frankland**, University of Illinois at Urbana-Champaign (1077-55-1731)

3:00PM (2438) *Stable homotopy 1-types and symmetric Picard groups.* Preliminary report. **Angelica M. Osorno***, University of Chicago, and **Niles Johnson**, University of Georgia (1077-55-2644)

3:30PM (2439) *Obstruction theory for E_∞ maps.* Preliminary report. **Niles Johnson***, University of Georgia, and **Justin Noel**, Max Planck Institute and University of Bonn (1077-55-2103)

4:00PM (2440) *Truncated Brown-Peterson spectra.* **Tyler Lawson***, University of Minnesota, and **Niko Naumann**, Universität Regensburg (1077-55-1363)

4:30PM (2441) *Higher Geometry and Algebraic K-theory.* **John A. Lind**, The Johns Hopkins University (1077-55-1371)

5:00PM (2442) *K-homology and index theory : Beyond ellipticity.* **Paul Frank Baum**, Penn State University (1077-19-403)

5:30PM Discussion

AMS Special Session on Mathematical Principles and Theories of Integrable Systems

1:00 PM – 5:50 PM

Organizers: **Wen-Xiu Ma**, University of South Florida
Syed Tauseef Mohyud-Din, HITEC University
Zhijun Qiao, University of Texas-Pan American

1:00PM (2443) *On the Maxwell-Bloch equations with non-zero boundary conditions.* **Gino Biondini***, State University of New York at Buffalo, and **Gregor Kovacic**, Rensselaer Polytechnic Institute (1077-35-1093)

1:30PM ► (2444) *Multipeakons in the Degasperis-Procesi Equation I.* Preliminary report. **Jacek Szmigielski**, University of Saskatchewan, Saskatoon, SK, Canada (1077-35-1160)

2:00PM (2445) *Wronskian and Paffian solutions to nonlinear partial differential equations.* **Alrazi M Abdeljabbar**, University of South Florida (1077-35-1055)

2:30PM (2446) *Constructing Integrable Systems From Graded Classical r-Matrices.* Preliminary report. **Peter Fedak**, Harvey Mudd College, **Gizem Karaali***, **Keith McHugh**, Pomona College, **Aaron Pribadi**, Harvey Mudd College, and **Sundeep Sampath**, Claremont Graduate University (1077-17-120)

3:00PM ► (2447) *Painleve integrability of coupled variable coefficient higher-order nonlinear Schrodinger equations with free parameters.* Preliminary report. **Zhenyun Qin***, Fudan University, **Wenxiu Ma**, University of South Florida, and **Hong Cai Ma**, Donghua University (1077-03-1219)

3:30PM ► (2448) *Hirota Bilinear Equations and their Connection with Linear Superposition Principle.* Preliminary report. **Magaji Y Adamu***, **Dauda G Yakubu** and **Enoch Suleiman**, Abubakar Tafawa Balewa University, Bauchi, Nigeria (1077-35-504)

4:00PM (2449) *Integrability of geometric evolution equations using Hasimoto variables.* Preliminary report. **Stephen C. Anco**, Brock University (1077-35-2787)

4:30PM (2450) *On the long-time stability of a semi-impicit Euler scheme for the 2d thermohydraulics equations.* **Florentina Tone***, University of West Florida, and **Xiaoming Wang**, Florida State University (1077-35-791)

5:00PM (2451) *Standing wave solutions of nonlinear Schrödinger equation with saturable nonlinearity.* Preliminary report. **Guoping Zhang**, Morgan State University (1077-35-912)

5:30PM (2452) *The Grammian and Pfaffian solutions to the (3+1)-dimensional non-linear partial differntial equations.* **Magdy G. Asaad**, Tampa (1077-35-1442)

AMS Special Session on Mathematical Theory of Control of Quantum Systems, II

1:00 PM – 5:50 PM

Organizers: **Francesca Albertini**, University of Padua
Domenico D'Alessandro, Iowa State University
Raffaele Romano, University of Trieste
Francesco Ticozzi, University of Padua

1:00PM (2453) *Are traps lurking on quantum control landscapes to impede reaching the objective?*
Herschel Rabitz, Princeton University (1077-81-1511)

1:30PM ► (2454) *Gradient flow in quantum control problems and the role of singular controls.*
Ruixing Long, Department of Chemistry, Princeton University (1077-49-680)

2:00PM (2455) *Indirect controllability of quantum systems; General Lie algebraic conditions and some special cases.*
Domenico D'Alessandro*, Iowa State University, and **Raffaele Romano**, Department of Physics, Universita' di Trieste, Italy (1077-93-624)

2:30PM (2456) *Symmetry Principles in Quantum Systems Theory with Applications in Simulation and Control.*
Thomas Schulte-Herbrueggen, TU-Munich (TUM) (1077-49-349)

3:00PM (2457) *Controllability with Periodic Pulsing.*
Philip Owrutsky* and **Navin Khaneja**, Harvard University (1077-93-1992)

3:30PM (2458) *Adiabatic control of the Schroedinger equation via conical intersections of the eigenvalues.*
Ugo Boscain*, CMAP, Ecole Polytechnique, CNRS, and INRIA team GECO, **Mario Sigalotti**, INRIA team GECO, CMAP, Ecole Polytechnique, **Paolo Mason**, LSS-Supelec, CNRS, and **Francesca Chittaro**, DIGITEO, CMAP, Ecole Polytechnique (1077-81-1512)

4:00PM (2459) *Weakly coupled bilinear quantum systems.*
Thomas Chambrion, IECN, INRIA, Nancy University (1077-93-37)

4:30PM ► (2460) *Control by quantum dynamics on graphs.*
Chris Godsil, University of Waterloo, and **Simone Severini***, University College London (1077-05-1906)

5:00PM (2461) *On efficiency of Hamiltonian-based quantum computation for low-rank matrices.*
Zhenwei Cao* and **Alexander Elgart**, Virginia Tech (1077-81-2783)

5:30PM Discussion

AMS Special Session on Mathematics and Statistics in Computational Biology

1:00 PM – 5:50 PM

Organizer: **Mark A. Kon**, Boston University

1:00PM (2462) *RNA folding prediction: the continued need for interaction between biologists and mathematicians.*
Christine E Heitsch, School of Mathematics, Georgia Institute of Technology (1077-92-1452)

1:30PM (2463) *Combining simplified Markov random fields with simulated evolution improves remote homology detection for beta-structural proteins into the twilight zone.* Preliminary report.
Noah M. Daniels, **Lenore J. Cowen***, Tufts University, **Raghavendra Hosur** and **Bonnie Berger**, Massachusetts Institute of Technology (1077-92-835)

2:00PM (2464) *RNAG: A New Gibbs Sampler for Predicting RNA Secondary Structural Ensembles of Unaligned Sequences.*
Charles (Chip) E. Lawrence*, Brown University, **Donglai Wei**, Department of Computer Science, MIT, and **Lauren Alpert**, Brown Univeristy (1077-92-673)

2:30PM (2465) *Inferring transcriptional and microRNA-mediated regulatory programs in glioblastoma.*
Christina S Leslie, Memorial Sloan-Kettering Cancer Center (1077-92-2283)

3:00PM ► (2466) *Branching Process Models of Ovarian Cancer Progression.* Preliminary report.
Richard Durrett*, Math Dept. Duke U, **Kaveh Danesh**, Duke U., **Laura Havrilesky** and **Evan Myers**, Ob/Gyn Duke Medical Center (1077-60-555)

3:30PM ► (2467) *Machine Learning Approaches for Genomic Medicine.*
Jill P. Mesirov, Broad Institute of MIT and Harvard (1077-92-1697)

4:00PM (2468) *Noise Attenuation in Biological Systems.*
Qing Nie, University of California, Irvine (1077-92-335)

4:30PM ► (2469) *Darwin, Development and Dysplasia: Signalling Games that Cells Play.* Preliminary report.
Bud Mishra, Courant Institute (1077-92-1975)

5:00PM (2470) *Theory and experiments in molecular systems biology.*
Eduardo Sontag, Rutgers University (1077-92-484)

5:30PM (2471) *Siphons in Chemical Reaction Networks.*
Anne Shiu, University of Chicago, and **Bernd Sturmfels***, UC Berkeley (1077-92-36)

AMS Special Session on Matrices and Graphs, II

1:00 PM – 5:50 PM

Organizers: **Leslie Hogben**, Iowa State University and American Institute of Mathematics
Bryan L. Shader, University of Wyoming

1:00PM (2472) *Applications and limitations of the normalized Laplacian matrix for graphs.* Preliminary report.
Steve Butler, Iowa State University (1077-05-2452)

1:30PM ► (2473) *Bipartiteness and the Signless Laplacian Matrix of a Graph.*
Shaun M Fallat, University of Regina (1077-15-950)

2:00PM (2474) *On the Extremal Energy of Integral Weighted Graphs.*
Richard A Brualdi*, University of Wisconsin, Madison, **Jia-yu Shao**, Tongji University, Shanghai, **Shi-Cai Gong**, **Chang-Qing Xu** and **Guang-Hui Xu**, Zhejiang A & F University, Lin'An, Hangzhou (1077-15-493)

2:30PM (2475) *Eventually r-cyclic matrices.*
Ulrica Wilson*, Morehouse College, and **Leslie Hogben**, Iowa State University (1077-15-2574)

3:00PM ► (2476) *Drazin and Group Inverses of Matrices with Bipartite Digraphs.*
Minerva Catral*, Xavier University, Cincinnati OH, **Dale Olesky**, Department of Computer Science, University of Victoria, British Columbia, Canada, and **Pauline van den Driessche**, University of Victoria, British Columbia, Canada (1077-15-1048)

3:30PM (2477) *Nilpotent and spectrally arbitrary matrix patterns over $\mathbb{C}$.*
Natalie Campbell, **Kevin N. Vander Meulen***, Redeemer University College, and **Adam van Tuyl**, Lakehead University (1077-15-137)

4:00PM (2478) *Partition Regular Matrices from a Linear Algebraic Perspective.*
Leslie Hogben, Iowa State University, and **Jillian McLeod***, U.S. Coast Guard Academy (1077-15-2213)

4:30PM (2479) *2-Matching covered loopy graphs.* Preliminary report.
Adam H. Berliner*, St. Olaf College, and **Richard A. Brualdi**, University of Wisconsin - Madison (1077-05-1429)

5:00PM (2480) *Average mixing on graphs.* Preliminary report.
Chris Godsil, University of Waterloo (1077-05-737)

5:30PM ► (2481) *An open problem concerned with the combinatorial structure of unitary matrices.*
Simone Severini, University College London (1077-05-2642)

AMS Special Session on My Favorite Graph Theory Conjectures, II

1:00 PM – 5:50 PM

Organizers: **Ralucca Gera**, Naval Postgraduate School
Craig Larson, Virginia Commonwealth University

1:00PM (2482) *Chvátal's t_0-tough conjecture.* Preliminary report.
Linda M. Lesniak, Drew University/Western Michigan University (1077-05-417)

1:30PM (2483) *The Many Forms of the Matthews - Sumner Conjecture.*
Ronald J. Gould, Emory University (1077-05-854)

2:00PM ► (2484) *Favorite Graph Conjectures.*
Daniel J. Kleitman, M.I. T. (1077-05-953)

2:30PM (2485) *Chromatic symmetric functions of certain graphs.*
Richard P. Stanley, M.I.T. (1077-05-457)

