

Notices

of the American Mathematical Society

March 2014

Volume 61, Number 3

Paul Roesel Garabedian
(1927-2010)

page 244

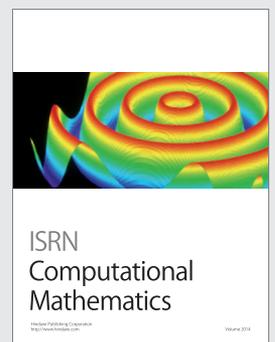
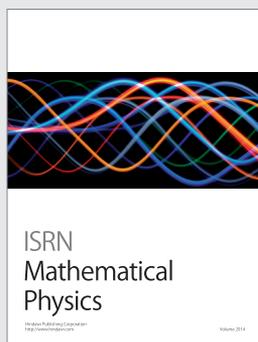
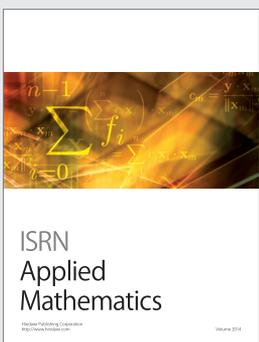
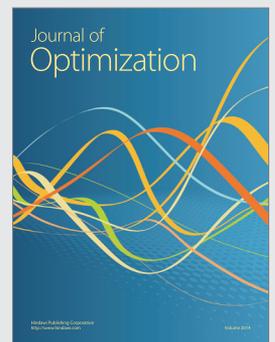
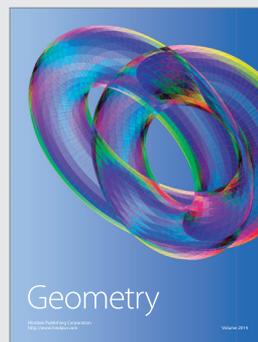
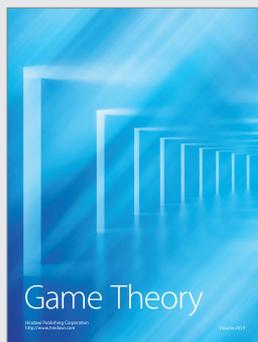
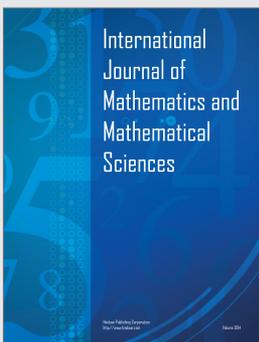
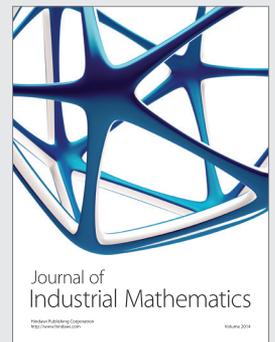
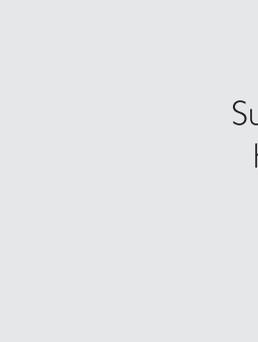
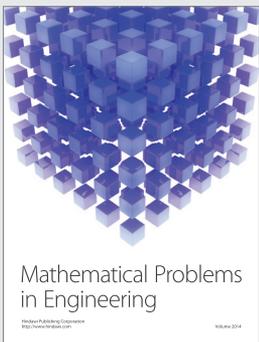
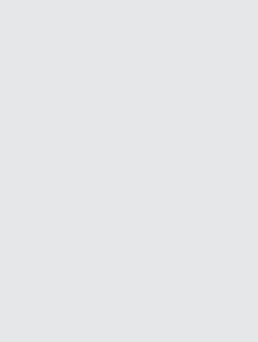
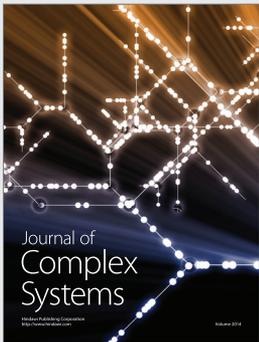
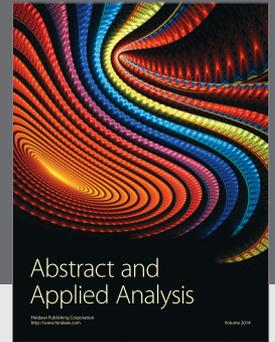
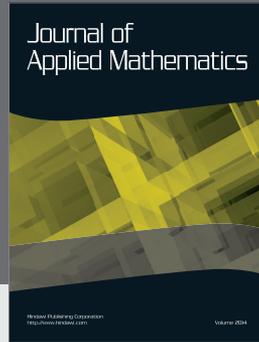
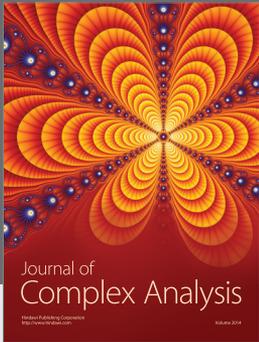
Alan Turing, Marshall
Hall, and the Alignment
of WW2 Japanese Naval
Intercepts

page 258

Viewing “Mathematics
for Teaching” as a Form
of Applied Mathematics:
Implications for
the Mathematical
Preparation of Teachers

page 266

レ	---	エ	---●---	ー	---●---
タ	---●	コ	-----	。	---●---
ヨ	---	フ	---●●	ッ	---●
カ	---●●	ケ	---●---	ン	---●---
ワ	---●-	マ	---●●-	ス	-----
ヲ	---●---	ヤ	---●-	セ	---●---
ル	---●---	ク	---●-	モ	---●---
ヌ	---●●	オ	---●●-	ヒ	---●---
リ	---●-	ノ	---●-	エ	---●---
チ	---●-	キ	---●---	シ	---●---
ト	---●●-	ウ	---●-	ミ	---●---
ヘ	---●	ム	---	メ	---●---
ホ	---●-	ラ	---●	ユ	---●---
ニ	---●-	ナ	---●-	キ	---●---
ハ	---●-	ネ	---●-	サ	---●---
ロ	---●-	ツ	---●-	ア	---●---
イ	---●-	ソ	---●-	テ	---●---



Submit your manuscripts at
<http://www.hindawi.com>

AMS Mathematical Moments & Mathematics of Planet Earth

A grid of 24 small posters, each featuring a title, a brief text description, an image, and the AMS logo. The posters are arranged in a grid that recedes into the distance against a background of a blue sky and a green grid pattern.

- Harnessing Wind Power:** Mathematics contributes to the way we harness wind power. Large-scale weather models are used to find suitable locations for wind farms, which more accurately forecast models incorporating wind direction and speed. From there, engineers can specify how to design individual turbines within a farm to adjust for wind direction or flow and the ground surface. This helps ensure that the ground surface is suitable for the blades, both structurally and aerodynamically to extract as much energy as possible, and keep some birds and bats safe.
- Sounding the Alarm:** Hearing an alarm is a common experience. But in many cases, alarms are not intended to warn of danger, but to sound the alarm. Mathematical models, based on partial differential equations, are used to determine the speed and magnitude of a sound or an alarm. These models help predict the time it takes for a sound to travel a certain distance, and help determine the best way to sound an alarm.
- Building Efficiently:** Buildings are so much more than just a structure. They are a complex system of interacting components, such as air conditioning and lighting, that are increasingly interconnected. To design a building that is both efficient and sustainable, it is important to consider the entire system, from the design of the building to the way it is used. This integrated approach, known as building information modeling (BIM), helps architects and engineers design buildings that are more efficient and sustainable.
- Knowing Rogues:** It doesn't take a perfect storm to generate a rogue wave—its appearance is more frequent and more massive than we thought. But the ocean is a complex system, and its behavior is difficult to predict. Mathematicians and other researchers are collecting data from buoys and satellite imagery to help understand the ocean's behavior. This data is used to develop models that can predict the occurrence of rogue waves, which can be used to improve shipping and offshore platform operations.
- Resisting the Spread of Disease:** One of the most useful tools in understanding the spread of disease is a system of ordinary differential equations that describe the interactions between different classes of people. These equations allow us to model the spread of a disease, and to predict the impact of different interventions. By using these models, researchers can identify the most effective ways to control the spread of a disease, and to develop strategies to prevent future outbreaks.
- Predicting Climate:** What is more for our climate and life? It is an extraordinarily complex question, one that requires the use of advanced mathematical models. These models, based on partial differential equations, describe the interactions between the atmosphere, the ocean, and the land. By using these models, researchers can predict the future of our climate, and to develop strategies to mitigate the effects of climate change.
- Going with the Floes:** Sea ice is one of the most abundant components of our planet. It plays a crucial role in the Earth's climate system, and its behavior is difficult to understand. Mathematicians are using advanced mathematical models to study the dynamics of sea ice, and to predict its future behavior. This research is important for understanding the impact of climate change on the Arctic and Antarctic regions.
- Getting It Together:** The collection means of every group of animals can be a complex task. It requires the use of advanced mathematical models to analyze the data and to identify the most effective ways to manage the group. By using these models, researchers can develop strategies to improve the health and welfare of the animals, and to prevent the spread of disease.
- Burying Carbon Dioxide:** One possible way to deal with the high concentration of carbon dioxide in the atmosphere is to bury it underground. This process, known as carbon capture and storage (CCS), involves the use of advanced mathematical models to predict the behavior of the carbon dioxide as it is buried. By using these models, researchers can identify the most effective ways to store the carbon dioxide, and to prevent it from leaking back into the atmosphere.
- Finding Oil:** As high as gas prices are, they would be much higher if it weren't for the oil that we use. Finding oil is a complex task, one that requires the use of advanced mathematical models. These models, based on partial differential equations, describe the interactions between the oil reservoir and the surrounding rock. By using these models, researchers can identify the most effective ways to find and produce oil.
- Predicting Storm Surge:** Storm surge is often the most devastating part of a hurricane. It is caused by the combination of high winds and low pressure, and it can cause significant damage to coastal areas. Mathematicians are using advanced mathematical models to predict the behavior of storm surge, and to develop strategies to reduce its impact.
- Locating, locating, locating:** Originally designed for military use, the Global Positioning System (GPS) is now used in a wide range of applications. It is used to track the location of objects, to navigate, and to provide timing information. The GPS system is based on advanced mathematical models, and its accuracy is improved by the use of these models.
- Defeating Disease:** From modeling microscopic genes and proteins to tracing the progression of an infection through a community, mathematics is playing a crucial role in understanding and defeating disease. By using advanced mathematical models, researchers can identify the most effective ways to control the spread of a disease, and to develop strategies to prevent future outbreaks.
- Revealing Nature's Secrets:** Mathematical models are a growing and active area of interdisciplinary research between mathematics and biology. These models, based on partial differential equations, describe the interactions between different components of a biological system. By using these models, researchers can identify the most effective ways to understand and control biological processes.
- Forecasting Weather:** Forecasting the weather is a complex task, one that requires the use of advanced mathematical models. These models, based on partial differential equations, describe the interactions between the atmosphere, the ocean, and the land. By using these models, researchers can predict the future of the weather, and to develop strategies to reduce its impact.
- Describing the Oceans:** Imagine trying to describe the circulation and temperature of the ocean. It is a complex task, one that requires the use of advanced mathematical models. These models, based on partial differential equations, describe the interactions between different components of the ocean. By using these models, researchers can identify the most effective ways to understand and control the ocean's behavior.



See how math is connected to understanding our planet and its many dynamic processes at www.ams.org/mathmoments and ams.org/samplings/mpe-2013.

There's
nothing
wrong with
being an
Overachiever

WebAssign exceeds expectations every time.

WebAssign aims high when it comes to math. While most online learning systems support only one publisher's textbook offerings, WebAssign supports textbooks from every major academic publisher.

It's something only an overachiever could accomplish.

WebAssign. Smart teaching. Inspired Learning.



www.webassign.net
919.829.8181 | 800.955.8275

WebAssign[®]

Visit bit.do/WA-New-Math to view our latest textbook content from several of our publishing partners.

Notices

of the American Mathematical Society

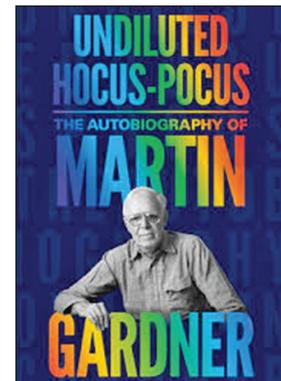
March 2014

Communications

- 265** About the Cover: Low-level cryptography
Bill Casselman
- 277** *Scripta Manent*: Access and Accessibility for the London Mathematical Society Journals
Susan Hezlet
- 284** Donoho Awarded 2013 Shaw Prize
- 286** Writing about Math for the Perplexed and the Traumatized
Steven Strogatz
- 292** *Doceamus*: How Well Are Secondary Mathematics Teacher Education Programs Aligned with the Recommendations Made in *MET II*?
Jill Newton, Yukiko Maeda, Vivian Alexander, and Sharon L. Senk

Commentary

- 239** *Opinion*: The Welcoming Side of Mathematics
Allyn Jackson
- 240** Letters to the Editor
- 281** Undiluted Hocus-Pocus—A Book Review
Reviewed by Andy Magid



March brings with it a warm and entertaining article about communicating mathematics to the perplexed and the traumatized. Something from which we can all learn. There is also a piece on Turing and cryptography. And an article on modern perspectives on problem solving. Finally, we offer memories of the mathematician Paul Garabedian.