3:00PM ► (2486) *"Nature is tricky, but she is not nasty." - Uncle Paul.*
Peter John Slater, University of Alabama in Huntsville (1077-05-514)

3:30PM (2487) *Ringel and Kotzig after fifty years.*
Alexander Rosa, McMaster University, Hamilton, Ontario, Canada (1077-05-923)

4:00PM ► (2488) *The Binding Number of a Graph.*
Wayne D. Goddard, Clemson University (1077-05-869)

4:30PM ► (2489) *Graph Theory Problems Arising from Partially Ordered Sets.*
William T. Trotter, Georgia Institute of Technology (1077-05-1166)

5:00PM (2490) *Conjectures reaching from groups and graphs to graphs and groups.*
Wilfried Imrich, Montan University of Leoben, Austria (1077-05-1931)

5:30PM ► (2491) *Some of My Unsolved Problems in Graph Theory.* Preliminary report.
Nathaniel Dean, Texas State University-San Marcos (1077-05-1937)

AMS Special Session on Noncommutative Birational Geometry and Cluster Algebras, III

1:00 PM – 5:40 PM

Organizers: **Arkady Berenstein**, University of Oregon
Vladimir Retakh, Rutgers University

1:00PM (2492) *Stasheff polytopes and the coordinate ring of the cluster $\mathcal{X}$-variety of type A_n.*
Linhui Shen, Yale University (1077-14-1735)

1:30PM (2493) *Non-abelian quadratic Poisson brackets: From noncommutative ODE to noncommutative Algebraic Geometry and back.* Preliminary report.
Alexander V. Odesskii, Brock University, **Vladimir N. Rubtsov***, University of Angers, France, and **Sokolov V. Vladimir**, Landau Istitut of Theoretical Physics, Russian Academy of Sciences,Moscow (1077-16-1502)

2:00PM ► (2494) *Semi-invariants and the representation type of Artin algebras.* Preliminary report.
Calin Chindris, University of Missouri, **Piotr Dowbor**, N. Copernicus University, Torun, Poland, **Ryan Kinser** and **Jerzy Weyman***, Northeastern University (1077-16-2742)

3:00PM (2495) *Topological Hall algebras and exponentials in categories.* Preliminary report.
Arkady Berenstein, University of Oregon, Eugene, and **Jacob Greenstein***, University of California Riverside (1077-16-2733)

4:00PM (2496) *Noncommutative reflections.*
Yuri Bazlov*, University of Manchester, United Kingdom, and **Arkady Berenstein**, University of Oregon (1077-20-2261)

5:00PM (2497) *Littlewood-Richardson coefficients for reflection groups.*
Edward Richmond*, University of British Columbia, and **Arkady Berenstein**, University of Oregon (1077-16-2764)

AMS Special Session on Nonlinear Analysis of Partial Differential Equation Models in Biology and Chemical Physics, II

1:00 PM – 3:50 PM

Organizers: **Zhon1hai Ding**, University of Nevada, Las Vegas
Zhaosheng Feng, University of Texas-Pan American

1:00PM (2498) *Boundary Control of the Korteweg-de Vries Equation.*
Bingyu Zhang* and **Ivonne Rivas**, University of Cincinnati (1077-93-631)

1:30PM (2499) *On one dimensional nonlinear equations with negative exponents.*
Jingbo Dou, University of Oklahoma, and Xi'an University of Finance and Economy, and **Meijun Zhu***, University of Oklahoma (1077-35-1327)

2:00PM ► (2500) *Remarks on Computing the Williamson Normal Form.*
Viswanath Ramakrishna, University of Texas at Dallas (1077-81-870)

2:30PM ► (2501) *Stripes Versus Spots in Reaction-Diffusion Systems: Comparison of Vegetative and Chemical Turing Pattern Formation.*
Bonni J Kealy* and **David J Wollkind**, Washington State University (1077-92-431)

3:00PM (2502) *Approximation techniques for traveling waves of a single species delay diffusive model with age-structure and nonlocality.* Preliminary report.
Majid Bani-Yaghoub, Texas A & M University (1077-41-1427)

3:30PM (2503) *Lie symmetries to the parabolic system.*
Zhaosheng Feng, University of Texas-Pan American (1077-35-1713)

AMS Special Session on Operator Theory on Analytic Function Spaces, II

1:00 PM – 5:50 PM

Organizers: **Robert F. Allen**, University of Wisconsin, La Crosse
Katherine C. Heller, North Central College
Matthew A. Pons, North Central College

1:00PM (2504) *Invariant Subspaces for Composition Operators.* **Carl C. Cowen**, I U P U I (1077-47-264)

2:00PM (2505) *Restrictions to Invariant Subspaces of Composition Operators.* Preliminary report. **Derek Allen Thompson**, Indiana University-Purdue University Indianapolis (1077-47-1097)

2:30PM (2506) *Invertible weighted composition operators.* **Paul S. Bourdon**, Washington and Lee University (1077-47-779)

3:00PM (2507) *On the Point Spectrum of the Adjoints of Some Composition Operators and Weighted Composition Operators.* **Maria Neophytou**, Belmont University (1077-47-1746)

3:30PM (2508) *Numerical Ranges of Some Cubic Operators.* Preliminary report. **Linda J. Patton**, Cal Poly San Luis Obispo (1077-47-1979)

4:00PM (2509) *Complex Symmetric Composition Operators.* Preliminary report. **Christopher Hammond**, Connecticut College (1077-47-2318)

4:30PM (2510) *Commutants of Composition Operators on the Hardy Hilbert Space.* Preliminary report. **James M Carter**, IUPUI (1077-47-2228)

5:00PM (2511) *Generalization of Schur's test and its application.* **Ruhan Zhao**, SUNY Brockport (1077-47-1497)

5:30PM (2512) *Algebraic and Operator-theoretic properties of Hardy-Hilbert space PTOs.* **Mehdi Nikpour**, The University of Toledo (1077-47-1159)

AMS Special Session on Radon Transforms and Geometric Analysis (in honor of Sigurdur Helgason's 85th birthday), IV

1:00 PM – 5:50 PM

Organizers: **Jens Christensen**, University of Maryland
Fulton Gonzalez, Tufts University
Todd Quinto, Tufts University

1:00PM (2513) *Decomposition of spaces of distributions using Gårding vectors.* **Jens Gerlach Christensen**, Tufts University (1077-43-1820)

1:30PM (2514) *Penrose transforms between symmetric spaces.* Preliminary report. **Hideko Sekiguchi**, The University of Tokyo (1077-22-2432)

2:00PM (2515) *Cusp forms for semisimple symmetric spaces.* Preliminary report. **Erik P. van den Ban**, Utrecht University (1077-22-1515)

3:00PM (2516) *On multilinear generalized Radon transforms.* **Allan Greenleaf**, **Alex Iosevich** and **Eyvindur Ari Palsson***, University of Rochester (1077-42-1441)

3:30PM (2517) *On the associated cycle of* $(\mathfrak{g}, K)$*-modules for* $\mathfrak{g}_{\mathbb{R}} = \mathfrak{sp}(p,q)$ *or* $\mathfrak{so}^*(2n)$. **Leticia I Barchini**, Oklahoma State University (1077-22-1640)

4:00PM (2518) *Segal-Bargmann transforms: Old and new.* Preliminary report. **Bent Orsted**, Aarhus University, Denmark (1077-22-1388)

5:00PM (2519) *Cusp Forms on hyperbolic spaces.* **Nils Byrial Andersen**, Aarhus University, Denmark. (1077-44-1319)

5:30PM Discussion

AMS Special Session on Reaction Diffusion Equations and Applications, III

1:00 PM – 5:50 PM

Organizers: **Jerome Goddard II**, Auburn University Montgomery
Junping Shi, College of William and Mary
Ratnasingham Shivaji, University of North Carolina Greensboro

1:00PM (2520) *Multiple Solitary Wave Solutions of Nonlinear Schrödinger Systems.* **Rushun Tian*** and **Zhi-Qiang Wang**, Utah State University (1077-35-1771)

1:30PM (2521) *Effective Boundary Conditions Resulting from Anisotropic and Optimally Aligned Coatings: the Two Dimensional Case.* **Xinfu Chen**, University of Pittsburgh, **Cody Pond** and **Xuefeng Wang***, Tulane University (1077-35-538)

2:00PM ► (2522) R_0 *analysis of a spatiotemporal model for a stream population.* Preliminary report. **Jon Jacobsen***, Harvey Mudd College, **Yu Jin**, **Mark Lewis** and **Hannah McKenzie**, University of Alberta (1077-35-321)

2:30PM (2523) *Steklov-Fucik Spectrum and Nonlinear Elliptic Equations with Nonlinear Boundary Conditions.* Preliminary report. **N. Mavinga***, Swarthmore College, **M. N. Nkashama**, University of Alabama at Birmingham, and **S. Robinson**, Wake Forest University (1077-35-2245)

3:00PM ► (2524) *Upper and lower estimates for positive solutions of the higher order Lidstone boundary value problem.* **Bo Yang**, Kennesaw State University (1077-34-2227)

3:30PM ► (2525) *On Radial Solutions of certain Nonlinear Elliptic PDE's.* **Florin Catrina**, St. John's University (1077-35-502)

4:00PM ► (2526) *A remark on the entire solutions for a class of elliptic system with linear gradient terms.* Preliminary report. **Jaffar Ali*** and **Peng Feng**, Florida Gulf Coast University (1077-35-2446)

4:30PM (2527) *Advance of Advantageous Genes in a Three-Allele Population Genetics Model.* Preliminary report. **Linlin Su*** and **Roger Lui**, Worcester Polytechnic Institute (1077-35-1996)

5:00PM (2528) *Abstract analytical bifurcation theory and its applications.* **Ping Liu***, Harbin Normal University, **Junping Shi**, College of William and Mary, and **Yuwen Wang**, Harbin Normal University (1077-35-1084)

5:30PM (2529) *Three solutions theorem for p-Laplacian boundary value problems.*
Chan-Gyun Kim, College of William and Mary (1077-34-1096)

AMS Special Session on Recent Advances in Mathematical Biology, Ecology, and Epidemiology, III

1:00 PM – 5:50 PM

Organizers: **Sophia R. Jang**, Texas Tech University
Andrew L. Nevai, University of Central Florida
Lih-Ing W. Roeger, Texas Tech University

1:00PM (2530) *Efficacy of infection control interventions in reducing the spread of multidrug-resistant organisms in the hospital.*
Joanna R Wares*, University of RIchmond, **Erika M. C. D'Agata**, Harvard Medical School, **Mary Ann Horn**, NSF, **Shigui Ruan**, University of Miami, and **Glenn F Webb**, Vanderbilt University (1077-92-2079)

1:30PM (2531) *Analysis of a Predator-Prey Model.*
Ronald E. Mickens, Clark Atlanta University (1077-92-1551)

2:00PM (2532) *Applications of Reaction Diffusion Systems Defined on Evolving Surfaces.*
Necibe Tuncer, University of Tulsa (1077-92-773)

2:30PM (2533) *Basic Stochastic Models for Viral Infection Within a Host.* Preliminary report.
Linda J.S. Allen and **Sukhitha W Vidurupola***, Texas Tech University, Lubbock, Texas (1077-60-168)

3:00PM (2534) *High dimensional semelparous Leslie models.*
Jim M. Cushing*, University of Arizona, and **Shandelle M. Henson**, Andrews University (1077-92-1912)

3:30PM ► (2535) *Analyzing Cholera Dynamics and Controls.* Preliminary report.
Jin Wang, Old Dominion University (1077-92-88)

4:00PM ► (2536) *The community level effects of phenotypic variation within a predator population.*
Sebastian Schreiber*, University of California, Davis, **Reinhard Bürger**, University of Vienna, and **Dan Bolnick**, University of Texas, Austin (1077-92-2147)

4:30PM (2537) *Stability and Stabilization for Chemostat Models: A Survey.*
Michael Malisoff, Louisiana State University (1077-92-145)

5:00PM (2538) *Initial exponential growth rates in compartmental models.*
Fred Brauer, University of British Columbia (1077-92-1463)

5:30PM (2539) *The influence of a resource subsidy on predator-prey interactions.*
Andrew Nevai*, Univesity of Central Florida, and **Robert Van Gorder**, University of Central Florida (1077-92-1466)

AMS Special Session on Tensor Categories and Representation Theory, II

1:00 PM – 5:50 PM

Organizers: **Deepak Naidu**, Northern Illinois University
Dmitri Nikshych, University of New Hampshire

1:00PM (2540) *Brauer characters and Frobenius-Schur indicators for bismash products.* Preliminary report.
Andrea Jedwab and **M. Susan Montgomery***, University of Southern California (1077-16-576)

1:30PM (2541) *Frobenius Schur indicators of Symmetric Tensor Categories and Doubles of Groups.* Preliminary report.
Miodrag Cristian Iovanov*, University of Southern California and University of Bucharest, **Geoffrey Mason**, University of California, Santa Cruz, and **Susan Montgomery**, University of Southern California (1077-20-1493)

2:00PM (2542) *Twisted Frobenius–Schur Indicators for Hopf Algebras.*
Maria D. Vega* and **Daniel S. Sage**, Louisiana State University (1077-20-966)

2:30PM (2543) *Localization of Braid Group Representations.*
Eric C Rowell*, Texas A&M University, **Cesar Galindo**, Universidad de los Andes, and **Seung-Moon Hong**, University of Toledo (1077-20-704)

3:00PM (2544) *Classification of braided near-group categories.*
Josiah E. Thornton, University of Oregon (1077-81-1634)

3:30PM (2545) *On some fusion subcategories of the modular category of representations of a semisimple Drinfeld double.*
Sebastian Marius Burciu, Institute of Mathematics "Simion Stoilow" of Romanian Academy (1077-81-1550)

4:00PM (2546) *Congruence property and Galois symmetry of modular categories.*
Siu-Hung Ng, Iowa State University (1077-16-1787)

4:30PM (2547) *Conductors and Exponents.*
Yorck Sommerhäuser, University of South Alabama (1077-16-2707)

5:00PM ► (2548) *A fibration controlling G-graded extensions of fusion categories.* Preliminary report.
Pinhas Grossman, Instituto Nacional de Matematica Pura e Aplicada, **David A Jordan***, The University of Texas at Austin, and **Noah Snyder**, Columbia University (1077-18-1570)

5:30PM (2549) *Tensor categories and the classification of subfactors.*
Emily Peters, MIT (1077-18-2423)

MAA Invited Paper Session on Climate Change and Sustainability

1:00 PM – 4:50 PM

Organizers: **Mary Lou Zeeman**, Bowdoin College
Chris Danforth, University of Vermont

1:00PM ► (2550) *A Toy Climate Laboratory for Chaos and Differential Equations.*
Chris Danforth, Complex Systems Center, University of Vermont (1077-AE-1780)

1:30PM ► (2551) *Teaching with 'Weather in a Tank'.*
John Marshall, Massachusetts Institute of Technology (1077-AE-1777)

2:00PM ► (2552) *A Model Hierarchy for Undergraduate Education in Radiative and Convective Heat Transfer.*
Kerry A Emanuel, Massachusetts Institute of Technology (1077-AE-1828)

2:30PM ► (2553) *Exploring Sustainability in a Developmental-Level Mathematics Course.*
Rikki B. Wagstrom, Metropolitan State University (1077-AE-1867)

3:00PM ► (2554) *Sustainability in pre-calculus: leveraging biofuels data to write novel conceptual problems on function behavior and other concepts.*
Guadalupe I. Lozano, The University of Arizona (1077-AE-2788)

3:30PM ► (2555) *Environmental Mathematics in a First Year Program.* Preliminary report.
John B Little, College of the Holy Cross (1077-AE-1825)

4:00PM ► (2556) *Mathematical Modeling and Public Policy Decisions Aimed at Mitigating Climate Change.*
Frank Wattenberg, United States Military Academy (1077-AE-1822)

4:30PM (2557) *Short Term (Non-Asymptotic) Linear Stability of Ecosystems: The Role of Non-Self-Adjointness in Homogeneous and Heterogeneous Agricultural Systems.*
Gidon Eshel*, Bard College, **Andrew Ma**, Univ. of Wisconsin, and **Olivia Romeo**, Bates College (1077-AE-703)

MAA Minicourse #2: Part B

1:00 PM – 3:00 PM

A dynamical systems approach to the differential equations course.

Presenters: **Paul Blanchard**, Boston University
Robert Devaney, Boston University

MAA Minicourse #10: Part B

1:00 PM – 3:00 PM

Geometry and art: A liberal arts mathematics course.

Presenter: **Anneke Bart**, Saint Louis University

MAA Minicourse #9: Part B

1:00 PM – 3:00 PM

Reading original sources in Latin for the historian and mathematician.

Organizers: **Amy Shell-Gellasch**, Beloit College
Dominic Klyve, Central Washington University

Presenters: **Kim Plofker**, Union College
Stacy Langton, University of San Diego

AMS Session on Algebraic Topology

1:00 PM – 5:10 PM

1:00PM (2558) *Some relations in the cohomology of classifying spaces of manifold bundles.*
Ilya Grigoriev, Stanford University (1077-55-2916)

1:15PM (2559) *Homotopy Kac-Moody groups and infinite pseudoreflection groups.* Preliminary report.
John D. Foley, University of Califorina-San Diego (1077-55-2649)

1:30PM (2560) *What is the algebraic structure of topological manifolds?* Preliminary report.
Nathaniel Rounds, Indiana University (1077-55-2465)

1:45PM ► (2561) *Reflection diagrams and mixed-sign Coxeter Systems.* Preliminary report.
Johnathon Kyle Armstrong, Florida State University (1077-55-2958)

2:00PM (2562) *Homological stability properties of spaces of rational J-holomorphic curves in $\mathbb{C}P^2$.*
Jeremy Kenneth Miller, Stanford University (1077-55-1775)

2:15PM (2563) *Embedding, sectioning and compression of thickenings.*
Mokhtar Aouina, Jackson State University (1077-55-2294)

2:30PM (2564) *The Anodyne Theorem in Model Category Theory.*
David T Oury, Saint Louis University (1077-55-2376)

2:45PM ► (2565) *Applications of computational homology and cohomology theory.* Preliminary report.
Pawel Dlotko, Institute of Computer Science, Jagiellonian University in Krakow, Poland (1077-55-2362)

3:00PM Break.

3:15PM (2566) *Structured Orientations of Thom Spectra.*
Greg Chadwick, Indiana University (1077-55-416)

3:30PM (2567) *An Algebraic Proof of the Equivalence of Two Quantum 3-Manifold Invariants: The Hennings Invariant and the Kuperberg Invariant.*
Matt Sequin, The Ohio State University (1077-55-2594)

3:45PM ► (2568) *Generalizing Penner's Asymptotics For Minimal Dilatation Pseudo-Anosov Mapping Classes.*
Aaron David Valdivia, Florida State University (1077-55-1412)

4:00PM (2569) *The Milnor fiber associated to parallel connections of hyperplane arrangements.* Preliminary report.
Kristopher Williams, Doane College (1077-55-1321)

4:15PM (2570) *Proof of Edwards-Walsh resolution theorem without Edwards-Walsh complexes.*
Vera Tonic, Nipissing University, North Bay, ON, Canada (1077-55-675)

4:30PM ► (2571) *On Kawauchi's 4-moves Question.*
Noureen Khan, Unversity of North Texas at Dallas (1077-55-313)

4:45PM (2572) *The homotopy limit problem in stable representation theory.*
Daniel A. Ramras, New Mexico State University (1077-55-215)

5:00PM (2573) *A new algorithm for the Multivariable Alexander Polynomial of a Link.*
K. Grace Kennedy, University of California, Santa Barbara (1077-54-1433)

AMS Session on Classical and Abstract Harmonic Anaysis: Topological and Lie Groups

1:00 PM – 4:40 PM

1:00PM (2574) *Some characterizations of local bmo and h^1 on metric measure spaces.*
Galia Dafni, Concordia University, Canada, and **Hong Yue***, Trine University, USA (1077-42-2086)

1:15PM (2575) *Finite Biorthogonal Transforms and Multiresolution Analyses on Intervals.* Preliminary report.
David Ferrone, University of Connecticut (1077-42-1727)

1:30PM (2576) *On the WAT conjecture on the Torus.*
Faruk F. Abi-Khuzam, American University of Beirut (1077-42-1308)

1:45PM (2577) *Some Weak Convergence Theorems on Topological Semihypergroups.*
Norbert N Youmbi, Saint Francis University (1077-43-2331)

2:00PM (2578) *Multitemporal Wave Equations on Symmetric Spaces: Mean Value Solutions.* Preliminary report. **Fulton Gonzalez**, Tufts University (1077-43-2549)

2:15PM (2579) *Existence of p-Flows in $\mathbb{Z}^n$ and T_d.* **Lucio M-G Prado**, BMCC-The City University of New York (1077-31-2160)

2:30PM (2580) *Structure of shift-invariant subspaces for the Heisenberg group.* Preliminary report. **Azita Mayeli**, Queensborough College, City University of New York (CUNY) (1077-43-1236)

2:45PM Break.