—Steven G. Krantz, Editor

Features

- 244** Paul Roesel Garabedian (1927–2010)
Jerry L. Kazdan, Peter D. Lax, Albert B. J. Novikoff, C. Denson Hill, Antony Jameson, Eva V. Swenson, Ruth Bers Shapiro, Cathy Garabedian, and Emily Garabedian
- 258** Alan Turing, Marshall Hall, and the Alignment of WW2 Japanese Naval Intercepts
Peter W. Donovan
- 266** Viewing “Mathematics for Teaching” as a Form of Applied Mathematics: Implications for the Mathematical Preparation of Teachers
Andreas J. Stylianides and Gabriel J. Stylianides

Notices

of the American Mathematical Society

EDITOR: Steven G. Krantz

ASSOCIATE EDITORS:

Krishnaswami Alladi, David Bailey, Eric Bedford, Jonathan Borwein, Susanne C. Brenner, Danny Calegari, Bill Casselman (*Graphics Editor*), Jennifer Chayes, Gerald Folland, Susan Friedlander, Robion Kirby, Rafe Mazzeo, Harold Parks, Mark Saul, Carla D. Savage, Steven Strogatz, James Walker

SENIOR WRITER and DEPUTY EDITOR:

Allyn Jackson

MANAGING EDITOR: Sandra Frost

CONTRIBUTING WRITER: Elaine Kehoe

CONTRIBUTING EDITOR: Randi D. Ruden

EDITORIAL ASSISTANT: David M. Collins

PRODUCTION: Kyle Antonevich, Deborah Antuono, Anna Hattoy, Teresa Levy, Mary Medeiros, Stephen Moye, Lori Nero, Arlene O'Sean, Karen Ouellette, Courtney Rose, Donna Salter, Deborah Smith, Peter Sykes

ADVERTISING SALES: Anne Newcomb

SUBSCRIPTION INFORMATION: Subscription prices for Volume 61 (2014) are US\$569 list; US\$455.20 institutional member; US\$341.40 individual member; US\$512.10 corporate member. (The subscription price for members is included in the annual dues.) A late charge of 10% of the subscription price will be imposed upon orders received from nonmembers after January 1 of the subscription year. Add for postage: Surface delivery outside the United States and India—US\$27; in India—US\$40; expedited delivery to destinations in North America—US\$35; elsewhere—US\$120. Subscriptions and orders for AMS publications should be addressed to the American Mathematical Society, P.O. Box 845904, Boston, MA 02284-5904 USA. All orders must be prepaid.

ADVERTISING: *Notices* publishes situations wanted and classified advertising, and display advertising for publishers and academic or scientific organizations. Advertising material or questions may be sent to classifieds@ams.org (classified ads) or notices-ads@ams.org (display ads).

SUBMISSIONS: Articles and letters may be sent to the editor by email at notices@math.wustl.edu, by fax at 314-935-6839, or by postal mail at Department of Mathematics, Washington University in St. Louis, Campus Box 1146, One Brookings Drive, St. Louis, MO 63130. Email is preferred. Correspondence with the managing editor may be sent to notices@ams.org. For more information, see the section "Reference and Book List".

NOTICES ON THE AMS WEBSITE: Supported by the AMS membership, most of this publication is freely available electronically through the AMS website, the Society's resource for delivering electronic products and services. Use the URL <http://www.ams.org/notices/> to access the *Notices* on the website.

[*Notices of the American Mathematical Society* (ISSN 0002-9920) is published monthly except bimonthly in June/July by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2294 USA, GSTNo. 12189 2046 RT****. Periodicals postage paid at Providence, RI, and additional mailing offices. POSTMASTER: Send address change notices to *Notices of the American Mathematical Society*, P.O. Box 6248, Providence, RI 02940-6248 USA.] Publication here of the Society's street address and the other information in brackets above is a technical requirement of the U.S. Postal Service. Tel: 401-455-4000, email: notices@ams.org.

© Copyright 2014 by the American Mathematical Society.
All rights reserved.

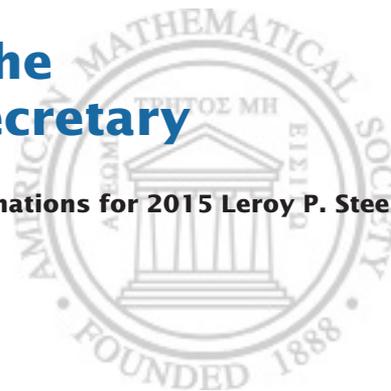
Printed in the United States of America. The paper used in this journal is acid-free and falls within the guidelines established to ensure permanence and durability.

Departments

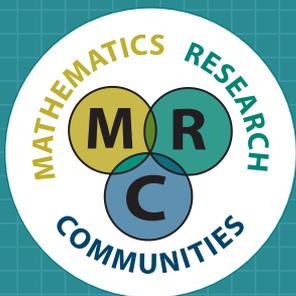
Mathematics People	296
<i>Guth Awarded 2013 Salem Prize, Kamran Awarded 2014 CRM-Fields-PIMS Prize, ICMI Klein and Freudenthal Medals Awarded, Boyd Receives IEEE Control Systems Award, Fox and Yun Awarded 2013 Packard Fellowships, 2013 Rosenthal Prize Awarded, Prizes of the Math Society of Japan, Rhodes Scholars Announced, AAAS Fellows Chosen, Donald W. Bushaw (1926–2012).</i>	
Mathematics Opportunities	299
<i>Call for Nominations for Prizes of the Academy of Sciences for the Developing World, Call for Nominations for Graham Wright Award, Project NEXt 2014–2015.</i>	
For Your Information	300
<i>Mathematics Awareness Month 2014: Mathematics, Magic, and Mystery.</i>	
Inside the AMS	301
<i>From the AMS Public Awareness Office, Deaths of AMS Members.</i>	
Classified Advertisements	302
Reference and Book List	304
Mathematics Calendar	309
New Publications Offered by the AMS	319
Meetings and Conferences of the AMS	326
Meetings and Conferences Table of Contents	336

From the AMS Secretary

Call for Nominations for 2015 Leroy P. Steele Prizes 308



Opinions expressed in signed *Notices* articles are those of the authors and do not necessarily reflect opinions of the editors or policies of the American Mathematical Society.



CALL FOR CONFERENCE PROPOSALS

2016 Mathematics Research Communities

The American Mathematical Society invites individuals and groups of individuals to serve as organizers of the conferences of the Mathematics Research Communities (MRC) program to be held in Snowbird, Utah, during the summer of 2016.

The goal of the MRC program is to create research cohorts of early-career mathematicians that will sustain themselves over time, fostering joint research and coherent research programs. The MRC program aims to achieve this goal through:

- One-week conferences for each topic
- Special Sessions at the national meeting
- Discussion networks by research topic
- Funding for additional collaborations
- Longitudinal study of early-career mathematicians

Additional information about the MRC program and guidelines for proposal preparation can be found at <http://www.ams.org/programs/research-communities/mrc-proposals-16>.

This program is supported by a grant from the National Science Foundation.



SEND INQUIRIES AND PROPOSALS TO:

Mathematics Research Communities
American Mathematical Society

by email: mrc2016@ams.org

by mail: 201 Charles Street, Providence, RI 02904

by fax: 401-455-4001

Deadline for proposals for the 2016 MRC:
September 15, 2014



AMS Centennial Fellowship Fund

Fostering outstanding mathematical research

2006-2007: Christopher Hacon



Awarded annually to promising early-career mathematicians, the Centennial Fellowship Fund provides one-year mathematical research fellowships.

2011-2012: Andrew S. Toms
Photo courtesy of the Purdue University
Department of Mathematics



2006-2007: Bryna Kra



2007-2008: Martin Kassabov



Give to the
Centennial Fellowship Fund
online at
www.ams.org/support



2005-2006: Yuan-Pin Lee

2005-2006: Mihnea Popa



2013-2014: Xinwen Zhu



2012-2013: Karin Melnick
Photo by Riza Falk



2008-2009: Christopher Hoffman



2009-2010: Antonio Montalbán



2010-2011: Joel Bellaïche



To learn more about the Centennial Fellowship visit www.ams.org/centfellow

Contact the AMS Development Office by phone: 401-455-4111
or email: development@ams.org

The Welcoming Side of Mathematics

In spring 2013, the IAS Women and Mathematics (IAS-WaM) program turned twenty years old. To get a sense of what the atmosphere was like around the time the program started, consider the shock waves that went through the mathematical community when a 1991 article in *Science* magazine carried a table showing the number of women faculty in the “top ten” mathematics departments in the U.S. The eight zeros in the column marked “tenured women” painted a sobering picture of the upper echelons of the field. That today none of the numbers would be a zero is due in part to the contributions of programs like IAS-WaM. That today all of those numbers remain in the single digits might make a compelling argument for the continuing need for these programs.

Held each summer at the Institute for Advanced Study in Princeton, IAS-WaM brings together women mathematics students, postdocs, and professors for two intense weeks of lectures, tutorials, panel discussions, and social activities. IAS-WaM is one of a growing constellation of programs—such as Research Experiences for Undergraduates, the AMS Mathematics Research Communities, Project NExT, etc.—that show how the mathematical community is taking an increasingly sophisticated approach to nurturing and supporting the next generation of mathematicians.

One striking aspect of IAS-WaM is the way it brings together women with diverse backgrounds, interests, and views—including some who are not at all sure that women-only programs are a good thing. Marthe Bonamy, a graduate student at the University of Montpellier in France, had always believed that such programs work against the ideal of having it not matter whether one is a man or a woman in mathematics. But when one of the IAS-WaM lecturers, Maria Chudnovsky of Columbia University, met Bonamy at a workshop and invited her to attend IAS-WaM, Bonamy immediately said yes. Once in Princeton, Bonamy found her skepticism quickly giving way to enjoyment of the mathematics and immersion in a friendly community. After nearly two weeks in the program, she found it strange to contemplate its end. She said of her fellow program participants, “I can’t believe I won’t keep seeing these people.” Some months after IAS-WaM ended, Bonamy said her views about women-only programs had changed. IAS-WaM “helped me a lot, in ways I didn’t know I needed help.”

Another participant, Anastasia Chavez, is a graduate student at the University of California at Berkeley and a mother of two. At a panel discussion about alternative careers in mathematics (full disclosure: I was a panelist), Chavez brought up “stereotype threat”, a term that denotes the effect that stereotypes can have on academic performance. Some studies of stereotype threat suggest that reminding test-takers of common stereotypes—such as the notion that women or African-American people do poorly in mathematics—can

influence their performance on the test. Chavez finds that, in her high-powered department where mathematics research dominates, few people want to discuss such issues, which she finds are on her mind as she prepares for a future that will likely involve teaching. At IAS-WaM, Chavez found the climate to be more open and receptive to such topics.

In many of the top mathematics doctoral programs, and even in some elite bachelor’s programs, women are still fairly isolated. Often there is an expectation that it’s supposed to be all about the mathematics and that anyone needing anything more, like camaraderie and moral support, is weak and lacking ability. There’s a lot of pretending to know and hiding of ignorance. One participant observed that in her department all the graduate students seemed to be “masochistically pushing through”. IAS-WaM provides a welcome respite from such hyper-competitive milieux. “Part of the idea of this program is to get people to enjoy doing mathematics and feel successful at doing it,” said Dusa McDuff of Barnard College, one of the IAS-WaM organizers. “They work together and find ways to tackle problems in an area they don’t know very well and to approach it with an open mind. They also get to see how other people think about mathematics, because the discussion is quite open in the tutorial sessions. And there are no consequences. There is no exam. It’s not as though [the participants] are all going to be judged... This relieves stress.”

Of course, making a career in mathematics is difficult and stressful for nearly everyone. Nancy Hingston of the College of New Jersey, who has been on the IAS-WaM program committee for several years, noted that many women entering the field today take a very pragmatic approach to negotiating the hurdles. “There is no hand-wringing,” she observed. “It’s just: Okay, tell me what I need to do to get this job, or succeed in graduate school, or whatever it is.” Indeed, the main concern for many women in mathematics today is how to juggle career and family. This is a substantial problem, but it’s a logistical one. The problem of breaking into what’s considered to be a “man’s field” is far more difficult—and seems increasingly to be receding into the past.