3:00PM (2581) *Explicit Construction of Normalized Tight Frames and Wavelets for a Class of 2-step Nilpotent Lie Groups.* Preliminary report. **Vignon S Oussa**, Saint Louis University (1077-43-693)

3:15PM (2582) *On the Fourier inversion formula for SL_3.* Preliminary report. **Keith Ouellette**, UCLA Extension (1077-22-2489)

3:30PM (2583) *Convergence of Aluthge Iteration in Semisimple Lie Groups.* Preliminary report. **Mary Clair Thompson*** and **T.Y. Tam**, Auburn University (1077-22-840)

3:45PM (2584) *On representations and L-functions for the classical groups in positive characteristic.* Preliminary report. **Luis Alberto Lomelí**, Purdue University (1077-22-135)

4:00PM (2585) *Self-dual representations with vectors fixed under an Iwahori subgroup.* Preliminary report. **Kumar Balasubramanian**, University of Oklahoma (1077-22-1600)

4:15PM (2586) *Gradient Flows for the Minimum Distance to the Sum of Adjoint Orbits.* **Xuhua Liu*** and **Tin-Yau Tam**, Auburn University (1077-22-568)

4:30PM (2587) *Global SL(2,R) representations of the Schrodinger equation with time-dependent potentials.* Preliminary report. **Jose A Franco**, Baylor University (1077-22-1220)

AMS Session on Combinatorics and Graph Theory, VIII

1:00 PM – 5:40 PM

1:00PM ► (2588) *Total embedding distributions for some types of graphs.* Preliminary report. **Chen Yichao**, Hunan University (1077-05-594)

1:15PM ► (2589) *Generating All de Bruijn Sequences Using Preference Functions of Different Spans.* Preliminary report. **Abbas Mahdi Alhakim**, American University of Beirut (1077-05-1851)

1:30PM ► (2590) *Minor monotone floor and ceiling of certain graph parameters.* Preliminary report. **Thomas Milligan***, University of Central Oklahoma, and **Xander Rudelis**, University of Central Oklahoma / California Institute of Technology (1077-05-1926)

1:45PM ► (2591) *Performance of covert networks. (Preliminary report).* Preliminary report. **Chris Caragianis**, University of Louisville (1077-05-752)

2:00PM ► (2592) *The Metamorphosis of Maximum Packings of $2K_n$ with Triples into Maximum Packings of $2K_n$ with 4-cycles.* **P. J. Couch**, Auburn University (1077-05-725)

2:15PM ► (2593) *Hamiltonian Cycles and Symmetric Chain Partitions of Boolean Lattices.* **Noah Streib**, Georgia Institute of Technology (1077-05-694)

2:30PM (2594) *Symmetric subgroup orbit closures on the flag variety, Richardson varieties, and Schubert structure constants for (p, q)-pairs.* **Benjamin J. Wyser**, University of Georgia (1077-05-686)

2:45PM ► (2595) *On tree rotations and common parse words.* **Rik Sengupta**, Princeton University (1077-05-682)

3:00PM (2596) *Central sets and C-sets – similarities and differences.* Preliminary report. **Neil Hindman**, Howard University (1077-05-663)

3:15PM Break.

3:30PM (2597) *Acyclic List Edge Coloring of Planar Graphs.* **Hsin-Hao Lai***, National Kaohsiung Normal University, and **Ko-Wei Lih**, Academia Sinica (1077-05-519)

3:45PM (2598) *Quantum codes from finite geometry designs.* **David C Clark*** and **Vladimir D Tonchev**, Michigan Technological University (1077-05-482)

4:00PM ► (2599) *Nim on wheel graphs.* Preliminary report. **Risto Atanasov**, **Mark Budden**, Western Carolina University, **Joseph DiNatale**, Armstrong Atlantic State University, **Lindsay Erickson**, North Dakota State University, **Robert Fenney**, **William Nathan Hack**, **Maxwell Hostetter***, **Joshua Lambert**, Armstrong Atlantic State University, and **Warren Shreve**, North Dakota State University (1077-05-445)

4:15PM (2600) *Automorphisms of Random Trees.* Preliminary report. **Eric Schmutz** and **Le Yu***, Drexel University (1077-05-483)

4:30PM (2601) *Distinguishing Chromatic Numbers of Planar Maps.* **Jeffrey Manning**, California Institute of Technology (1077-05-387)

4:45PM ► (2602) *An oriented hypergraphic approach to algebraic graph theory.* **Lucas J Rusnak***, Texas State University, and **Nathan Reff**, Binghamton University (1077-05-491)

5:00PM ► (2603) *On the strong chromatic index of cubic Halin graphs.* **Ko-Wei Lih***, Academia Sinica, Taipei, and **Daphne Der-Fen Liu**, California State University, Los Angeles (1077-05-209)

5:15PM ► (2604) *On Minimun Excluded Type Algorithm, Golden Ratio, Beatty and Sturmian Sequences.* **Geremias Polanco Encarnacion**, University of Illinois at Urbana-Champaign (1077-05-208)

5:30PM ► (2605) *Geometric triangulation of interior polytope number sequences.* Preliminary report. **Michael A Jackson**, Grove City College (1077-05-70)

AMS Session on Dynamic Systems and Ergodic Theory

1:00 PM – 4:40 PM

1:00PM ► (2606) *A dynamical systems analysis of afferent control in a neuromechanical model of locomotion.* **Lucy E. Spardy***, University of Pittsburgh, **Sergey N. Markin**, **Natalia A. Shevtsova**, Drexel University College of Medicine, **Boris I. Prilutsky**, Georgia Institute of Technology, **Ilya A. Rybak**, Drexel University College of Medicine, and **Jonathan E. Rubin**, University of Pittsburgh (1077-37-2905)

1:15PM (2607) *Ambiguous shifts: symbolic dynamics from open covers.* **David Richeson**, Dickinson College, and **Jim Wiseman***, Agnes Scott College (1077-37-2518)

1:30PM (2608) *Kleinian Limit Sets in Hilbert Space.*
Tushar Das, University of North Texas (UNT) (1077-37-2302)

1:45PM (2609) *Gibbs states for non-irreducible countable Markov shifts.* Preliminary report.
Eugen Andrei Ghenciu*, East Central University, and **Mario Roy**, York University (1077-37-2029)

2:00PM (2610) *Uncovering the Lagrangian from observations of trajectories.* Preliminary report.
Yakov I Berchenko-Kogan, Massachusetts Institute of Technology (1077-37-2183)

2:15PM (2611) *Speedups of ergodic $\mathbb{Z}^d$ actions.*
Aimee S.A. Johnson and **David M. McClendon***, Swarthmore College (1077-37-2936)

2:30PM (2612) *Perturbations in the Quadratic Family with Multiple Poles.*
Elizabeth D Russell, US Military Academy (West Point) (1077-37-1964)

2:45PM Break.

3:00PM ► (2613) *A Mathematical Model of the Unfolded Protein Response to Stress in the Endoplasmic Reticulum of Mammalian Cells.*
Danilo Diedrichs, University of Iowa (1077-37-2010)

3:15PM ► (2614) *Predicting Catastrophes In Dynamical Systems Using Machine Learning.*
Jesse Berwald*, College of William and Mary, **Tomas Gedeon** and **John Sheppard**, Montana State University (1077-37-1905)

3:30PM (2615) *Dynamics of random selfmaps of surfaces with boundary and graphs.*
P. Christopher Staecker, Fairfield University (1077-37-1598)

3:45PM (2616) *Global Asymptotic Stability in a Model of Biological Networks.*
Hassan M Fathallah-Shaykh* and **Abraham Freiji**, The University of Alabama at Birmingham (1077-37-1549)

4:00PM ► (2617) *Reinventing the Wheel: The Chaotic Sandwheel.* Preliminary report.
Anthony Tongen*, **Roger J. Thelwell**, James Madison University, and **David Becerra-Alonso**, ETEA - University of Cordoba (1077-37-2527)

4:15PM (2618) *Limit Cycles, Bistability, and Global Stability by Two-Element Negative Loops in Biological Networks,.*
Abraham Freiji* and **Hassan M Fathallah-Shaykh**, The University of Alabama at Birmingham (1077-37-1545)

4:30PM ► (2619) *On μ-Compatible Metrics and Measurable Sensitivity.*
Ilya Grigoriev, **Catalin Cătălin Lubin**, Stanford University, **Amos Lubin**, University of California, Berkeley, **Nathaniel Ince**, Boston, MA, and **Cesar E. Silva***, Williams College (1077-37-2417)

AMS Session on Functional Analysis and Operator Theory, III

1:00 PM – 4:10 PM

1:00PM (2620) *Cyclicity of vectors inducing an orbit with a non-zero limit point.*
Irina Seceleanu, Bridgewater State University (1077-47-393)

1:15PM (2621) *Similarity of Operators in the Bergman Space Setting.*
Hyun Kwon*, Seoul National University, **Ronald Douglas**, Texas A & M University, and **Sergei Treil**, Brown University (1077-47-2356)

1:30PM (2622) *Algebraic Elements and Invariant Subspaces.*
Yun-Su Kim, Toledo, OH (1077-47-2234)

1:45PM (2623) *On Random Fields and Their Wavelet Transforms.*
George K. Yang, Tennessee State University (1077-44-1933)

2:00PM (2624) *Compact Weighted Composition Operators on Bergman Spaces.*
Waleed K. Al-Rawashdeh, Montana Tech of The university of Montana (1077-47-1648)

2:15PM (2625) *The many faces of linear chaos.* Preliminary report.
Gabriel T Prajitura, SUNY Brockport (1077-47-1434)

2:30PM (2626) *Convergence of the spherical averages for Markov semigroups on operator algebras.*
Genady Ya. Grabarnik*, St Johns University, and **Alexander A. Katz**, St. John's University (1077-46-2260)

2:45PM Break.

3:00PM (2627) *Feynman's Operational Calculi: Using Cauchy's Integral Formula.*
Lance Nielsen, Creighton University (1077-44-1773)

3:15PM (2628) *Rank one unitary perturbations via the theory of dilations.*
Constanze Liaw* and **Ronald G. Douglas**, Texas A&M University (1077-47-495)

3:30PM (2629) *Equations involving pseudomonotone mappings with respect to two Banach spaces.*
Dan D. Pascali, Courant Institute, New York University (1077-47-436)

3:45PM (2630) *p-operator spaces and approximation properties.*
Guimei An, Nankai University, **Jung-Jin Lee***, Mount Holyoke College, and **Zhong-Jin Ruan**, University of Illinois at Urbana-Champaign (1077-46-1743)

4:00PM (2631) *E-theory for Continuous Fields of C* algebras.* Preliminary report.
Prahlad Vaidyanathan, Purdue University, West Lafayette, IN (1077-46-2092)

AMS Session on Number Theory, Field Theory, and Polynomials, IV

1:00 PM – 4:55 PM

1:00PM (2632) *Generalizations of V.I. Arnold's version of Euler's Theorem for matrices.*
Bogdan Petrenko*, SUNY Brockport, and **Marcin Mazur**, Binghamton University (1077-11-1453)

1:15PM ► (2633) *On the behaviour of the Liouville function on polynomials with integer coefficients.*
Himadri Ganguli, Simon Fraser University (1077-11-131)

1:30PM (2634) *A New Approach to Multiplicative Arithmetic Function NumberTheory Through Isobaric Polynomials.*
Huilan Li, Drexel University, and **Trueman MacHenry***, York University (1077-11-458)

1:45PM ► (2635) *A Note on the Three-pile problem.* Preliminary report.
Roy O. Quintero, Universidad de Los Andes (1077-11-454)

2:00PM (2636) *Bounds for dimensions of degree 2 newforms.* Preliminary report.
Jeffery Breeding, Saint Louis University (1077-11-2635)

2:15PM ► (2637) *Recovering the sequence of approximation coefficients from a pair of successive pairs.*
Avraham Bourla, Trinity College (1077-11-1915)

2:30PM (2638) *On the number of positive integers not representable by a linear form in three variables.* **Amitabha Tripathi**, Indian Institute of Technology Delhi (1077-11-140)

2:45PM (2639) *Some identities involving Bernoulli and Euler numbers.* **Dae San Kim**, Sogang University (1077-11-2298)

3:00PM Break.

3:15PM (2640) *A note on Artin's primitive root conjecture.* **Maosheng Xiong**, Hong Kong University of Science and Technology (1077-11-472)

3:30PM (2641) *Generalizing Kovacic's algorithm to second order homogeneous linear differential equations with parameters.* Preliminary report. **Carlos E Arreche**, CUNY - Graduate Center (1077-12-2676)

3:45PM (2642) *A Class of Multidimensional Repeated-root Cyclic Codes.* **Edgar Martìnez-Moro**, Universidad de Valladolid, Soria, Spain, **Hakan Özadam**, Ohio University, **Ferruh Özbudak**, Universiteler Mah. Dumlupinar, Ankara, Turkey, and **Steve Szabo***, Eastern Kentucky University (1077-12-1073)

4:00PM (2643) *Linear Algebraic Groups as Paramterized Picard-Vessiot Galois Groups.* **Michael F. Singer**, North Carolina State University (1077-12-833)

4:15PM (2644) *Relations between class numbers of binary cubic forms with different splitting types over a place in an imaginary quadratic field.* **Jorge Dioses**, Oklahoma State University (1077-11-2923)

4:30PM (2645) *Number of solutions in nonnegative integers x and y to the generalized Pillai equation $\pm ra^x \pm sb^y = c$.* Preliminary report. **Robert A Styer**, Villanova University (1077-11-1786)

4:45PM (2646) *Measuring Security.* **Daniel C Smith**, National Institute of Standards and Technology (1077-12-289)

AMS Session on Numerical Analysis, II

1:00 PM – 4:55 PM

1:00PM (2647) *A nonoverlapping domain decomposition preconditioner for a symmetric interior penalty Galerkin method.* **Susanne C. Brenner**, **Eun-Hee Park*** and **Li-yeng Sung**, Louisiana State University (1077-65-1029)

1:15PM (2648) *Solution of Time-Dependent PDE Through Component-Wise Approximation of Matrix Functions.* Preliminary report. **James V Lambers**, University of Southern Mississippi (1077-65-956)

1:30PM (2649) *A Projective Method for Numerical Solution of Differential Equations.* **Oksana Bihun**, Concordia College (1077-65-996)

1:45PM (2650) *Bi-direction Projected PDHG based Multi-phase Soft Segmentation.* **Fuhua Chen***, **Yunmei Chen**, University of Florida, and **Xiaojing ye**, University of Geogia Technology (1077-65-432)

2:00PM (2651) *A Field Expansions Method for Acoustic Scattering by a Doubly Crossed Multilayered Media.* **David P. Nicholls** and **Jun Niu***, University of Illinois at Chicago (1077-65-17)

2:15PM (2652) *A Preconditioned LSQR Algorithm.* **James Baglama** and **Daniel Richmond***, University of Rhode Island (1077-65-1355)

2:30PM (2653) *Varying Iteration Accuracy Using Inexact Conjugate Gradients in Control Problems governed by PDE's.* **Xiuhong Du***, Alfred University, and **Daniel B Szyld**, Temple University (1077-65-2038)

2:45PM (2654) *On the Numerical Solution of One Nonlinear Parabolic Equation.* **Mikheil Tutberidze**, Ilia State University (1077-65-480)

3:00PM Break.

3:15PM (2655) *Time-splitting scheme for nonhydrostatic atmospheric model.* **Andrei Bourchtein*** and **Ludmila Bourchtein**, Pelotas State University, Brazil (1077-65-1814)

3:30PM (2656) *Matrix Multiplication Approximation Using Orthogonalized Outer Products.* Preliminary report. **Daniel Peach***, Bates College, **Ilse Ipsen**, **Thomas Wentworth**, North Carolina State University, and **Colin Gray**, University of Evansville (1077-65-2124)

3:45PM (2657) *Robust rational interpolation and least-squares.* **Lloyd N. Trefethen**, Oxford University Mathematical Institute (1077-65-2441)

4:00PM (2658) *Spectral Methods For The Nonlinear Hamiltonian Systems.* **Nairat Kanyamee**, Silpakorn University (1077-65-2595)

4:15PM (2659) *A mixed finite element method for Helmholtz transmission eigenvalues.* **Tiara D. Turner***, **Jiguang Sun**, Delaware State University, and **Xia Ji**, Chinese Academy of Science (1077-65-1112)

4:30PM (2660) *Immersed Finite Element Spaces with an Interior Penalty Method For Elliptic Interface Problems.* **Mohamed Ben Romdhane***, **Slimane Adjerid** and **Tao Lin**, Virginia Polytechnic Institute and State University (1077-65-1210)

4:45PM (2661) *An analytic function without radial boundary values.* **J. Marshall Ash**, DePaul University (1077-30-1942)

AMS Session on Undergraduate Research, VI

1:00 PM – 3:55 PM

1:00PM (2662) *Metapopulation Modeling and Analysis with Demographic Stochasticity.* Preliminary report. **Eric Eager**, University of Nebraska, Lincoln, **Mary Hebert**, Northwestern State University, **Elise Hellwig***, Colorado College, **Francisco Hernandez-Cruz**, Occidental College, **Richard Rebarber**, **Brigitte Tenhumberg**, University of Nebraska, Lincoln, and **Bryan Wigianto**, Rice University (1077-92-1995)

1:15PM (2663) *Finger Motion Modeling for Bionic Fingers.* Preliminary report. **Myrielle N Allen-Prince***, Bennett College, and **Jay Walton**, Texas A&M University (1077-92-1324)

1:30PM (2664) *A Reservoir Model of Chagas Disease.* **Sara Anne Krueger***, Bethany Lutheran College, **May Boggess** and **Jay Walton**, Texas A&M University (1077-92-362)

1:45PM (2665) *Eradicating Invasive Species through Sex Reversal.* Preliminary report. **Katie Storey***, Carleton College, **May Boggess** and **Jay Walton**, Texas A&M University (1077-92-356)

2:00PM (2666) *An Analysis of the Coexistence of Three Competing Species with a Shared Pathogen.* **Vrushali A. Bokil** and **Margaret-Rose W. Leung***, Oregon State University (1077-92-1758)

2:15PM ► (2667) *Periodic Rigidity of Protein Crystal Structures.* Preliminary report.
Samantha Monastra*, **Pamela Clark**, **Jessica Grant** and **Ileana Streinu**, Smith College (1077-92-1946)

2:30PM Break.

2:45PM ► (2668) *3D Numerical Simulation of Microscopic Flagellar Movement With Prescribed Motion at Low Reynolds Number.*
Olga Stulov*, State University of New York at New Paltz, and **Xingzhou Yang**, Mississippi State University (1077-92-1890)

3:00PM ► (2669) *How does the effort a mother bird expends on her offspring depend on the attractiveness of her mate?* Preliminary report.
Tucker Gilman, **Tony Jhwueng**, National Institute of Mathematical and Biological Synthesis (NIMBioS), **Dana Botesteanu***, Mount Holyoke College, **Frances Goglio**, University of Wisconsin at Madison, and **Yicong Yong**, University of Florida (1077-92-196)

3:15PM ► (2670) *Topological Obstructions to Consensus on $SO(3)$.*
Eric B Auld, Arizona State University (1077-93-2922)

3:30PM ► (2671) *An Extension of the Fundamental Theorem of Calculus.* Preliminary report.
Zengxiang Tong* and **Zhen Huang**, Otterbein University (1077-97-1080)

3:45PM (2672) *Teacher Change in the Context of a Proof-Centered Professional Development.*
Osvaldo Daniel Soto, University of California at San Diego (1077-97-2781)

MAA Session on Innovations in Teaching Statistics in the New Decade, II

1:00 PM – 4:55 PM

Organizers: **Andrew Zieffler**, University of Minnesota
Brian Gill, Seattle Pacific University
Nancy Boynton, SUNY Fredonia

1:00PM ► (2673) *Introducing Statistical Inference using Randomization Methods.* Preliminary report.
Todd Swanson* and **Jill VanderStoep**, Hope College (1077-E5-2338)

1:20PM (2674) *From Tactile to Computer Simulation: An Intermediate Activity to Increase Understanding of Sampling Distributions.* Preliminary report.
Sean D Simpson*, Westchester Community College, **Stacey Hancock**, Clark University, **Jennifer Noll**, Portland State University, and **Aaron Weinberg**, Ithaca College (1077-E5-2468)

1:40PM ► (2675) *Using Alternative Forced Choice Models to Introduce the Concepts of Statistical Inference.*
Christopher John Malone*, **Tisha Hooks** and **April Kerby**, Winona State University (1077-E5-2007)

2:00PM ► (2676) *Engaging Students in Reasoning About the Logic of Hypothesis Testing.*
Christina Erbacher* and **Hollylynne Stohl Lee**, North Carolina State University (1077-E5-1353)

2:20PM ► (2677) *Engaging Adult Learners in the Application of Statistical Processes to Solve Real World Problems.*
Michael D. Miner, American Public University (1077-E5-2567)

2:40PM ► (2678) *Teaching by the Test.*
John D. McKenzie, Babson College (1077-E5-2763)

3:00PM ► (2679) *Statistics and the (Post-) Millennial Student.*
Patricia B Humphrey, Georgia Southern University (1077-E5-2317)

3:20PM ► (2680) *New Trends in Teaching an Introductory Biostatistics Course.*
Magdalena Luca, Massachusetts College of Pharmacy and Health Sciences (1077-E5-2074)

3:40PM ► (2681) *Teaching an effective multi-section elementary statistics course.* Preliminary report.
Katarzyna Kowal, Ramapo College of New Jersey (1077-E5-1234)

4:00PM ► (2682) *Introducing Sampling Distributions and Hypothesis Testing using Hands-On Simulations and Student Response Technology.*
Chris Oehrlein, Oklahoma City Community College (1077-E5-2429)

4:20PM ► (2683) *Teaching Statistical Literacy Entirely Online: 2011.* Preliminary report.
Milo Schield, Statistical Literacy Project (1077-E5-2503)

4:40PM ► (2684) *A Statistical Odyssey: Modernizing the Discussion Board to Enhance Student Engagement.* Preliminary report.
Kimberly J Presser, Shippensburg University (1077-E5-1341)

MAA Session on Trends in Teaching Mathematics Online, II

1:00 PM – 5:55 PM

Organizer: **Michael B. Scott**, California State University, Monterey Bay

1:00PM ► (2685) *WIRIS collection, a repository of ready-made online exercises for self-assessment.*
Carles Aguilo* and **Ramon Eixarch**, WIRIS team at Maths for More (1077-O5-201)

1:20PM ► (2686) *Using SmartPens to Facilitate Math Communication Online.*
Katrina M Palmer, Appalachian State University (1077-O5-210)

1:40PM (2687) *Increasing interaction in online courses.*
Revathi Narasimhan, Kean University (1077-O5-404)

2:00PM ► (2688) *Providing Intelligent Step-by-Step Help in Solving Practice Problems Online.* Preliminary report.
John C. Miller, The City College of C.U.N.Y. (1077-O5-396)

2:20PM ► (2689) *Connecting Students with Mathematics: The Power of Combining ALEKS and Wimba.*
Cheryll E Crowe, Eastern Kentucky University (1077-O5-577)

2:40PM (2690) *Gluing together Blackboard, Facebook, and Twitter.*
Matthew Leingang, New York University (1077-O5-841)

3:00PM ► (2691) *Improving Pedagogy Through Adaptive Problem Selection in Online Tutors.*
Douglas B. Meade*, University of South Carolina, and **Philip B. Yasskin**, Texas A&M University (1077-O5-1158)

3:20PM ► (2692) *"Elluminate-ing" Online Course Meetings.*
Sarah L Mabrouk, Framingham State University (1077-O5-2912)