During a panel discussion on succeeding in graduate school, several women mathematicians described their own experiences. There was drama, surprise, and plenty of laughter. There was also the sense that, while one needs toughness and persistence to make it in mathematics, the field welcomes all kinds of people. Stick with it, and be open to the opportunities that come along, Shabnam Beheshti of Rutgers University told the participants. “There is a place in this world for all of us... It may not be the box you think you fit into. But it’s there.” By uniting a wide variety of women around their interest in mathematics, IAS-WaM showcases the open, welcoming side of mathematics.

—Allyn Jackson
Senior Writer and
Deputy Editor of the Notices
axj@ams.org

Letters to the Editor

Statement from *Notices* Editor

The article by Thomas L. Saaty and H. J. Zoffer that appeared in the November 2013 issue of the *Notices* has engendered considerable discussion. As chief editor of the *Notices*, I made the decision to publish the piece. With several favorable reviews in hand, I felt that this represented a new sort of scholarship and an interesting direction in the application of mathematics to real-world problems. In spite of the strong emotions connected with issues in the Middle East, I felt that these were ideas worth examining and discussing. Of course I knew that readers would react, but nobody anticipated the spirited outburst that we have received.

Some readers have suggested that the Saaty/Zoffer article is less than objective; others have objected to the choice of graphics. These are valid concerns, and we need mechanisms to detect them in a timely fashion. AMS President David Vogan appointed a Presidential Advisory Committee to make recommendations in this regard. The committee created a set of new editorial guidelines, addressing how articles are refereed, particularly articles with a nonmathematical component, and the role of the *Notices* Editorial Board. The implementation of the guidelines will increase input and oversight by the board and will, I believe, maintain a high level of quality for the material we publish.

To my mind the most important issue here is the integrity of the *Notices*. I want it to be an exciting and vibrant organ for our professional society, but I also want it to be a feature of our professional lives of which we can all be proud and with which we are all comfortable. It is not my job to aggravate already existing schisms and wounds. It is instead my task to showcase new mathematics that will be of broad interest and stimulate new learning. That will be our focus in the future.

Here we present a selection of Letters to the Editor that provide a good representation of the many

reactions to the Saaty/Zoffer article. Many of the issues discussed in these letters are political ones that ordinarily would not be suitable for the *Notices*. But in this extraordinary circumstance, it is important to let the critics have their say. We do not plan to prolong the discussion in future issues of the *Notices*.

—Steven G. Krantz
Editor

As one with children and grandchildren living in Israel, I am as desirous as anyone for a peace treaty between Israel and the Palestinians. The article “Principles for implementing a potential solution to the Middle East conflict”, which appeared in the November 2013 *Notices*, proposes methods to resolve the conflict between Israel and the Palestinians. While I am dubious that these methods would be any more successful than all previous attempts, the article does seem a reasonably well-balanced attempt to find a middle path between the goals of Israelis and Palestinians. The article is accompanied by five illustrations. The first, a map of the territories involved, is useful to those unfamiliar with the geography. The other four, however, add little to the discussion. Curiously, they are described as “self-explanatory”, yet an explanation is provided.

Unfortunately, two of the explanations are one-sided and misleading. Figure 4 is described as showing “Israeli settlements in Palestinian lands”. It is unclear what particular “settlement” is being shown. In some cases, such as the city of Efrat, land was purchased from Arab owners. In other cases, Jewish kibbutzim lost in the 1948 war were reestablished after 1967. In other cases, building occurred on land uninhabited by anyone.

Figure 5 is described as “The wall built to prevent Palestinians from entering Israel.” The wall was built to deter terrorists from entering Israel, something far different from stopping Palestinians per se.

I have no desire to have the conflict between Palestinians and Israelis taking up valuable space in the *Notices*, but if the conflict is to be discussed, let it be done in a fair and impartial way.

—Edward S. Boylan
Professor Emeritus
Department of Mathematics and
Computer Science
Rutgers University
eboy1an@andromeda.rutgers.edu

(Received October 28, 2013)

I am appalled by the decision of editors of the *Notices* to accept for publication the paper “Principles for implementing a potential solution to the Middle East conflict”, authored by Thomas L. Saaty and H. J. Zoffer in the November 2013 issue.

I used to believe that the *Notices* was a journal of the mathematical community and so published papers connected to mathematics or to the life of the mathematical community. The paper in question is neither.

I think there is no need to explain to a professional mathematician that an arbitrary choice of issues and an arbitrary assignment of numerical values can justify any result the author wishes.

A similar type of “mathematical modeling” was very popular in the now-nonexistent USSR, where I happened to live for some thirty years. Let me share with you my personal experience with this method of research. Some thirty-five years ago I was approached by a distant relative who worked in a Research Economics Institute in Moscow. She told me that her task was to construct a mathematical model that would “mathematically” justify doubling the price of meat (the prices were regulated by the government, of course) and asked me for mathematical advice.

I found a hint in the paper by Saaty and Zoffer that may indicate that the referee was not very fond of the mathematical content of the paper. Therefore, am I allowed to suggest

that it was not the mathematical content of the paper but the beautiful illustrations that attracted the editors?¹

I think that the management of *Notices* has to explain to the mathematical community how publication of the mentioned article became possible. Otherwise there is a danger that *Notices* will cease to be considered as a journal worth reading.

—Vladimir Hinich
Department of Mathematics
University of Haifa
hinich@math.haifa.ac.il

(Received November 6, 2013)

The article by Professors Saaty and Zoffer [*Notices*, November 2013] displays some of the problems in applying decision support techniques to a complex conflict.

The list of outstanding issues and the “Pittsburgh principles” are incomplete. They include many references to Palestinian refugees, but none to the similar number of Jewish refugees from Arab countries. The article might have profited by showing the tent camps that housed Jewish refugees from countries like Yemen and Iraq but were uplifted into development towns. Instead, it ran photos of Palestinian refugee camps that still exist due to ongoing refusal by countries like Lebanon to uplift Arab refugees. Such one-sidedness not only rewards manipulation of Arab refugees, it also punishes Israel for absorbing their Jewish counterparts. It will invariably be abused as a pretext for further conflict under the guise that no “just solution” has been found.

To wit, Palestinian President Mahmoud Abbas continues to demand that Palestinian refugees and their descendants be resettled in pre-1967 Israel and not in the West Bank. This makes a mockery of a two-state solution. It denies the rights of Jewish

refugees from Arab countries. It sidesteps Arab responsibility for starting the wars that led to BOTH refugee issues, and it runs counter to the way every other population exchange has been resolved.

The imbalance on refugees is not the only one. The article talks of a “retributive conflict” in which “both sides profess to desiring a solution but are equally committed to inflicting pain on the other party.” This ignores the fact that Jews repeatedly accepted a two-state solution prior to and in 1948, but the Arab world responded with successive wars. Moreover, Israeli territorial concessions have not led to a comprehensive peace, instead amplifying calls for Israel to be dismantled.

At least the final list of “most important” Palestinian concessions refers to a major Israeli concern. Namely, that if they handed over the West Bank and removed all Jews (aka “settlers”) from East Jerusalem, where they were a majority until the 1920s riots, thereby returning them to the very insecure situation before 1967, the conflict would not end. Statements by leading Palestinian Authority officials, let alone those of Hamas and other countries in the region, make clear that this is a very real concern. The core issue in the conflict remains Arab refusal to accept a permanent Israel behind any boundaries.

—D. Lubinsky
Georgia Institute of Technology
lubinsky@math.gatech.edu

(Received November 8, 2013)

The November 2013 issue of the *Notices* devotes its cover and 22 pages to “Principles for implementing a potential solution to the Middle East conflict”, by Thomas L. Saaty and H. J. Zoffer. Given the Syrian civil war, with 120,000 dead and 2 million refugees, or the failed Egyptian revolution, it is bizarre that the “Middle East conflict” mentioned in the title actually refers to the Israeli-Palestinian conflict.

In any case, the authors’ “Analytic Hierarchy Process” (AHP) considers

responses of Israeli and Palestinian participants to a set of “outstanding issues” and then balances costs and benefits of concessions by each side to find a “fair solution” to the conflict. Remarkably, the article does not give the number of participants or how they are chosen, something which could produce almost any result.

Further, choosing “outstanding issues” requires a deep knowledge of the conflict, which is clearly not the case here. For example, the Golan Heights are listed as an unresolved “Geographic and Demographic” issue. The Golan Heights are not part of the Israeli-Palestinian conflict. They are claimed by Syria and Lebanon and have never been claimed by the Palestinians.

Another strange choice of issues is the Israeli concession to “Abolish the Law of Return”. This refers to the automatic grant of Israeli citizenship to Jews around the world—something which reflects the goal of providing safe haven to Jewish refugees. This issue has been a matter of internal Israeli debate; however, it has never been an issue in peace negotiations. Presumably, a two-state solution would make the law of return an Israeli matter.

Consider another example—the Israeli concession to “solve the Palestinian refugee problem in a just and agreed upon manner.” This is not a concession—it is an oft-repeated slogan. The refugee problem is one of the most important issues in the Israeli-Palestinian negotiations, and the slogan should be replaced by a clearly articulated concession.

Finally, the accompanying photographs are tendentious. On the cover of the *Notices* is a photo of a four-story building decorated with several wall posters typically used to memorialize suicide bombers (!). Why not a photograph of the aftermath of a café bombing by such a Palestinian-declared “martyr”? Another photo titled “Palestinian refugee camps in Lebanon” appears to be of an established urban environment, which in another context might be called a “neighborhood”. The term “refugee camp” should evoke the terrible conditions suffered by refugees struggling

¹As I was later informed by the editors, my suggestion was incorrect. The illustrations were added at the request of the *Notices* editor Steven Krantz after the article was accepted for publication.

this winter in Lebanon and Jordan or the millions of refugees elsewhere in the world.

—Jonathan Beck
Department of Mathematics
Bar Ilan University
Ramat Gan, Israel
 beck@math.biu.ac.il

(Received November 13, 2013)

The article “Principles for implementing a potential solution to the Middle East conflict” by Saaty and Zoffer, which appeared in the November 2013 issue of the *Notices*, attempts to use mathematics to suggest policy decisions, and this letter is aimed at raising some questions about that effort. It should be noted that the present Middle East conflict which has, according to supposedly reliable estimates, cost 120,000 lives already is not the subject of this article. Rather, it concerns the dispute between Israel and the quasi-governments of the Gaza Strip and the “West Bank” (which Israel calls “Judea and Samaria”).

When two entities of any kind are involved in a dispute, there are hal-
 lowed methods for resolving it that are based on the fundamental fact that each issue or factor can have different relative significance to those entities. If one isolates these factors and understands their rankings in importance by each of the two sides, it often becomes possible to find a resolution of the problem in which each side gets its way on the issues most important to it, conceding on those that it cares less about. In this way both sides can consider the resolution a victory for itself, and the conflict can disappear, as if by magic, with both sides happy about it.

The approach of this paper has a similar goal, but it does not deal with actual issues. Instead it lists what it terms “concessions” by each side. The mathematical content consists of description of an iterative scheme for obtaining an optimal resolution based upon assumptions about the relative importance of the various concessions to the two sides.

Unfortunately the problems of the paper have little to do with the mathematics but involve the zany and almost comic choices of the “con-

cessions” and even with the choice of antagonists in the basic dispute.

The basic objection to this paper can be stated very simply. The only Palestinian concessions that involve material action are stopping terrorist activity against Israel and stopping the teaching of hate against Jews in Palestinian schools. Many of the concessions listed for Israel, if made by the Israeli government, which respects its commitments, are very significant and jeopardize its very existence. As a practical matter, however, making any concession at all in exchange for a promise of stopping terrorist action actually encourages future terrorist action, made in the hopes of extracting more concessions for again promising to stop them. It therefore solves no problem and in the long run postpones the prospects of peace.

—Daniel Kleitman
Massachusetts Institute
of Technology
 djc@math.mit.edu

(Received December 2, 2013)

Response from the Authors

We would like to respond to several concerns raised in the foregoing letters.

We are less than objective in our reporting. Nothing in the article represents our opinions. The Analytic Hierarchy Process (AHP) allows every position to be exposed, no matter how unhappy it makes one side. Negative and positive reactions are measured through mathematically-based weights. There are no pre-discussion agreements. Everything is on the table, wise or unwise, sensible or ridiculous. Mathematics sorts it all out.

The participants in the study are not identified, nor the method of selection indicated. There are a limited number of participants, equally representative of each side, constituting a wide range of extremely credible citizens in both communities and including ambassadors, high-ranking military officers, members of the legislatures, prominent academics, editors of major journals, etc. The participants believe their opinions reflect about 70 percent of the people in their respective communities.

Their identities must remain confidential so that their judgments can reflect their true opinions and not be subject to public review.