3:40PM ► (2693) *Designing, Developing and Assessing an Online Mathematics Course.* Preliminary report.
Ahlam E.H Tannouri, Morgan State University (1077-O5-2887)

4:00PM (2694) *High Touch to High Tech: Distance Learning in a Small Liberal Arts College.*
Ellen Cunningham, Saint Mary-of-the-Woods College (1077-O5-2536)

4:20PM (2695) *A new kind of online homework: Flash enabled WeBWorK homework problems.*
Barbara Margolius*, Cleveland State University, **Daniel Gries**, Hopkins School, **L Felipe Martins** and **Yuping Wu**, Cleveland State University (1077-O5-2498)

► 4:40PM (2696) *Distributome–An Interactive Web-based Resource for Probability Distributions.* Preliminary report.
Kyle Siegrist*, University of Alabama in Huntsville, **Ivo Dinov**, University of California, Los Angeles, and **Dennis Pearl**, The Ohio State University (1077-O5-2544)

► 5:00PM (2697) *The Instructor's Perspective: How to Make Learning Mathematics an Interactive Experience in an Online Environment.*
Aimee J Ellington, Virginia Commonwealth University (1077-O5-2472)

► 5:20PM (2698) *Teaching Python In One Browser Window.*
Graeme Kemkes, Ryerson University, and **David Pritchard***, University of Waterloo (1077-O5-2391)

► 5:40PM (2699) *Teaching an Online Sophomore-Level Differential Equations Course.* Preliminary report.
William M. Kinney, Bethel University (1077-O5-2333)

MAA Session on the Mathematical Preparation of Teachers: The Impact of the Common Core State Standards Initiative, II

1:00 PM – 2:35 PM

Organizers: **Kenneth C. Millett**, University of California, Santa Barbara
Elizabeth Burroughs, Montana State University
Holly Peters Hirst, Appalachian State University
William McCallum, The University of Arizona

1:00PM (2700) *Designing Professional Development around the CCSS Standards for Mathematical Practice: A Mathematician-Teacher Collaboration.*
Juliana V. Belding, Harvard University (1077-F5-2746)

► 1:20PM (2701) *The Standards for Mathematical Practice: Principles Guiding Pre-service Preparation and In-service Professional Development.* Preliminary report.
Bernadette Mullins*, Birmingham-Southern College, **Faye Clark**, **Ann Dominick** and **Sherry Parrish**, University of Alabama at Birmingham (1077-F5-2581)

► 1:40PM (2702) *Integrating content, pedagogy, and cognitive coaching: a professional development model.* Preliminary report.
Barbara Henriques and **Ekaterina Lioutikova***, Saint Joseph College (CT) (1077-F5-1533)

► 2:00PM (2703) *Professional Development for Grades K-8 Mathematics Coaches.*
Elizabeth A. Burroughs, Montana State University (1077-F5-1012)

2:20PM (2704) *Early Implementation of CCSS via Standards for Mathematical Practice.*
Davida D Fischman, CSU San Bernardino (1077-F5-795)

SIAM Minisymposium on Variational and PDE Methods in Imaging Science

1:00 PM – 5:55 PM

Organizers: **Otmar Scherzer**, University of Vienna
Alexandru Tamasan, University of Central Florida
Luminita Vese, University of Californina Los Angeles

1:00PM (2705) *Consistency Conditions for Cone-Beam CT Data Acquired with a Linear Source Trajectory.*
Margo S Levine*, Harvard University, School of Engineering and Applied Sciences, **Emil Y Sidky** and **Xiaochuan Pan**, Department of Radiology, The University of Chicago (1077-35-2558)

1:30PM (2706) *Thermoacoustic and Photoacoustic Tomography with a variable continuous or discontinuous sound speed.*
Plamen Stefanov, Purdue University (1077-35-1240)

2:00PM (2707) *Characterization of Sobolev and BV spaces.*
Giovanni Leoni, Carnegie Mellon University, and **Daniel Spector***, Zhejiang University (1077-46-1815)

2:30PM (2708) *Reconstruction Formulas for Photoacoustic Sectional Imaging.*
Peter Elbau, Johann Radon Institute for Computational and Applied Mathematics (RICAM) (1077-35-2146)

3:00PM (2709) *Regularization of Optical Methods for Computing Flow Dynamics.* Preliminary report.
Aaron Luttman*, **Erik Bollt**, **Ranil Basnayake** and **Sean Kramer**, Clarkson University (1077-49-2055)

3:30PM (2710) *Acousto-Optic Tomography and Related Inverse Problems.*
John C. Schotland, University of Michigan (1077-78-1311)

4:00PM (2711) *Multiobjective Optimization Methods for Shape-Based Joint Inversion.*
Alireza Aghasi* and **Eric Miller**, Tufts University (1077-35-2380)

► 4:30PM (2712) *Coherent Interferometry Algorithms for Photoacoustic Imaging.*
Vincent Jugnon*, Massachusetts Insitute of Technology, **Habib Ammari**, **Josselin Garnier**, Ecole Normale Superieure Paris, and **Elie Bretin**, Ecole Polytechnique (1077-35-1850)

5:00PM (2713) *A Computational Method for Measure Matching Using Metamorphosis.*
Casey L Richardson*, Center for Imaging Science, Johns Hopkins University, and **Laurent Younes**, Johns Hopkins University (1077-49-2477)

5:30PM (2714) *Conductivity imaging from one interior measurement in the presence of perfectly conducting and insulating inclusions.*
Amir Moradifam*, **Adrian Nachman**, University of Toronto, and **Alexandru Tamasan**, University of Central Florida (1077-35-1895)

SIGMAA on Math Circles for Students and Teachers Poster and Activity Sessions

1:00 PM – 4:00 PM

Presentations on the Circle activities listed below will be given at the indicated times; complete programs will be available in the session room.

Organizers: **Philip B. Yasskin**, Texas A&M University
James Tanton, St. Mark's School
Tatiana Shubin, San Jose State University
Sam Vandervelde, St. Lawrence University

1:00PM *Rolling Dice; Slide Rules Rule; Tiling Torment; Six Choose Three.*

1:30PM *Math Education Perspective on Math Circles; Drawing Pictures: How Projective Geometry Was Discovered; Symmetries of the Trihexaflexagon; Making Change for a Dollar.*

2:00PM *Math Education Perspective on Math Circles; Excel vs. Fibonacci; Slide Rules Rule; 3x3 Magic Squares.*

2:30PM *Rolling Dice; Peering Through Tubes; Symmetries of the Trihexaflexagon; The Handshake Problem.*

3:00PM *Excel vs. Fibonacci; Tiling Torment; The Handshake Problem; Making Change for a Dollar.*

3:30PM *Peering Through Tubes; Drawing Pictures: How Projective Geometry Was Discovered; 3x3 Magic Squares; Six Choose Three.*

AWM Workshop Panel Discussion

1:00 PM – 2:15 PM

Career options: Industry, government, and academia

Moderator: **Alissa Crans**, Loyola Marymount University

Panelists: **Jennifer Chayes**, Microsoft Research

Melissa Choi, Massachusetts Institute of Technology Lincoln Laboratory

Navah Langmeyer, National Security Agency

Peter March, The Ohio State University

AMS Session on Linear and Multilinear Algebra: Matrix Theory

1:15 PM – 4:55 PM

1:15PM (2715) *A fast iterative Toeplitz solver.* Preliminary report.
Joseph Kolibal* and **Eowyn Cenek**, The University of Southern Mississippi (1077-15-2225)

1:30PM (2716) *Clustering edges and vertices using fuzzy logic, case study: news documents.*
Walid Sharabati, Purdue University (1077-15-2926)

1:45PM (2717) *Variations of orbit reflexivity for matrices.*
Ileana Ionascu, Philadelphia University (1077-15-2917)

2:00PM ► (2718) *Enumerating Invariant Subspaces of* $\mathbb{R}^n$.
Joshua Ide* and **Lenny Jones**, Shippensburg University (1077-15-2250)

2:15PM (2719) *Identifying a Basis in a Frame.*
Dominic Kramer, Iowa State University (1077-15-2067)

2:30PM (2720) *Lower Rank Approximation: A Generalization of Schmidt-Mirsky Theorem and Algorithms.*
Yang Liu, College of William & Mary (1077-15-1806)

2:45PM (2721) *A characterization of Leonard pairs using the parameters* $\{a_i\}_{i=0}^{d}$.
Edward D. Hanson, University of Wisconsin-Madison (1077-15-2602)

3:00PM Break.

3:15PM (2722) *The algebraic connectivity of graphs as a function of genus.*
Jason J Molitierno, Sacred Heart University (1077-15-1548)

3:30PM ► (2723) *Positive Semidefinite Zero Forcing.* Preliminary report.
Travis A. Peters, Iowa State University (1077-15-1387)

3:45PM ► (2724) *On the eigenvalues and eigenvectors of the adjacency matrices of the complete graphs and complete bipartite graphs.* Preliminary report.
Nasser Dastrange, Buena Vista University (1077-15-1076)

4:00PM ► (2725) *Lower Bounds for Minimum Semi-definite Rank from Orthogonal Removal and Chordal Supergraphs.*
Sivaram K. Narayan, Central Michigan University (1077-15-100)

4:15PM (2726) *Lehmer's conjecture for Hermitian matrices over the Eisenstein and Gaussian integers.* Preliminary report.
Gary Greaves, Royal Holloway, University of London., and **Graeme Taylor***, University of Bristol (1077-15-66)

4:30PM ► (2727) *Dense 2-generator subsemigroups of* 2×2 *matrices.*
Mohammad Javaheri, Siena College (1077-15-368)

4:45PM (2728) *On the structure of certain class of Toeplitz-like Kernels.*
Troy V Banks, Salisbury University (1077-15-2873)

AMS Session on Partial Differential Equations, III

1:15 PM – 4:10 PM

1:15PM (2729) *Global Attractors for Damped Semilinear Wave Equations with a Robin–Acoustic Boundary Perturbation.* Preliminary report.
Joseph L. Shomberg*, Providence College, and **Sergio Frigeri**, University of Pavia (1077-35-853)

1:30PM (2730) *Explicit Flow Equations and Recursion Operator of the ncKP hierarchy.*
Jingsong He, Ningbo University, **Junyi Tu***, U of South Florida, **Xiaodong Li**, China, and **Lihong Wang**, Ningbo University (1077-35-586)

1:45PM (2731) *Dynamics of single species influenced by age-dependent dispersal and maturation time delay.* Preliminary report.
Majid Bani-Yaghoub, Texas A & M University (1077-35-465)

2:00PM ► (2732) *An inverse electromagnetic scattering problem for cavity.*
Fang Zeng*, **Jiguang Sun**, Delaware State University, and **Fioralba Cakoni**, University of Delaware (1077-35-1111)

2:15PM (2733) *Sign-changing solutions of the semilinear hyperbolic equations.*
Karen Yagdjian, University of Texas-Pan American (1077-35-2443)

2:30PM Break.