The concessions do or do not reflect appropriate positions as viewed by one side or the other. We have nothing to do with the concessions. We ask participants to indicate every relevant issue they know or have heard of, what concessions the other side needs to make, and what concessions they are prepared to make. Through a process of trade-offs detailed in the article, we seek to group concessions such that the cost and benefits to each side are approximately equal. We do not attempt to seek out what is right or wrong, important or trivial. The beauty of the mathematics is that outlier positions either may not trade off, or the judgments made will reflect strong opinions of the participants. Issues that are not germane will be washed out.

The choice of graphics. The editor of *Notices* asked us to provide some graphics. We chose a few pictures that identify the conflict as being the Israeli-Palestinian matter. The graphics are intended to make the journal attractive and interesting.

We refer to the Israeli-Palestinian conflict as the “Middle East Conflict”, ignoring the Syrian situation and other middle eastern controversies. We plead guilty to this. We started this process some years ago when reference to the Middle East conflict automatically meant the Israeli-Palestinian situation.

The Pittsburgh Principles are not detailed enough. This is a fair criticism. Starting in late January, 2014, all of the Principles are being examined from the point of view of implementability, and specific approaches will be outlined. The participants believe the Pittsburgh Principles represent a breakthrough even in their pre-implementation stage.

—Thomas L. Saaty
University of Pittsburgh
 saaty@katz.pitt.edu

—H. J. Zoffer
University of Pittsburgh
 zoffer@katz.pitt.edu

(Received January 15, 2014)

The Purpose of Rigor, Revisited

This is in response to the letters in the *Notices*, Vol. 61, No. 2, February 2014, pp. 128–129, entitled “Outdoing the Soviets”, “The Purpose of Rigor”, and “Reply from Zeilberger”.

I would like to mention the widely used Newton-Leibniz definition of derivative: $v(t) = dx/dt = \lim [x(t + dt) - x(t)] / dt$, as $dt > 0$ tends to zero.

If $x(t)$ is a distance in motion or some parameter of a process, then $v(t)$ means the velocity. The value $v(t)$ does not exist at the moment t of its definition and thus cannot be measured or computed, since at any moment t the value $x(t + dt)$ does not yet exist if $dt > 0$. This means that all classical theories for ODEs, PDEs, etc., are operating with unreal values that do not exist at the time t of their definition, although they can be postulated as some future increments tending to zero.

All mathematical theories based on right derivatives are just frozen mental constructions that can be used as approximations to reality at low velocities but fail at high velocities and small values of $x(t)$ considered in quantum mechanics and elsewhere.

In reality, the velocity is realized as the left derivative $v(t) = \lim [x(t) - x(t - dt)]$, $dt > 0$ and should be used in this way in the theory and applications of mathematics.

—Efim A. Galperin
University of Quebec
Montreal
galperin.efim@uqam.ca

(Received January 26, 2014)

Statistics Needs Math

Charles Radin’s letter (“Do Scientists Need Math?”) in the November 2013 *Notices* concerning the disagreement between Wilson and Frenkel mentions that “many biological and social scientists do not need much mathematics beyond statistics.” I agree. However, in order to understand statistical modeling, such scientists need to understand multivariable calculus, linear algebra, and probability. For example, the workhorse of applied statistics, multiple linear regression, requires understanding

random vectors and the difference between stochastic independence and linear independence. This requires at least a math minor.

The reason that understanding is required, beyond which buttons to push in a statistical software package, is that the hypotheses of the theorems that are being used are infrequently satisfied in actual applications. The user must then decide to what degree the conclusions of such theorems should still be accepted. Lack of such understanding is a major reason why so many mistakes have been made in applying statistics. Examples illustrating this point appear in two critiques that have recently been in the news: Lyons, R. “The spread of evidence-poor medicine via flawed social-network analysis”, *Statistics, Politics, Policy*, 2(1) (2011), Article 2. (27 pp.) DOI: 10.2202/2151-7509.1024, and Myhrvold, N.P. (2013) “Revisiting the Estimation of Dinosaur Growth Rates”, *PLoS ONE* 8(12): e81917. doi:10.1371/journal.pone.0081917.

—Russell Lyons
Indiana University
Bloomington
rdlyons@indiana.edu

(Received December 23, 2013)

Intellectual Needs in School Geometry

This is about Professor G. Harel’s article on the Common Core State Standards for geometry (*Notices*, January 2014). Professor Harel is concerned about these standards’ “lack of attention to students’ intellectual needs”. Such needs have in fact been laid out clearly on pp. 258–259 of H. Wu, *Pre-Algebra*, <http://math.berkeley.edu/~wu/Pre-Algebra.pdf>. Briefly, if students wanted to compare two triangles to see if they are “the same”, they would realize the need to find ways to move the plane around. Hence the need for rotations, reflections, and translations.

The reference to *Pre-Algebra* is not an accident. This is the same document as “Wu, H., ‘Lecture Notes for the 2009 Pre-Algebra Institute’, September 15, 2009” on page 92 of the Common Core State Standards

for Mathematics. The writers of the latter document knew about this intellectual need for sure.

Professor Harel is unhappy about what he terms the “standard approach” to the Common Core in the curriculum materials developed, and well he should be. But I think it is wrong to ascribe the perceived curricular defects to some inherent defects of the geometry standards of the Common Core. The truth is that, given the deplorable state of school math textbooks, any approach to geometry (including Professor Harel’s own) will be perverted in the marketplace.

—H. Wu
Department of Mathematics
University of California
Berkeley
wu@berkeley.edu

(Received December 19, 2013)

Corrections

The news item announcing the winners of the 2013 International Mathematical Olympiad (*Notices*, November 2013, p. 1344) contained two errors. Gold medal winner Mark Sellke’s name was misspelled and the location of his high school should have been listed as West Lafayette, Indiana.

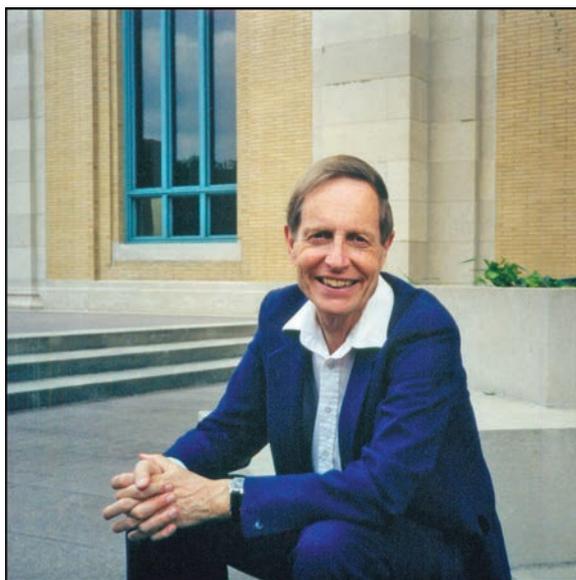
—Russell Lyons

The February 2014 issue of the *Notices* carried my review of *Théorème vivant* by Cédric Villani. The review misstated the name of one of Villani’s collaborators. His name is Clément Mouhot, not Clément Boutot. I apologize for the mistake; credit should be given where it is due, in particular for such a nice theorem.

—Jacques Hurtubise

Paul Roesel Garabedian (1927–2010)

Jerry L. Kazdan



Paul Garabedian, 2000.

Background

Mathematics was in Paul's genes: both his father and his two uncles were mathematicians. Paul and his sister, Caroline Coulon, were home schooled. At age sixteen he was not admitted to Harvard because Paul's father's Ph.D. advisor, G. D. Birkhoff, was concerned that he might be immature. Instead, Paul went to Brown—and excelled. He simply was a prodigy. In the enlightening oral history conducted by Philip Davis in 2004 [2], Paul remarked (with insight), "I was a child prodigy. I am still a child prodigy, but there are very few people who know that, perhaps yourself and a few others." Philip Davis laughed.

After graduating from Brown in 1946 he began graduate school at Harvard. Two years later at the age of twenty he received his Ph.D., working

Jerry L. Kazdan is professor of mathematics at the University of Pennsylvania. His email address is kazdan@math.upenn.edu.

DOI: <http://dx.doi.org/10.1090/noti1088>

with Lars Ahlfors. Paul also benefited from many conversations with Max Schiffer, who was visiting Harvard's applied mathematics department. This was the beginning of Paul's important mathematical interaction with Schiffer—and a lifetime of work where complex analysis played a major role either for itself or as a key ingredient in applications.

In 1948, after receiving his Ph.D., Paul was a National Research Council Fellow at Stanford. The following year he became an assistant professor at the University of California, Berkeley. One year later he simply resigned from the university before it became mandatory to sign the loyalty oath required of University of California faculty.

Stanford immediately offered Paul a position. He flourished there: promoted to associate professor in 1952 and to professor in 1956. In 1959 Paul came to NYU's Courant Institute. He was appointed the director of the Division of Computational Fluid Dynamics at the Courant Institute in 1978. Paul remained a member of the NYU faculty for fifty-one years. Paul also often spoke fondly of his ten years at Stanford, maintained many friends there, and returned often to visit and give lectures.

The obituary published by the Courant Institute [1] is a good source for more information.

Research

One early influential result with Schiffer (1950) was where they used Hilbert space ideas with the Bergman kernel function to prove existence theorems for elliptic partial differential equations.

Another problem he considered deeply was the *Bieberbach Conjecture* for the family of holomorphic functions $f(z)$ that are 1-1 maps of the unit disk to the complex plane normalized by $f(0) = 0$ and $f'(0) = 1$. Then $f(z) = z + a_2z^2 + a_3z^3 + \dots$. In 1916 Bieberbach proved that $|a_2| \leq 2$ with equality essentially only for the Koebe function

$$f(z) := \frac{z}{(1-z)^2} = z + 2z^2 + 3z^3 + \dots$$

Bieberbach conjectured that $|a_n| \leq n$, with equality only for this function.

In 1985, after more than sixty years, the conjecture was proved true by de Branges. But the road was not straight. In 1923 Löwner proved that $|a_3| \leq 3$, but it took until 1955 for Garabedian and Schiffer to prove that $|a_4| \leq 4$. The proof by Garabedian and Schiffer that $|a_4| \leq 4$ involved tedious numerical calculations. Although Paul's desk was always notoriously empty except for one small pad, this work was a real exception. These calculations on the Bieberbach Conjecture for a_4 were not done in his head.

Subsequently Charzynski and Schiffer (1960) found a much simpler, more conceptual, proof that $|a_4| \leq 4$, one that was also now *shorter* than Löwner's proof that $|a_3| \leq 3$ but did not imply that $|a_3| \leq 3$. Since one anticipates that the difficulty of the proof should increase with n , this violation led Paul to question the conjecture itself. Some related conjectures had already been found to be naive.

As a thesis topic for me as a graduate student at the Courant Institute, Paul suggested that I try to find a counterexample. So I tried. With Eva Swenson's superb help on the computer, I sought—but did not find. This lack of monotonicity in the difficulty of proof persisted. Peterson and Ozawa (1968, 1969, respectively) proved that $|a_6| \leq 6$ before Pederson and Schiffer (1972) proved that $|a_5| \leq 5$. The eventual proof by de Branges uses Löwner's approach. Crooked paths make life more interesting. I personally value this experience of struggling with a conjecture whose resolution is uncertain. It taught me to be dubious about conjectures—and diffuse evidence—until they are really proved.

In the early 1950s, Paul, in joint work with Donald Spencer on the $\bar{\partial}$ -Neumann problem, was attempting to understand some problems involving functions of several complex variables. This work was seminal. See Denny Hill's note below for his personal insight on the collaboration.

In 1952 Paul's article with Lewy and Schiffer on Riabouchinsky flow was one of his earliest works on fluid flow.

Beginning in the mid 1950s, Paul's research focus was decisively influenced by specific questions on transonic fluid flow that were asked by David Young at Ramo-Wooldridge Corporation. Paul's contributions involved analytic continuation to the complex plane and were viewed with suspicion—until people calmed down and realized that even though they were mystified, the results seemed to be both correct and better than anything their own research could yield. This work was influenced by earlier results of Hans Lewy. Paul's beautiful *Partial Differential Equations* text is a wonderful introduction to these seminal ideas. This work was also the beginning of his pioneering use of computers to solve basic problems in science

and engineering. It is surprising that although Paul didn't write computer code himself, he was superb as a leader to produce fundamental results. The article below by Antony Jameson gives an introduction to the problems and Paul's profound contributions, particularly to the design of a transonic airfoil, now used in commercial airplanes. This is a wonderful example of very applied mathematics at its best.

In his next period, Paul focused on *magnetic fusion*, where one studies fluid flow coupled with an electromagnetic field. One goal is the important practical application of designing a nuclear "power plant" based on fusion, not fission. The valuable articles by Geoffrey McFadden [3], [4] discuss both this and Paul's work on transonic airfoils.