2:45PM ► (2734) *Implementation of a Direct D-bar Reconstruction Algorithm for Recovering a Complex Admittivity Distribution from Electrical Impedance Tomography Data.* Preliminary report.
Sarah Jane Hamilton, Colorado State University (1077-35-220)

3:00PM (2735) *Multipeakons in the Degasperis-Procesi Equation II.*
Lingjun Zhou, Tongji University (1077-35-1303)

3:15PM (2736) *Frechet Sensitivity Analysis for the Convection-Diffusion Equation.*
Vitor Leite Nunes, Virginia Polytechnic Institute & State University (1077-35-287)

3:30PM (2737) *Well-Posedness of Liquid Crystal Flow in* L^3_{uloc}.
Preliminary report.
Jay Lawrence Hineman, University of Kentucky (1077-35-2819)

3:45PM (2738) *The Nonlinear Schrödinger equation via fixed point principles.*
Mihaela Manole*, Timpson ISD, Texas, and **Radu Precup**, Babes Bolyai University (1077-35-41)

► 4:00PM (2739) *Standing-waves solutions to a system of non-linear Klein-Gordon equations with a sub-critical growth non-linearity.* Preliminary report.
Daniele Garrisi, POSTECH (1077-35-713)

MAA Session on Early Assessment: Find Out What Your Students Understand (and Don't Understand) before They Take the Test

1:20 PM – 3:35 PM

Organizers: **Miriam Harris-Botzum**, Lehigh Carbon Community College
Bonnie Gold, Monmouth University

► 1:20PM (2740) *Making sure the students understand a concept by watching them working with it.*
Rodica Cazacu, Georgia College (1077-D1-1615)

► 1:40PM (2741) *Using Online Pretests and Try It Quizzes for Early Assessment and Remediation.* Preliminary report.
Brenda Burns-Williams* and **Megan Sawyer**, North Carolina State University, Raleigh (1077-D1-2735)

► 2:00PM (2742) *Voting your way to good discussions.* Preliminary report.
Christopher K Storm, Adelphi University (1077-D1-2177)

► 2:20PM (2743) *Formative Assessments in Upper Division Mathematics.*
Brian P Kelly, Bryant University (1077-D1-2915)

► 2:40PM (2744) *Formative assessment and learning trajectories in first semester calculus.* Preliminary report.
Rebecca Anne Dibbs, University of Northern Colorado (1077-D1-1184)

► 3:00PM (2745) *An Enhanced Implementation of the WeBWorK Online Homework System as a Formative Assessment Instrument.* Preliminary report.
Gulden Karakok*, University of Northern Colorado, **Aaron Wangberg**, Winona State University, and **Nicole Engelke**, California State University Fullerton (1077-D1-2634)

► 3:20PM (2746) *MathLynx: the Online and CAS-based Mathematics Pedagogy Environment - Tools for Learning and Practice.*
John A. Velling, Brooklyn College (1077-D1-2484)

AMS Special Session on Geometric Invariants of Groups and Related Topics, II

1:30 PM – 4:50 PM

Organizers: **Nic Koban**, University of Maine, Farmington
Peter N. Wong, Bates College

1:30PM (2747) *Sigma invariants of some self-similar groups.*
Susan Hermiller, University of Nebraska, and **Zoran Sunic***, Texas A&M University (1077-20-2773)

2:00PM (2748) *Sigma invariants for Thompson and generalised Thompson groups.* Preliminary report.
Dessislava Hristova Kochloukova*, State University of Campinas (UNICAMP), Campinas, SP, Brazil, **Robert Bieri** and **Ross Geoghegan**, University of Binghamton, SUNY (1077-20-429)

2:30PM (2749) *The BNS-invariant of pure braid groups.* Preliminary report.
John Meier, Lafayette College (1077-20-1838)

3:00PM (2750) *The Ω-invariant of a semi-direct product of groups.* Preliminary report.
Nic Koban*, University of Maine Farmington, and **Peter Wong**, Bates College (1077-20-1666)

3:30PM (2751) *Sigma theory and twisted conjugacy classes.*
Daciberg Lima Goncalves*, IME-Unversity of São Paulo, and **Dessislava H. Kouchloukova**, University of Campinas (1077-20-729)

4:00PM (2752) *Ω^n invariants and twisted conjugacy classes.*
Nic Koban, University of Maine, Farmington, and **Peter Wong***, Bates College (1077-20-2323)

4:30PM Discussion

ASL Invited Address

2:15 PM – 3:05 PM

(2753) *Twenty Questions.*
Roman Kossak, CUNY Graduate Center (1077-03-156)

AMS Session on Mathematics Education

2:15 PM – 5:10 PM

2:15PM (2754) *Using Dynamic Web Tools Across the Early Undergraduate Mathematics Curriculum.*
Michael E Martin, Johnson County Community College (1077-97-317)

► 2:30PM (2755) *Self paced mathematics in college and high school.*
Jay P Belanger, Truman State University (1077-97-2943)

► 2:45PM (2756) *Exhibit Designs for the Museum of Mathematics.*
George W. Hart, Museum of Mathematics (1077-97-2889)

3:00PM (2757) *On Doing Mathematics: Why We Should Not Encourage Feeling, Believing or Interpreting Mathematics..*
Padraig M. McLoughlin, Kutztown University of Pennsylvania (1077-97-1254)

► 3:15PM (2758) *Developing a Protocol for Analyzing the Quality of Classroom Interactions in an Undergraduate Calculus Course.* Preliminary report.
Matthew Thomas*, **Guadalupe Lozano**, **Cody Patterson** and **Jennifer Eli**, University of Arizona (1077-97-2342)

3:30PM Break

► 3:45PM (2759) *Learning Math by Making Math.*
Bruce Carpenter* and **Debra Woods**, University of Illinois (1077-97-2506)

► 4:00PM (2760) *Playing with Multivariable Calculus Concepts Wearing 3D Glasses.* Preliminary report.
Paul E Seeburger, Monroe Community College (1077-97-2080)

► 4:15PM (2761) *Two for One: Combining Developmental and Intermediate Algebra into a Four-Credit Course Using Youtube and ALEKS.* Preliminary report.
Shubhangi Sadanand Stalder*, University of Wisconsin Waukesha, and **Paul Arthur Martin**, University of Wisconsin Marathon (1077-97-2656)

► 4:30PM (2762) *Understanding Representations and Manipulatives through the Eyes of Preservice Teachers.* Preliminary report.
James R. Valles, Jr.*, Saint Mary-of-the-Woods College, **Rebecca Ortiz** and **Xiaobo She**, Texas Tech University (1077-97-2913)

► 4:45PM (2763) *Assessing the impact of a computer-based college algebra course.*
Ningjun Ye, University of Southern Mississippi (1077-97-676)

5:00PM ► (2764) *The Mathematics of Proofs in Number Theory and Algebra for High Achieving High School Students.* Preliminary report.
Richard Millman*, **Daniel Connelly** and **Cher Hendricks**, Georgia Institute of Technology (1077-97-521)

AWM Workshop: Research Presentations by Recent Ph.D.s

2:30 PM – 4:20 PM

Organizers: **Alissa Crans**, Loyola Marymount University
Rachelle DeCoste, Wheaton College
Kirsten Eisentraeger, Pennsylvania State University
Susan Williams, University of South Alabama

2:30PM ► (2765) *Algebraic theory for discrete models in systems biology.*
Franziska Hinkelmann*, Mathematical Biosciences Institute, Ohio State University, and **Reinhard Laubenbacher**, Virginia Bioinformatics Institute, Virginia Tech (1077-92-203)

3:00PM (2766) *Theories without the independence property.*
Lynn C. Scow, University of Illinois at Chicago (1077-03-246)

3:30PM (2767) *A Functional Central Limit Theorem for Empirical Processes.*
Cristina Tone, University of Louisville (1077-60-247)

4:00PM (2768) *A fluid-structure interaction problem for a supercavitating elastic curvilinear foil.*
Anna Zemlyanova, Texas A&M University (1077-76-253)

AMS-MAA-SIAM Gerald and Judith Porter Public Lecture

3:00 PM – 4:00 PM

(2769) *Geometric puzzles: Algorithms and complexity.*
Erik D. Demaine, Massachusetts Institute of Technology (1077-51-15)

MAA Session on Writing the History of the MAA, II

3:00 PM – 4:55 PM

Organizers: **Victor J. Katz**, University of the District of Columbia
Janet Beery, University of Redlands
Amy Shell-Gellasch, Beloit College

3:00PM (2770) *Digging up the History of a Capital Section.* Preliminary report.
Betty Mayfield*, Hood College, and **Jon Scott**, Montgomery College (1077-Q1-771)

3:20PM ► (2771) *The Kentucky Section.* Preliminary report.
Daniel J. Curtin, Northern Kentucky University (1077-Q1-661)

3:40PM ► (2772) *Dean Meder and the Origins of the MAA - New Jersey Section.* Preliminary report.
Lawrence A. D'Antonio, Ramapo College of New Jersey (1077-Q1-742)

4:00PM ► (2773) *Women Welcome in the Metro New York Section!* Preliminary report.
Agnes M. Kalemaris, Farmingdale State College (1077-Q1-2249)

4:20PM ► (2774) *Writing a History of an MAA Section.* Preliminary report.
James R Choike, Oklahoma State University (1077-Q1-1275)

4:40PM ► (2775) *Know Your Wisconsin Mathematician: The Oral History of an MAA Section.*
Benjamin V.C. Collins*, University of Wisconsin-Platteville, and **Jeganathan Sriskandarajah**, Madison College (1077-Q1-374)

ASL Invited Address

3:15 PM – 4:05 PM

(2776) *Continuous first order logic and Gurarii's universal homogeneous separable Banach Space.*
C. Ward Henson, University of Illinois at Urbana-Champaign (1077-03-154)

ASL Contributed Paper Session, III

4:15 PM – 6:15 PM

4:15PM (2777) *Superstable generic graphs with rich geometries.*
Justin Brody, Franklin and Marshall College

4:40PM (2778) *Classical consequences of continuous choice principles from intuitionistic analysis.*
François G. Dorais, Appalachian State University

5:05PM (2779) *Computing boundary extensions of conformal maps.*
Timothy H. McNicholl, Lamar University

5:30PM (2780) *The decision problem of $T_{\to}$.*
Katalin Bimbó*, University of Alberta, and **J.Michael Dunn**, Indiana University

5:55PM (2781) *An Umbrella Formalism for Examining Self-Justifying Systems.*
Dan E. Willard, University at Albany

AMS Banquet Reception

6:30 PM – 7:30 PM

AMS Banquet

7:30 PM – 10:00 PM

Michel L. Lapidus
AMS Associate Secretary
Riverside, California

Gerard A. Venema
MAA Associate Secretary
Grand Rapids, Michigan

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

Western Section: Michel L. Lapidus, Department of Mathematics, University of California, Surge Bldg., Riverside, CA 92521-0135; e-mail: lapidus@math.ucr.edu; telephone: 951-827-5910.

Central Section: **Georgia Benkart**, University of Wisconsin-Madison, Department of Mathematics, 480 Lincoln Drive, Madison, WI 53706-1388; e-mail: benkart@math.wisc.edu; telephone: 608-263-4283.

Eastern Section: **Steven H. Weintraub**, Department of Mathematics, Lehigh University, Bethlehem, PA 18105-3174; e-mail: steve.weintraub@lehigh.edu; telephone: 610-758-3717.

Southeastern Section: **Matthew Miller,** Department of Mathematics, University of South Carolina, Columbia, SC 29208-0001, e-mail: miller@math.sc.edu; telephone: 803-777-3690.