While most of Paul's work after 1970 was on applied mathematics, he published a few very short gems on topics in pure mathematics, such as a simple proof of a variant of the Lewy example of a linear unsolvable PDE. These always involve complex analysis and often some functional analysis.

Paul had twenty-seven Ph.D. students and many postdocs.

Honors

Fairchild Distinguished Scholar, Caltech (1975)
 NASA Public Service Group Achievement Award (1976)
 Boris Pregel Award, New York Academy of Sciences (1980)
 Birkhoff Prize of the AMS and SIAM (1983)
 Theodore von Kármán Prize, SIAM (1989)
 National Academy of Sciences Award in Applied Mathematics and Numerical Analysis (1998)
 American Physical Fellow (2004)
 SIAM Fellow in the inaugural class (2009)

He was a member of both the National Academy of Sciences and the American Academy of Arts and Sciences.

Paul is survived by his wife, Lynnel, his daughters, Emily and Cathy, and two grandchildren, as well as his sister, Caroline Coulon. He was an active father, who played an important role in his daughters' lives. Once when Paul and I happened to meet in Japan, he described proudly several trips he took to Kyoto accompanied by his younger daughter, Cathy, and how she helped "take care" of him. For me, these stories were a model. I regret that I never had an opportunity to have a similar experience with either of my own daughters.

References

- [1] Courant Institute's obituary for Paul Garabedian, http://cims.nyu.edu/webapps/content/special/Garabedian_Obituary.

- [2] PHILLIP DAVIS, Oral history: An interview with Paul Garabedian, <http://history.siam.org/oralhistories/garabedian.htm>.
- [3] GEOFFREY B. MCFADDEN, Garabedian obituary in SIAM, <http://siam.org/pdf/news/1809.pdf>.
- [4] ———, Garabedian obituary in Stellarator, <http://www.ornl.gov/sci/fed/stelnews/pdf/sn126.pdf>.

Peter D. Lax

Paul Garabedian was an outstanding pure mathematician as well as one of the most original applied mathematicians. His strength was that he used very sophisticated pure mathematics to solve applied mathematics problems. Sometimes this had the effect that the engineering community did not comprehend his methods and therefore was reluctant to use his results (more about this later).

Paul's father was a mathematician, a Ph.D. student of G. D. Birkhoff at Harvard; his mother also had an advanced university degree. Paul and his sister were educated at home. When Paul turned sixteen, he was already excelling in mathematics; his father took him to Birkhoff as a prospective Harvard student. Birkhoff was concerned that home schooling did not prepare Paul for college life. As he put it, "Suicides give a school a bad name." He suggested that Paul go to boarding school for a year, and then he would be admitted to Harvard. His father took Paul to Brown University; there, too, the admission people were worried about the lack of social skills and suggested that Paul go to boarding school for a year. "If he goes to boarding school, he goes to Harvard," said his father, so Brown admitted him right away. His roommate was the fifteen-year-old Al Novikoff. According to Al, Paul taught him a lot of mathematics, and he taught Paul about women.

Paul was a brilliant undergraduate; he finished in 1946 and was admitted to Harvard as a graduate student. He earned his Ph.D. in 1948 under the direction of Lars Ahlfors; his dissertation was on the Szegő kernel function.

His first academic position was at Berkeley. He arrived at a time of anticommunist hysteria. The trustees of the university demanded that the faculty sign a loyalty oath. Paul was among the faculty who refused (Hans Lewy was another). He was immediately hired by Szegő at Stanford, where he spent nine fruitful years. He collaborated with his colleagues Don Spencer and Max Schiffer and made his first venture into applied mathematics. An outstanding problem in the 1950s was whether a ballistic missile would burn up upon reentering the earth's atmosphere. Since at that time ballistic missiles existed only on the drawing board, the

Peter D. Lax is emeritus professor of mathematics at New York University-Courant Institute. His email address is tlax@cims.nyu.edu.



Paul with Peter Lax (1968).

decision had to be made by theoreticians. Paul gave a brilliant mathematical formulation of the problem which could then be solved on the relatively slow computers available at the time. His calculation showed that ballistic missiles would not burn up upon reentry.

While at Stanford, Paul married Gladys Rappaport, a graduate student in statistics. She wrote the computer code for the reentry problem; miraculously, the code worked immediately. A second, more sophisticated, program contained some bugs; Paul gave her hell.

In 1957 Paul was named scientific attaché in London; the duties of the attaché were to travel around Europe and report on new scientific developments. During his visit to Italy, Paul learned that De Giorgi had solved a Hilbert problem about the regularity of solutions of nonlinear elliptic equations (at about the same time John Nash also solved this problem by an entirely different method). The paper by De Giorgi was published in a very obscure journal; the international mathematical community learned about it from Paul's report.

In 1959 Jim Stoker, Courant's successor as director of the institute at NYU, visited Stanford. He had had his eye on Garabedian for some time; so then and there he made an offer to Paul to come to NYU. After an afternoon of negotiations, well lubricated by martinis, Paul accepted. It was a happy outcome for both parties; Paul enjoyed and was stimulated by the atmosphere of the Courant Institute, and he liked to live in New York City.

Paul's father was of Armenian descent; his mother was not, and Paul resembled his mother.



Paul with his sister, Caroline, and niece, Aline (France, 1962).

When interviewed for admission to Harvard graduate school, Paul noticed that the interviewer was making notes; left alone momentarily, he took a peek at the notes; they said, “Wrong name, right appearance.”

Paul was a hero to the Armenian mathematical community. He was once invited to a mathematical congress in Yerevan, the capital of Soviet Armenia. He accepted gladly. When he stepped off the plane, the reception committee was shocked to behold the blue-eyed, blond guest; “That’s not Garabedian; it is a CIA agent.”

While in New York his first marriage ended in divorce. His second marriage, to Lynnel, was very happy. They had two adored daughters.

I would like to give now the broad outlines of some of Paul’s research. It started in function theory and potential theory. At Stanford he began his collaboration with Max Schiffer on the Bieberbach conjecture; very likely they were introduced to this problem by their colleague Charles Loewner, who did the deepest work on this problem back in 1923. Their approach was to use the calculus of variations. The formulas involved in this research were formidable. Ultimately, the complete solution, by de Branges, used the Loewner representation of schlicht functions.

There is a natural connection of analytic functions to fluid dynamics; two-dimensional incompressible, irrotational flows are described by analytic functions. Paul’s interest in fluid mechanics was much broader. He tackled many of the classical problems in fluid dynamics, such as the flow around a rising bubble, the shape of an electrified droplet, the vertical entry of a wedge into water, and other problems of flows with a free boundary.

In the 1970s aircraft companies were designing planes that could fly near the speed of sound. That

meant that over part of the wing the airflow would be supersonic. Cathleen Morawetz had shown that in general such transonic flows contain shocks; shocks increase the drag of the airplane and therefore they should be avoided if possible.

One of Paul’s most influential works, with David Korn, was the design of airfoils that carry shockless transonic flows. This required solving partial differential equations that are partly elliptic, partly hyperbolic. They accomplished this by introducing complex coordinates. This was so sophisticated a mathematical idea that the aerodynamic community was unable to comprehend it; therefore they ignored it. Finally a mathematically minded aerodynamicist in Canada tested the airfoil in a wind tunnel and found the flow to be indeed free of shocks.

After that, aerodynamicists pounced on the Garabedian-Korn design. One of the leading French aircraft companies invited Paul to be a consultant. Paul accepted the offer, under the condition that they fly him to France on the Concorde.

In 1964 Paul published a text on the theory of partial differential equations, designed as a text for a graduate course. It treated all the usual theoretical subjects, as well as numerical methods for solving partial differential equations, including the use of complex coordinates. The book became extremely popular and still is today.

Starting about thirty years ago Paul turned his attention to the mathematical and engineering problems of nuclear fusion. The physics subject, called magneto-hydrodynamics (MHD), is about flows of high temperature plasmas that typically contain shock-like discontinuities. Paul published about sixty papers on the subject, more than a third of his total publication of 167 papers (the last one appeared in 2010). He believed in the practicality of generating energy by nuclear fusion. Until the last months of his life, very weak physically but razor sharp mentally, he continued to work on problems of MHD. If fusion energy ever becomes a reality, Paul’s work will have played an important part in its success.

With much outstanding mathematics one can imagine the work having been done by a number of mathematicians. Not so with most of Paul’s accomplishments; his outlook was unique. He will be remembered for a long time.

Albert B. J. Novikoff

Here goes (stream of consciousness): we were both around sixteen years old, too young to be at (Brown) University, but it was war time, and compromises

Albert B. J. Novikoff is professor of mathematics at New York University, Courant Institute. His email address is albert.novikoff@gmail.com.

were the order of the day. I came first, from Bronx Science, and Paul arrived a year later, fresh from home schooling in a professor's household. I was, comparatively, the sophisticate, but we both wore long underwear in the winter, scandalizing our respective roommates and condemning us to room together. Items of forbidden winter clothing remain in my mind, stigmata of being under age and of controlling mothers, specifically, mittens and galoshes. He was already tall, but like a giant boy Pinocchio, all kneecaps and shins. I had not yet started the viola, and he, miraculously, already played Chopin ballades and (on the violin) the great Bach *Chaconne*. I had no one from Bronx Science to compare him to.

Mathematically, he had a comparable background. His father still marveled at his own experience at Harvard, under the great G. D. Birkhoff, and what it was like to be in class and watch the great man thinking his way before your very eyes. His father, by the way, played me an organ symphony by Widor, whose existence had until then escaped me.

Music, mathematics, and the intellectual life were his heritage, but apparently he had been left out of "kidhood," and my great (ha!) contribution was to introduce him to the humbler parts of human destiny. He was quick to enjoy the company of the graduate students we both frequented and remained tremendously grateful to me over the decades, when I did no more than turn a key in a metaphorical door.

As his roommate (and hopeless competitor in math classes) I can report that he was a "clean desk" type from the get-go; only the prescribed texts sullied the empty plane of his desk. What he worked on was his own, in every sense. I think he took pleasure in being obstinately independent, unbowing to written authority.

By the time he was taking senior (and also graduate) courses, the graduate students all recognized that he was exceptional. I never told him, but once a group of us were remarking on this when the senior member of our circle, a future physicist, remarked wryly, "He's going to be annoyingly useful some day."

Now the public in general has (or had) little understanding or interest in what mathematicians actually do. Regarding this, Fritz John noted some years ago that the mathematician's sole recognition is "the grudging appreciation of a few friends". Clearly, Paul started collecting his quota of such recognition from an early age.

As I learned from an early visit to his parents in Wheaton, MA, where his father was not only professor of mathematics but school organist and director of the (girls) choir, a lot was pretty much set in stone.



Paul with David Gilbarg (1950s).

A few years later I was at Stanford and heard Schiffer boast of the recent discoveries of his student, Paul, at Harvard. I had not ever been party to such generous pride. I remember him looking back at Harvard and commenting that he had been "pretty good" at ideal theory and wondering just what units he was using.

Other associations are Saint-Venant's problem (whatever that was, involving René de Possel), the Bieberbach Conjecture, et al.

He mellowed enormously with a happy marriage and adoring daughters and took to making jokes at his own expense. Just after moving to his new apartment, not so long ago, he had occasion to decide which reprints he wanted to save, and said, "I seem to have written each paper five times."

With more emotion than I care to admit, Al Novikoff

C. Denson Hill

In late August of 1961 I arrived at Idlewild [now Kennedy] Airport, having \$300 in my pocket and no idea how to get to NYU, where I was supposed to become a new graduate student. So I squandered part of it by taking a taxi into Manhattan and then asked the taxi driver if he knew of a cheap hotel near Washington Square Park. After a night of squishing cockroaches, I went to look for the

C. Denson Hill is professor of mathematics at Stony Brook University (SUNY). His email address is Dhill@math.sunysb.edu.

famous Courant Institute. I was dismayed to find out that it was located in an old hat factory, and I was shocked at how rude people were on the street and how much of a slum the neighborhood appeared to be. I had expected something quite different. But they had offered me a fellowship, and I had no other place to go, so I went inside to look for somebody to talk to. Almost immediately I found a kind secretary, who took me to “tea,” saying I might find some faculty member there. At Rice University I had already developed an interest in PDE, applied mathematics, and had some experience with numerical analysis. It was because of those interests that I had been advised to go to Courant, but nobody had suggested whom I should see there or exactly what I should do upon arrival.

At tea, there was only one guy, who I thought was another graduate student. But the secretary introduced him to me as “Professor Garabedian.” He looked much too young to be a professor. Over tea he politely asked me what my interests were, which courses I had taken, etc. Then he announced that he was writing a book on PDE and that he needed somebody to read and correct the manuscript, and he asked me if I would like to help him on his project. Of course I agreed. That is how, within twenty minutes of entering the building, I became a graduate student of Paul Garabedian.