The Meetings and Conferences section of the *Notices* gives information on all AMS meetings and conferences approved by press time for this issue. Please refer to the page numbers cited in the table of contents on this page for more detailed information on each event. Invited Speakers and Special Sessions are listed as soon as they are approved by the cognizant program committee; the codes listed are needed for electronic abstract submission. For some meetings the list may be incomplete. **Information in this issue may be dated. Up-to-date meeting and conference information can be found at** www.ams.org/meetings/.

Meetings:

2012

January 4–7	Boston, Massachusetts Annual Meeting	p. 112
March 3–4	Honolulu, Hawaii	p. 112
March 10–11	Tampa, Florida	p. 113
March 17–18	Washington, DC	p. 116
March 30–April 1	Lawrence, Kansas	p. 120
September 22–23	Rochester, New York	p. 121
October 13–14	New Orleans, Louisiana	p. 122
October 20–21	Akron, Ohio	p. 122
October 27–28	Tucson, Arizona	p. 122

2013

January 9–12	San Diego, California Annual Meeting	p. 123
March 1–3	Oxford, Mississippi	p. 123
April 6–7	Chestnut Hill, Massachusetts	p. 123
April 27–28	Ames, Iowa	p. 123
June 27–30	Alba Iulia, Romania	p. 124
October 5–6	Louisville, Kentucky	p. 124
October 18–20	St. Louis, Missouri	p. 124
November 2–3	Riverside, California	p. 124

2014

January 15–18	Baltimore, Maryland Annual Meeting	p. 124
June 16–19	Tel Aviv, Israel	p. 125

2015

January 10–13	San Antonio, Texas Annual Meeting	p. 125
June 11–14	Porto, Portugal	p. 125

2016

January 6–9	Seattle, Washington	p. 125

2017

January 4–7	Atlanta, Georgia	p. 125

2018

January 10–13	San Diego, California	p. 125

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 111 in the this issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

Abstracts

Speakers should submit abstracts on the easy-to-use interactive Web form. No knowledge of LaTeX is necessary to submit an electronic form, although those who use LaTeX may submit abstracts with such coding, and all math displays and similarly coded material (such as accent marks in text) must be typeset in LaTeX. Visit http://www.ams.org/cgi-bin/abstracts/abstract.pl. Questions about abstracts may be sent to abs-info@ams.org. Close attention should be paid to specified deadlines in this issue. Unfortunately, late abstracts cannot be accommodated.

Conferences: (see http://www.ams.org/meetings/ for the most up-to-date information on these conferences.)

February 16–20, 2012: AAAS Meeting in Vancouver, British Columbia, Canada(please see www.aaas.org/meetings for more information.)

March 11–14, 2012: Fourth International Conference on Mathematical Sciences, United Arab Emirates (held in cooperation with the AMS). Please see http://icm.uaeu.ac.ae/ for more information.

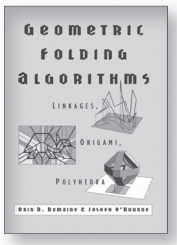
June 10–June 30, 2012: MRC Research Communities, Snowbird, Utah. (Please see http://www.ams.org/amsmtgs/mrc.html for more information.)

CAMBRIDGE

MATHEMATICS TITLES *from* CAMBRIDGE!

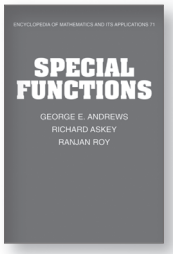
Books by Invited Speakers at the 2012 Joint Mathematics Meeting

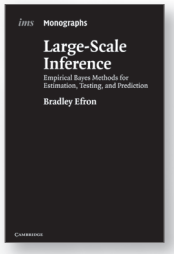
Geometric Folding Algorithms
Linkages, Origami, Polyhedra
Erik D. Demaine, Joseph O'Rourke
$104.00: Hb: 978-0-521-85757-4: 496 pp.



Integer Partitions
George E. Andrews, Kimmo Eriksson
$39.00: Hb: 978-0-521-84118-4: 152 pp.
$35.99: Pb: 978-0-521-60090-3

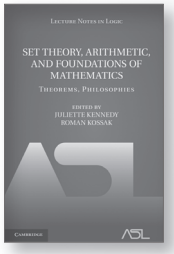
Special Functions
George E. Andrews, Richard Askey, Ranjan Roy
Encyclopedia of Mathematics and its Applications
$66.99: Pb: 978-0-521-78988-2: 682 pp.

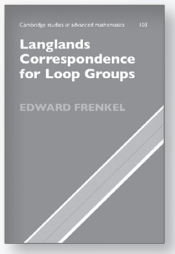




Large-Scale Inference
Empirical Bayes Methods for Estimation, Testing, and Prediction
Bradley Efron
Institute of Mathematical Statistics Monographs
$70.00: Hb: 978-0-521-19249-1: 276 pp.

Set Theory, Arithmetic, and Foundations of Mathematics
Theorems, Philosophies
Edited by Juliette Kennedy, Roman Kossak
Lecture Notes in Logic
$70.00: Hb: 978-1-107-00804-5: 242 pp.

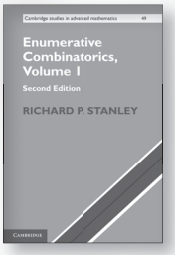


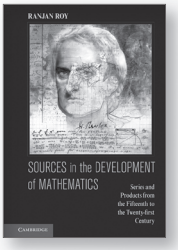


Langlands Correspondence for Loop Groups
Edward Frenkel
Cambridge Studies in Advanced Mathematics
$112.00: Hb: 978-0-521-85443-6: 396 pp.

Enumerative Combinatorics
Volume 1
Richard P. Stanley
Cambridge Studies in Advanced Mathematics
$125.00: Hb: 978-1-107-01542-5: 640 pp.
$49.99: Pb: 978-1-107-60262-5

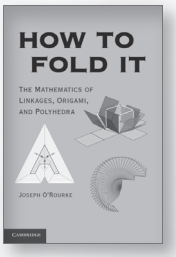
2nd Edition!

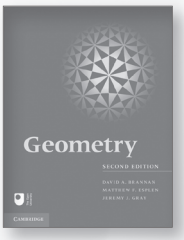




Sources in the Development of Mathematics
Series and Products from the Fifteenth to the Twenty-first Century
Ranjan Roy
$99.00: Hb: 978-0-521-11470-7: 994 pp.

How to Fold It
The Mathematics of Linkages, Origami and Polyhedra
Joseph O'Rourke
$80.00: Hb: 978-0-521-76735-4: 192 pp.
$27.99: Pb: 978-0-521-14547-3





Geometry
David A. Brannan, Matthew F. Esplen, Jeremy J. Gray
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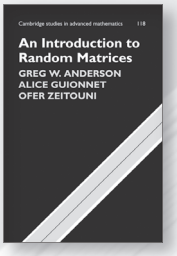

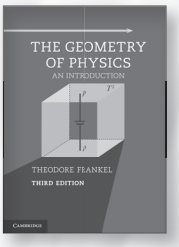

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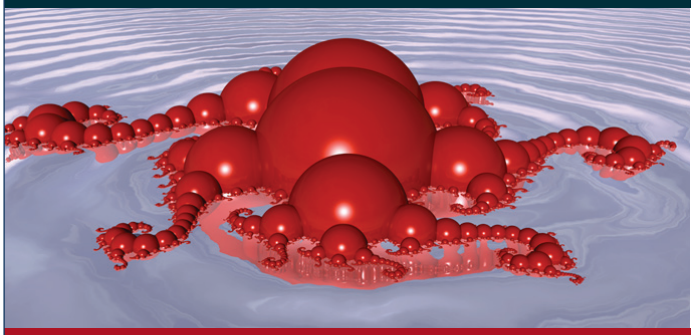
Friday, January 6, 2012, 1:00 PM to 4:45 PM

Room 200, Hynes Convention Center

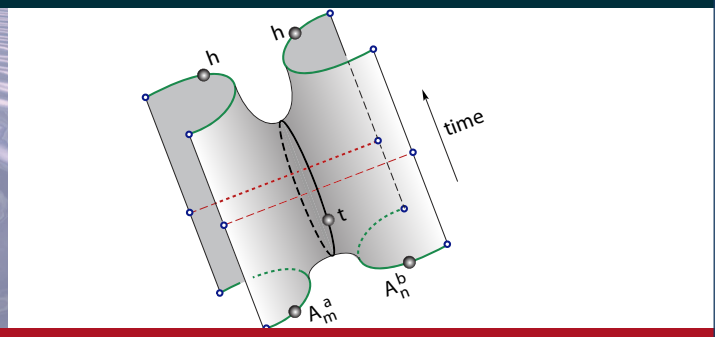
Joint Mathematics Meetings, Boston, MA



1:00 PM Jeffrey F. Brock

Assembling surfaces from random pants: mixing, matching and correcting in the proofs of the surface-subgroup and Ehrenpreis conjectures

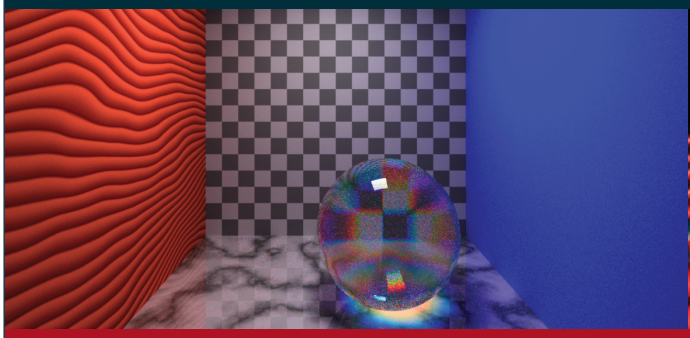
The revolution in low-dimensional topology precipitated by Thurston continues -- we will learn about two of the new breakthroughs descended from it.



2:00 PM Daniel S. Freed

The cobordism hypothesis: quantum field theory + homotopy invariance = higher algebra

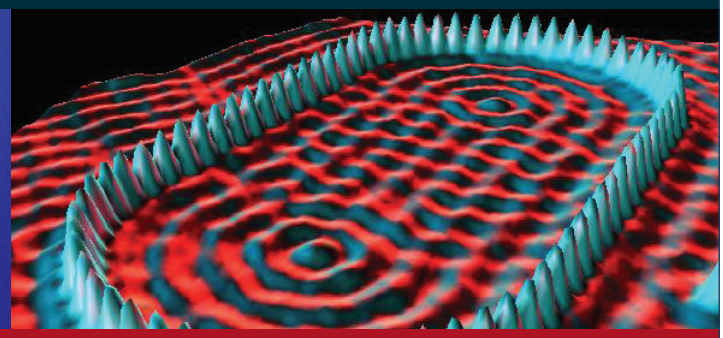
Lurie's spectacular work on the cobordism hypothesis is one of the latest demonstrations of the unreasonable effectiveness of physical theory in shaping recent mathematical thought.



3:00 PM Gigliola Staffilani

Dispersive equations and their role beyond PDE

Everyone has heard of the Schrödinger equation, but few understand its surprising interplay with other fields.



4:00 PM Umesh Vazirani

How does quantum mechanics scale?

Could quantum mechanics, bizarre as it is, possibly be true? Some aspects have been exquisitely tested, but others have not--they are too complex. Here is a computer science view of that complexity, and of how the difficulties could shape future developments.

Organized by David Eisenbud, University of California, Berkeley

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- **Majorana representation of A_6 involving 3C-algebras**, by A. A. Ivanov
- **On braided zeta functions**, by S. Majid and I. Tomašić

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