So for my first two and a half years as a graduate student, I had the side job of going over various drafts of Garabedian’s book [1]. At that time Paul had another student, Jerry Kazdan. He was a few years ahead of me, and Jerry had made detailed criticisms of the first draft of the book. My job was to go over various subsequent drafts. I wound up making extensive revisions to Chapter 10 on integral equations and Chapter 15 on free boundary problems. Needless to say, I learned an enormous amount, not only from the manuscript itself, but also from the sometimes heated discussions with Paul about my suggestions for changes. I was always pressing him to make precise definitions and state precise theorems, and Paul was always resisting. He kept telling me that he wanted the book to be read by engineers and other applied scientists and that he was trying to provide insight, not a list of theorems. His point was that if he tried to prove the sharpest versions of various theorems, it would clutter up the exposition and obscure the elegance of many arguments. Probably at that time I was too much enamored of my recent affair with Bourbaki. But luckily I had also read Goursat, so I did in fact get his point. After more than fifty years, I see clearly now that he was right.

What impressed me the most was Garabedian’s amazing ability to step out into imaginary directions and use several complex variables to gain

insight into various questions about PDE’s. In this aspect he was very much in the spirit of J. Hadamard and H. Lewy. So I read Hadamard’s book on the Cauchy problem, and a number of Lewy’s papers. (This set me up for my later work with Aldo Andreotti.) But eventually when I went to Paul and asked him to suggest a thesis problem which had something to do with several complex variables (a subject I knew nothing about at the time), he said, “Well, I used to work in SCV, but I gave it up because I did not understand it.” Later I found out that Garabedian was the man who invented the $\bar{\partial}$ -Neumann problem.

The story, as told to me by Paul, went like this: For some period he was working with D. Spencer. It was a friendly collaboration in which each was quite polite and respectful to the other. But the problem was that he never understood anything Spencer said, and he was not sure if Spencer understood him either. So it wound up with each of them writing his own paper and putting the other guy’s name on it [2], [3]. The $\bar{\partial}$ -Neumann problem was formulated in the paper [2] written by Garabedian. As is well known, Spencer later pushed his student J. J. Kohn to solve the problem, which was difficult due to the noncoercive nature of the Neumann boundary condition for $\bar{\partial}$.

Another story Paul told me was how he managed to get his Ph.D. at Harvard, in only two years, by solving his thesis problem over the weekend. Ahlfors had returned to Harvard as a full professor in 1946, and Garabedian was his first Ph.D. student there. Paul walked into Ahlfors’s office on a Thursday, or maybe a Friday, and asked him for a thesis problem to work on. Ahlfors promptly suggested a problem involving the Szegő kernel. But Garabedian did not understand exactly what Lars was getting at. Fortunately another mathematician, Menahem Schiffer, had also arrived at Harvard as a research lecturer in 1946, but he was over in applied mathematics. Paul had discovered that Schiffer was easy to talk to, so he went over to the applied mathematics department to ask Schiffer just what it was that Ahlfors wanted him to do. Schiffer was much more clear than Ahlfors had been and was able to explain to Paul what the problem actually was. Knowing now just what the question was, Garabedian went home, worked hard over the weekend, and went back to Ahlfors’s office on Monday and presented the solution. Ahlfors said, “You have a thesis.” Later Garabedian and Schiffer became colleagues and collaborators at Stanford.

References

- [1] PAUL R. GARABEDIAN, *Partial Differential Equations*, John Wiley and Sons, New York, 1964.



Alex Chorin, Paul, and Lynnel at the National Academy of Sciences award celebration.

- [2] PAUL R. GARABEDIAN AND D. C. SPENCER, Complex boundary value problems, *Trans. Amer. Math. Soc.* 73 (1952), 223–242.
- [3] ———, A complex tensor calculus for Kähler manifolds, *Acta Math.* 89 (1953).

Antony Jameson

Paul Garabedian's Contributions to Transonic Airfoil and Wing Design

This note on Paul Garabedian's work on transonic airfoil and wing design is written from the perspective of aeronautical engineering as well as applied mathematics. Paul's contributions in this area had a profound and lasting impact on the way people set about designing wings in the aircraft industry. Transonic flow is of great relevance to aircraft design because it is the most efficient regime for long-range transport aircraft. Transonic flow is also of great mathematical interest. Outside the boundary layer and wake the flow is well represented by the transonic potential flow equation which is of mixed type, elliptic in the subsonic zone and hyperbolic in the supersonic zone. This equation proved quite intractable to analytical methods of solution. In order to reduce the drag one must look for shapes that minimize the shock strength or even produce shock-free flow. This was the problem that Paul chose to tackle. It had been established, however, by Cathleen Morawetz that shock-free solutions are isolated points and shocks will appear with small perturbations of the shape or the flight condition. So the problem of designing a shock-free shape is not well posed.

Paul elected to pursue an inverse approach. Following earlier work by Lighthill, he used the hodograph transformation in which the velocity

Antony Jameson is Thomas V. Jones Professor of Engineering, Department of Aeronautics and Astronautics, Stanford University. His email address is jameson@baboon.stanford.edu.

components u and v are treated as the independent variables and the coordinates x and y become the dependent variables. While this results in a linear equation of mixed type, it remains hard to find solutions in the hodograph plane which correspond to physically realizable shapes. Nieuwland had previously generated a family of hodograph solutions which resulted in airfoils that were not practically useful. Paul applied the method of complex characteristics which he had successfully used to solve the supersonic blunt body problem in earlier work to solve the equations in the hodograph plane. He was able to find boundary conditions and integration paths that resulted in usable shock-free airfoils for a range of Mach numbers and lift coefficients. Working with his assistant Frances Bauer and his doctoral student David Korn, he published the first results in the book *Supercritical Wing Sections*.

In this period he made contact with Richard Whitcomb at NASA Langley, who had experimentally developed a supercritical airfoil with a flat-topped shape and heavy rear camber which produced a comparatively weak shock at its design condition. Paul's shock-free 78-06-10 airfoil had a similar though smoother shape. This influenced Whitcomb's thinking, and he decided to fund further studies of supercritical airfoils at the Courant Institute. Paul also made contact with R. T. Jones at NASA Ames and obtained additional funding from Jones to pursue studies of yawed wings.

In 1970, as a staff engineer at Grumman, I was asked to look into the state of the art in supercritical wing technology. I soon found out that Paul's group was at the cutting edge. Eventually I joined the group as a senior research scientist in 1972. Paul was now working on a second book, *Supercritical Wing Sections II*, which presented an improved series of shock-free airfoils, a transonic analysis method (Program H) which included a boundary layer correction, some results of experimental tests, and some preliminary results for yawed wings. My principal assignment was to write the three-dimensional analysis code for yawed wings (Program J, or Flo17) which subsequently evolved into a widely used code for calculating transonic flow over swept wings (Flo22). Program H and Flo22 are still in use today for preliminary design work at Boeing.

The concept of a yawed flying wing for supersonic cruise was the subject of intensive studies at NASA fifteen years later, but no viable design emerged. In the meanwhile Paul continued his studies of supercritical wing design, issuing a third book, *Supercritical Wing Sections III*, in 1977. With Geoffrey McFadden he also developed a three-dimensional inverse design method. By 1980 his interest had switched to magnetic containment

of plasma for fusion reactors, and this remained the main focus of his research for the rest of his career.

In the period I worked for him, Paul was a wonderful mentor. He exposed me to broad areas of mathematics in which my knowledge was quite deficient. He would do this in a very subtle way by casually asking if I was not aware of this or that, for example, the Bateman variational principle. Then I would be forced to go and find out what he was talking about. He had an extraordinary youthful appearance—at age forty-four one might easily have taken him to be twenty-eight.

To the best of my knowledge none of the airfoils listed in either of the two books was directly used in an actual aircraft, but they had a profound and lasting impact on the aircraft industry by showing for the first time that practically useful supercritical airfoils which are shock free or produce very weak shocks could be designed. This permanently changed the way engineers think about transonic wing design.

The 75-06-12 “Garabedian-Korn” airfoil has been widely used as a benchmark to validate new numerical methods for computational fluid dynamics (CFD). Due to three-dimensional effects, particularly near the fuselage, a satisfactory swept wing cannot be designed with a fixed wing section from root to tip. In a numerical experiment I have substituted the Garabedian-Korn section into a representative modern transonic wing design, the NASA Common Research Model (CRM), which is the test shape for the latest AIAA Drag Prediction Workshops. The initial design produced a very strong shock wave across the entire span. However, using an optimization method based on techniques drawn from control theory for partial differential equations, the wing can be redesigned to produce an essentially shock-free flow. This demonstrates that the Garabedian-Korn section could still be used as the starting point for a competitive wing. This calculation took four hours using a quad-core workstation which is about 5,000 times faster than the Control Data 6600 computers at the Courant Institute in the early 1970s and has about 8,000 times the memory. Evidently such a calculation would not have been feasible in that era. Nevertheless, the outcome after forty years is that all modern transonic commercial aircraft, including business jets as well as airliners, have wing sections which strongly resemble the sections designed by Paul Garabedian.

Eva V. Swenson

Paul Garabedian was my Ph.D. thesis supervisor during 1961–1965. I am indebted to him for taking me under his wing, for patiently coaching and supporting me through the Ph.D. process, and for maintaining an interest in my career and my life ever after. He provided me with a steady compass point that I knew I could turn to anytime I felt I needed to.

As a graduate student and research assistant, I felt fortunate to be assigned the office adjoining his which was quite small, enough for only one person. It allowed me to concentrate on work, and it provided enough space for the voluminous computer printouts that I was generating at that time. By contrast, his own office was a huge corner office minimally furnished with desk, chair, plant, and a couple of file cabinets. The desk itself held very few items; most notably he always had a 4" × 6" notepad and a pen. His office spoke volumes of his clear and uncluttered thinking. With Paul's steady guidance and gentle encouragement, I pursued various explorations until one day Paul excitedly declared, “Eva, I think you have your result!” He showed me that producing a Ph.D. thesis can be challenging and satisfying, and he enabled me to experience that fantastically rich world where pure and applied mathematics intersect.

He wasn't all work, though. Paul knew very well how to live in balance. I remember well the gatherings on Friday evenings with Paul and Lynnel and his graduate students and their respective girl/boyfriends of the day. On those occasions, I felt that he was just one of us, having a good time. We would go to the public pool for a swim, then to his apartment for martinis. Then we would go to the Old Mill Restaurant for cheap but excellent steaks. One summer, he invited us all out to his place on Fire Island. I remember a scene where we were all sunbathing on the beach, except that Paul was off to one side with his 4" × 6" notepad and pen, unobtrusively continuing to work on the theorem of the day.

In retrospect, I realize how extremely fortunate I was to have Paul as my mentor. He taught me through lectures, discussions, and, especially, by example. I learned to stay focused: to look for the essential and to trim the superfluous. I learned that if an idea can't be contained in a 4" × 6" notepad, it is not yet “ready for prime time.”

Eva V. Swenson's email address is eva.swenson@sympatico.ca.



Paul with daughters Cathy and Emily, 1989.

Ruth Bers Shapiro

The following is drawn from a talk that Ruth Bers Shapiro gave at the memorial for Paul on December 4, 2010. Ruth Bers Shapiro's email address is ruthbersshap@aol.com.

Remembering Paul

I am honored that Lynnel asked me to speak today about Paul as a friend and as a husband and father. Paul, Lynnel, and I often spoke of the many ways our lives intersected. Here is a brief chronology. I first met Paul in the early 1950s on a visit to Palo Alto. Paul had been a student of my father, Lipman Bers, at Brown University in the early 1940s. Before our meeting, my father described Paul with great affection as a highly gifted mathematician. He had neglected to tell me, however, that Paul was also handsome, had an irrepressible twinkle in his eye, and loved having a good time. He was by far the coolest mathematician I had ever met.

In the fall of 1957, Lynnel and I met in our freshman year at the University of Michigan, became roommates, and have remained best friends since then. After graduating from college and while working towards a master's degree in English literature at NYU, Lynnel took a job at the Courant Institute. I was not surprised that when she met Paul, she found him charming, adventuresome—before their meeting he had sailed from San Francisco to Hawaii on a four-man sailboat—and romantic.

They were from the start and remained throughout their marriage closely matched on how they saw the world. In politics, vociferous liberals. In religion, confirmed atheists but fully tolerant of others' beliefs. In friendships, unswerving in their loyalty and devotion to their friends. It is hard to speak of one without the other, but I do want to say a few words about Paul's essential values.

Although he could be exacting and discriminating about mathematical elegance, scientific rigor,

or musical performance—perhaps even elitist or snobbish—in terms of political and social justice, Paul was consummately egalitarian. He could not tolerate discrimination or injustice of any kind, and he felt that every human being deserved a fair break, an opportunity to have a good life. It was painful to him that in our wealthy nation, people were left stranded. He believed in a visceral way that the privileged and fortunate needed to care for the poor and disenfranchised. He was outspoken and courageous.

Paul was a wonderful friend. If there was a problem and he could help, he never turned away, even when it was uncomfortable and might put him in a difficult position. He remained grateful to people who befriended him or helped him in large or small ways.

Before becoming a parent, Paul expressed the worry that his preoccupation with mathematics would make it difficult for him to be a good father. Lynnel reassured him. In fact, Paul was a passionate, empathic, and supportive parent. It is Lynnel's view that he fell in love with his daughters and was transformed by the love he felt for them. I would second that.

I am sure everyone here knows that Paul could be meticulous—he worked on a cleared desk with only the sheet of paper on which he was writing. When it came to Emily and Cathy, only the constructive aspects of order remained. He wanted them to feel free, valued their spontaneity, and was charmed by their developing personalities. When they were young, Paul was known to refer to his daughters as his two best theorems.

Paul loved life. He fought against the ravages of cancer, refusing even an Advil because he did not want anything to interfere with the clarity of his thought—stubborn in ways, but passionate and intensely alive. It is not surprising that his last paper, written with his devoted student Geoffrey McFadden, was published just four months before he died.

I will miss him as long as I live: his humor, warmth, compassion, and his intensity.

Cathy Garabedian

Memories of My Dad

By the time I was born in 1975, my father was forty-eight years old and was already a well-established mathematician. Earlier that year, before I was even born, he had been elected to the National Academy of Sciences. This honor was lost to me, as my earliest memory of my father is being carried to bed on his shoulder, watching our cozy living room

Cathy Garabedian's email address is cathy.garabedian@gmail.com.

grow smaller as I clung to the neck of his six-foot frame. There I am sure he kissed me good night and told me he loved me before tucking me into bed, as he did year after year as I grew up.

As I grew older I slowly became aware that my father had an important role outside our home as someone other than “my Daddy.” I remember learning when I was about eight years old that he was writing a book about his work, so I asked him if he would dedicate it to me. When the book came out, I didn’t even understand the title, but I was extremely proud that it was dedicated to me, my sister, Emily, and the coauthor’s daughter. I still have a copy of *Magnetohydrodynamic Equilibrium and Stability of Stellorators* on my shelf with my dad’s handwritten dedication and a smiley face along with the printed inscription. It never mattered to me what the book was about; I was proud of my father just for being my dad. Looking back at my life, however, I realize that my father’s work had a great influence on me.

My father had great confidence in his own intellectual abilities and taught me and my sister to have the same confidence in ours. When I was in high school, he would help me with my calculus homework. He would read the problem and then think it through and start explaining how we would solve it, sketching out a plot and carefully writing down a couple of formulas. “See, it’s easy,” he would say, “You can do this.” His words came back many times over the years: while studying for organic chemistry tests in college, trying to understand the Hodgkin and Huxley model of the action potential in graduate school, and teaching myself how to program in Matlab to analyze data for my graduate thesis. “It’s easy,” I’d think to myself. I knew that my dad believed in me. His confidence in me is a strength I carry in myself. He believed in his daughters so strongly that we couldn’t help but believe in ourselves.

In fact, as a father of two daughters, he was fervent in his support of equal opportunity for all. He firmly told us that women were as capable as men in math and expressed his respect for the women he had advised as graduate students. This respect extended to his racially and internationally diverse group of students and colleagues. His egalitarian belief system informed his social and political views, such as his belief in a strong public education system for all and assistance programs for the disadvantaged. I believe that part of his choice and comfort with living in New York City was based in his appreciation of the multitudes of different people who live together in the city.

My father’s work as a mathematician took my family around the world, giving us exposure to cultures beyond what we could see even in New York. I spent my sixth birthday in Hong Kong,

on the way to Kyoto, Japan. My dad had become enamored with Japan the year before while he was there for a conference, and he and my mother decided to take the family there for his sabbatical. During our year in Japan, Dad started teaching himself Japanese, proudly practicing phrases from his language books and pointing out familiar Kanji signs to us in the subways.

Some of my dad’s travels that could have kept him away from his family instead became precious memories of time I shared alone with him. When I was in middle school, he took me back to Japan while he visited colleagues there and gave talks at Kyoto University. My sister was in high school, too busy with classes to join us, and my mom now worked full time. For three years these trips were our special father-daughter time. On the plane the airline attendants would dote on us, thinking it sweet that a single father was looking after his little girl. During my dad’s meetings I would do my school assignments, preparing for the presentations on “My trip to Japan” that I would give to my class when I returned.

Aside from math my dad’s passion was music. He would sit down almost every evening at our grand piano and play pieces by Chopin, Beethoven, or Mendelssohn. For a man whose work involved the logic and precision of mathematical calculations, his love of the Romantic composers revealed a more emotional side. He would fill the room with strong, intense passages followed by soft, beautiful melodies. My parents encouraged me to take piano lessons from the age of seven so I could share this interest. Later my dad brought out his old violin so we could play duets; we practiced Beethoven’s *Spring Sonata* together, culminating in a concert for my piano teacher that earned us both stickers as a token of our accomplishment. But my dad loved nothing more than hearing me sing. In the mornings he’d brush my hair before school, and as he wove it into two braids, I would sing him all the songs I could think of: *Somewhere Over the Rainbow*, *Tomorrow* (from “Annie”), and tunes from “The Sound of Music”. When I started performing in musicals, he would come to every show, making sure to get there early to get a good seat and beaming when I came out to take my bow. There was no more proud, dedicated parent.

My dad looked forward to spending the summer at his sanctuary, our house on Fire Island. There he would take walks along the beach each day, enjoying the hard sand and crashing waves at low tide. He would disappear for hours by the ocean. I imagine him mulling over some research problem as he walked mile after mile in the sun, finally returning to our family as the sun got low in the sky. He would wave to us as the outline of his figure got closer and closer on the beach, and he



Paul escorting daughter Emily at her wedding, 2003.

would finally sit down in the sand with us to enjoy the last warm breeze of a summer day. Sometimes he would sit on the porch of our cottage and watch the birds, finding joy in the new hatchlings learning to fly in the spring. My father's sometimes quick temper was balanced by an unbelievable soft spot for the beauty and innocence of nature.

My father was successful at mathematics at a young age and found fulfillment in his work through the very end of his life. He continued to feel passion about his research as he raised his family, running to the office after the presents were opened on Christmas morning to check his computer run, and quietly scribbling ideas in his notebook when he was on vacation with us. However, I never for a moment thought that his family was anything but his top, most important priority. I have never seen as much pride in his eyes as when he walked my sister down the aisle at her wedding, helped my little nephew put on his shoes, and held my giggling niece in his arms before she could even say "Grampa". My family has lost a loving father and husband and we will miss him, but we will never forget the wonderful memories he gave to us, and we will hold them with us always.

Emily Garabedian

The following is drawn from a talk Emily Garabedian gave at the memorial for Paul on December 4, 2010. Emily Garabedian's email address is emily.garabedian@gmail.com.

Memories of My Father

I am Paul's older daughter, Emily. Many of you know me. Some of you watched me grow up. Most of this day commemorates Paul's academic achievements and mathematical genius. But I am glad we will spend some time remembering his personal life, celebrating him for the father, husband, brother, grandfather, and friend that he was. I would like to share with you some of my memories of Paul as a father.

Growing up, I remember my father as an intellectual, an academic. He did math, and he played the piano. I never thought of him as an athlete. However, in preparing this eulogy, I realize many of my childhood memories are of sports activities my father did with me, including teaching me how to play tennis. He took me to Paragon Sports and bought me a racquet, and he would reserve a court on the roof of the Coles Sports Center. I'm afraid I never excelled at tennis. For a while, to my father's dismay, I insisted that he reserve a basketball court instead. He didn't play basketball, but he got me a basketball and took me to Coles and practiced with me. I expected my father to help me with my math homework and to give me confidence in my intellectual abilities. But I realize that he also tried to give me the confidence I needed to try out for the basketball team. When I didn't actually make the team, he was there to console me.

My father brought me to the pool at Coles, and we would swim together. Sometimes we would meet people he knew from NYU, and I could hear the pride in his voice when he introduced me, and I knew he thought I was one of the most important people in the world.

My father tried to teach me how to ride a two-wheeled bicycle. He tried to explain to me, at the age of five or six, the physics of keeping the device upright. I learned about gyroscopes and angular momentum, but I wasn't able to ride the bike. In the end it was our doorman who intervened. He would run behind me as I pedaled, holding on to the back of the bike just like my father did, only when I had achieved some speed, the doorman would let go. This was something my father was afraid to do. Although he knew I would have to fall to learn how to ride, he couldn't bear to feel responsible for it.

Paul enjoyed sailing and had a boat, a Flying Junior, that he kept on Fire Island where my family spent the summers. I recall him strapping a life jacket on me over my protests that I was a big girl and I knew how to swim even in water over my head. Paul encouraged me to learn how to sail myself and taught me how lift helps pull a boat forward when it is going upwind. When I proved to be much better at sailing than I was at tennis or



Paul, a lifelong pianist.

basketball, he sold his beloved Flying Junior and bought me a Sunfish, the style of boat that was sailed by the other teenage kids.

In the winter my father would take me ice skating, first at Sky Rink, an indoor rink on the top floor of a skyscraper, and later at the Wollman Rink in Central Park. He knew a few tricks, and we would do figure eights and little leaps he called bunny hops. I wanted him to teach me how to twirl like the figure skaters we would watch together. He wasn't able to do that trick, but he explained to me again about angular momentum and pointed out how the skaters would spin faster when they pulled their arms in close to their bodies. I loved holding hands with my father as we skated around and around the rink. I continued to hold his hand while we skated, many years after I no longer needed it for balance.

My daughter is turning four years old soon, and her big gift is going to be her first two-wheel bicycle. I'm sad that my father won't be around to see her learn to ride it. I was sad when I took my children ice skating last week. I told both my children that their grandfather could have taught them how to skate. I am trying to help my children retain their memories of their grandpa, talking to them about the kind of person he was and the things he liked to do with them, like helping them put on their shoes.

And so we keep my father's memory alive through our recollections of him, his dedication to his family and to his work which will be carried on.

Announcing...

The creators of MathJobs.Org welcome you to:

MathPrograms.Org



Receive, read, rate, and respond to electronic applications for your mathematical sciences programs, such as undergraduate summer research programs and travel grant competitions.

Customize your settings and control the application form; also set secure access for the admissions committee.

Enter program announcements for public display.

Download data to personal computers for use in word processing and spreadsheets or as a full permanent storage file.

Service is **FREE** to applicants.
Institutions pay annually for one program or for multiple programs.

Math in Moscow Scholarship Program

Study mathematics the Russian way in English

The American Mathematical Society invites undergraduate mathematics and computer science majors in the U.S. to apply for a special scholarship to attend a semester in the Math in Moscow program, run by the Independent University of Moscow.

Features of the Math in Moscow program:

- 15-week semester-long study at an elite institution
- Study with internationally recognized research mathematicians
- Courses are taught in English

Application deadlines for scholarships: September 15 for spring semesters and April 15 for fall semesters.

For more information about the Math in Moscow program, visit: mccme.ru/mathinmoscow

For more information about the scholarship program, visit ams.org/programs/travel-grants/mimoscow



Mathematical Reviews/MathSciNet Associate Editor



Applications are invited for a full-time position as an Associate Editor of Mathematical Reviews/MathSciNet, to commence as soon as possible after July 1, 2014, preferably before September 1, 2014. The Mathematical Reviews (MR) division of the American Mathematical Society (AMS) is located in Ann Arbor, Michigan, in a beautiful, historic building close to the campus of the University of Michigan. The editors are employees of the AMS; they also enjoy many privileges at the university. At present, the AMS employs over seventy people at Mathematical Reviews, including sixteen mathematical editors. MR's mission is to develop and maintain the MR Database, from which MathSciNet is produced.

An Associate Editor is responsible for broad areas of the mathematical sciences. Editors select articles and books for coverage, classify these items, determine the type of coverage, assign selected items for review to reviewers, and edit the reviews on their return.

The successful applicant will have mathematical breadth with an interest in current developments, and will be willing to learn new topics in pure and applied mathematics. In particular, the applicant should have expertise in one or more of the following areas: algebra, geometry, number theory, topology. The ability to write well in English is essential. The applicant should normally have several years of relevant academic (or equivalent) experience beyond the Ph.D. Evidence of written scholarship in mathematics is expected. The twelve-month salary will be commensurate with the experience that the applicant brings to the position.

Applications (including a curriculum vitae; bibliography; and the names, addresses, phone numbers, and email addresses of at least three references) should be sent to:

Dr. Graeme Fairweather
Executive Editor
Mathematical Reviews
P. O. Box 8604
Ann Arbor, MI 48107-8604

email: gxf@ams.org
Tel: (734) 996-5257
Fax: (734) 996-2916
URL: www.ams.org/mr-database

Applications received by March 28, 2014, will receive full consideration.

The American Mathematical Society is an
Affirmative Action/Equal Opportunity Employer.

Alan Turing, Marshall Hall, and the Alignment of WW2 Japanese Naval Intercepts

Peter W. Donovan

Marshall Hall Jr. (1910–1990) is deservedly well remembered for his role in constructing the simple group of order $604800 = 2^7 \times 3^3 \times 5^2 \times 7$ as well as numerous advances in combinatorics. A brief autobiography is on pages 367–374 of Duran, Askey, and Merzbach [5]. Hall notes that Howard Engstrom (1902–1962) gave him much help with his Ph.D. thesis at Yale in 1934–1936 and later urged him to work in Naval Intelligence (actually in the foreign communications unit Op-20-G).

I was in a research division and got to see work in all areas, from the Japanese codes to the German Enigma machine which Alan Turing had begun to attack in England. I made significant results on both of these areas. During 1944 I spent six months at the British Headquarters in Bletchley. Here there was a galaxy of mathematical talent including Hugh Alexander the chess champion and Henry Whitehead the eminent topologist...

Burroughs, Lieberman, and Reeds [2] clarified the work of Op-20-G on the Enigma in a contribution to the obituary of Andrew Gleason (1921–2008). Unfortunately the surviving records scarcely allocate credit to individuals. Hall was one of about ten core members of a team of about thirty not far from being another galaxy of mathematical talent. See Christenson [3].

Peter Donovan is retired from the mathematics department of the University of New South Wales in Sydney, Australia. His email address is p.donovan@unsw.edu.au.
DOI: <http://dx.doi.org/10.1090/noti1090>

The statistician Edward Simpson led the JN-25 team (“party”) at Bletchley Park from 1943 to 1945. His now declassified general history [12] of this activity noted that, in November 1943:

[CDR Howard Engstrom, U.S.N.] gave us the first news we had heard of a method of testing the correctness of the relative setting of two messages using only the property of divisibility by three of the code groups [5-groups is the usage of this paper]. The method was known as Hall’s weights and was a useful insurance policy just in case JN-25 ever became more difficult. He promised to send us a write-up of it.

The JN-25 series of ciphers, used by the Japanese Navy (I.J.N.) from 1939 to 1945, was the most important source of communications intelligence to the WW2 Allies in the Pacific.

Alan Turing’s Work on Applied Probability

The centenary of the birth of Alan Turing (1912–1954) was extensively publicized in the popular and semipopular media. His contributions to applied probability theory and the central role this played in WW2 cryptology were substantially overlooked. In fact, Jack Good published two papers ([6] and [7]) which set out the technical aspects of his work. Good had been Turing’s assistant for a while in his Bletchley Park years. Some analysis of the use made of this work in WW2 cryptology is now possible.

The greatest achievement of WW2 Allied cryptology was the breaking of the German encrypted teleprinter (teletype, teletypewriter), called *Tunny* by the cryptologists. Eventually this was handled

by the celebrated Colossus device, an (almost) electronic machine that replaced the optical punched tape-based Robinson. Good, Michie, and Timms [8] wrote a detailed account of this achievement in 1945. For present purposes the key sentence is:

The fact that Tunny can be broken at all depends upon the fact that P , χ , Ψ , K and D have marked statistical, periodic or linguistic characteristics which distinguish them from random sequences of letters.

This report states elsewhere that the method involved, using logarithmic Bayesian “weights” and Turing’s decibans, originated in the Naval Cryptology unit. Hugh Alexander in [1] leaves no doubt as to who was the dominant figure in work on Naval Enigma at Bletchley.

It is possible, but quite laborious, for anyone with appropriate skills to extract from [8] the substance of Turing’s work on (Bayesian) probability being applied to cryptology. However, the recent declassification of his working paper [14] (circa August 1941) on the subject helps considerably. A useful commentary on this point has been written by Zabell [16].

Andrew Hodges records on page 243 of his well-known book [9] that, around December 1942, Gleason and Turing were eating in a Washington restaurant. They discussed:

...statistical problems, such as that of how best to estimate the total number of taxicabs in a town, having seen a random selection of their licence numbers.

The theory needed for this “German tank” problem is Bayesian. One may speculate that this led to the initiative described by Ruggles and Brodie [10] in 1947:

In early 1943 the Economic Warfare Division of the American Embassy in London started to analyse markings and serial numbers obtained from captured German equipment in order to obtain estimates of German war production and strength.

Ruggles and Brodie show that interest in this matter was developing in the United States independently of Turing. Gleason’s role in this matter is not clear. In 1958–1960 I undertook the basic military training then commonly available for Australian boys aged fifteen to seventeen and was fascinated by the range of information engraved on the WW2 rifles used.

The statistician Edward Simpson was transferred to work on JN-25 at Bletchley Park in 1943. In 2010 he wrote an account [11] of this work, entitled *Bayes at Bletchley Park*. It explains the role of some of this material in decrypting Enigma traffic also.

The version of the Bayes Theorem needed for assessing whether a potential decryption should

be accepted and also for Hall weights is as follows. Suppose that it is known that exactly one of the two hypotheses S and T is valid and independent runs are made of an experiment whose output is an element of a finite set K . It is known that, if S holds, then for $k \in K$ the probability of the outcome being k is σ_k , while if T holds the probability is τ_k . Suppose that the experiment is run $N = \sum_k n_k$ times with n_k occurrences of output k . Let p_0 denote the “prior” probability (before the experiments) that S holds. Likewise let p_N denote the “posterior” probability (after the results of the experiments are available) that S holds. Then

$$\begin{aligned} \log_{\beta}(p_N/(1-p_N)) \\ = \log_{\beta}(p_0/(1-p_0)) + \sum_k n_k \log_{\beta}(\sigma_k/\tau_k). \end{aligned}$$

Here the logarithms can be taken to any convenient base $\beta > 1$. Once β is chosen, the $\log_{\beta}(\sigma_i/\tau_i)$ terms are known as “weights of evidence” or just “weights”. Initially Turing advocated using logarithms to the base $\beta = \sqrt[10]{10}$ and named the dimensionless unit of weight the “deciban”. These were rounded to the nearest half. Later Good pointed out that it was easier to take $\beta = \sqrt[20]{10}$ and so to work with the half deciban or “hdb”. Another option is to take $\beta = \sqrt[100]{10}$ and thus use the “centiban”. The lack of modern calculating devices at the time made some rounding of the logarithms essential.

In general it is clear from the formula that if p_0 is quite small, then quite a lot of strong evidence is needed to make p_N large enough so that S is highly likely.

Additive Ciphers. The JN-25 Systems

A description of the structure of the JN-25 cipher systems is needed in any explanation of the task faced by those trying to break them. The underlying algebraic structure of an abelian group \mathcal{A} (here of order 100,000) and a subset S (here of order 33,334 and not invariant under all automorphisms of \mathcal{A}) is quite unorthodox.

The word “group” was used in the communications community in the sense of a string of letters or digits. These had a fixed standard length determined by the context. To avoid confusion, strings of 5 digits are here called 5-groups. The set \mathcal{A} of 5-groups has an evident abelian group structure specified by what was then called “noncarrying” or “false” addition.

There is a natural way to use 5-groups as a reasonably secure communications system. A list of words and/or phrases intended for use is prepared. A different 5-group, the *code* 5-group, is allocated to each. A long random table (the “table of additives”) of 50,000 (say) 5-groups is generated somehow and copied out on 500 serially

numbered pages with ten rows each of ten of these 5-groups on each page. (This note uses the word “random” loosely. All the underlying sample spaces are finite.) The message is written out in plain language on the first of four lines of a suitable form. The corresponding code 5-groups are written out on the line immediately below. A starting 5-group in the table of additives is randomly chosen. Consecutive 5-groups from the table beginning at the chosen 5-group are then written out on a third line, and the noncarrying sums (“code” + “additive”) are then calculated and written on the fourth line. These were called GATs, or 5-Groups As Transmitted. The proposed recipient would need to be able to reverse this process and so needed to be able to recover the starting point. Information for this purpose was called the indicator or indicators and was sent as part of the message encoded, encrypted, or perhaps concealed among the GATs. Better still, two or all three of these methods of keeping the indicator secure would be superimposed.

The security of such a cipher system depends upon the indicators being unbreakable, the table of additives being replaced reasonably frequently, and the code book being replaced perhaps rather less often. The frequencies of occurrence of the common code 5-groups should be reduced by allocation of alternative code 5-groups to common words and/or phrases in use. Ideally there would be calculation of the maximum secure life of these systems. In practice, distribution of replacement cipher material presented problems. An army in retreat would sometimes allow its cryptographic material to be captured. Dice or suchlike were little used in the making of “random” choices, and so these choices were much less random than they should have been.

The allocation of code 5-groups is best done in a patternless or random way. The I.J.N. did not choose its JN-25 code 5-groups randomly but instead limited itself to *scannable* 5-groups. In the U.S.N. jargon of the day, a 5-group was said to be scannable if the sum of its digits was a multiple of three. The subset $S \subset \mathcal{A}$ of scannable 5-groups has 33,334 elements. Simpson used the alternative phrase “divisible by three”.

Initially we assume that the indicator system of the JN-25 cipher under attack can be decoded, decrypted, or located as may be necessary. (As this was the case in November 1943, the theory of Hall weights was just an “insurance policy” being kept in reserve.) It is then possible to have 1,000 large pieces of paper (“depth sheets”) printed with fifty reasonably wide columns and perhaps thirty rows on each. This gives 50,000 columns, one for each 5-group in the table of additives. Intercepted messages can then be written out on a line with

each GAT in the appropriate column. The task is now recovery of the additive involved.

The word “column” was sometimes replaced by “depth”: the intercepted signals were then said to be “placed in depth”. Confusingly, the word “depth” was also used for the number of different GATs in a column. A column would thus contain N distinct 5-groups $\mathbf{x}_1, \mathbf{x}_2, \dots, \mathbf{x}_N$ where $\mathbf{x}_k = \mathbf{y}_k + \mathbf{a}$ and where \mathbf{y}_k is scannable for $1 \leq k \leq N$ and \mathbf{a} is an unknown 5-group. If d denotes the depth, then $N \leq d$. Occasionally duplication (a “hit” or “click”) occurred and then $N < d$.

A *potential decryption* is then any 5-group \mathbf{b} such that $\mathbf{x}_k - \mathbf{b}$ is scannable for each k . Anachronistic large-scale random sampling shows that for various N (line 1 in the table below) the probability U_N that a column with N distinct GATs has a unique potential decryption, the average number A_N of potential decryptions, and the least number L_N such that 90% of samples have at most L_N potential decryptions are shown on lines two, three, and four respectively.

N	7	8	9	10	11	12	16	20
U_N	0%	0%	1%	3%	6%	11%	42%	68%
A_N	148	73.2	38.4	21.7	13.3	8.6	2.7	1.6
L_N	318	164	87	49	30	19	5	2

Hence only 68% of columns with twenty distinct GATs can be deciphered in isolation. However, what can be done in attacking a new JN-25 system is to examine those columns containing sixteen or more distinct GATs to identify which of these have unique decryptions. This gives provisional statistics on the frequency of occurrence of common code 5-groups to the cryptologists, who would have had some, admittedly imprecise, knowledge of the above table. Details on how to get started on a new JN-25 system are slurred over here. This phase would then work on the columns of greater depth to select potential decryptions \mathbf{b} for which several of the “stripped” 5-groups $\mathbf{x}_i - \mathbf{b}$ are common.

Turing’s 1941 exposition [14] on the use of probability theory in cryptanalysis compares the general task of finding the correct decryption to looking for a needle in a haystack. The limitation that all code 5-groups are scannable reduced the size of the haystack (if, for example, $N = 10$, the haystacks average 21.7 potential decryptions rather than 100,000) and so materially helped with the $\log_{\beta}(p_0/(1-p_0))$ term in the Bayes formula.

My paper [4] describes how, between August 1939 and February 1940, Turing and a few colleagues assisted in developing a method to discover potential decryptions of columns of smaller depth that contain common decrypted 5-groups $\mathbf{x}_i - \mathbf{b}$. In fact, there is another method which (usually) was more productive. Turing was involved in early 1940 in designing the first version of a special

purpose desk calculator for handling the search for potential decryptions. By December 1942 the U.S.N. had an elaborate powered version (the “fruit machine”) being manufactured in Dayton, Ohio. The paper gives a contrived example of one use of such a device. The following text in a report (December 1942) was written by Turing and quoted in [4]:

SUBTRACTOR MACHINE. At Dayton we also saw a machine for aiding one in the recovery of subtractor [5]-groups when messages have been set in depth. It enables one to set up all the cipher [5]-groups in a column of the material, and to add subtractor 5-groups to them all simultaneously. By having the digits coloured white, red or blue according to the remainders they leave on division by three it is possible to check quickly whether the resulting book [code] [5]-groups have digits adding up to a multiple of 3 as they should with the cipher to which they will apply it most. A rather similar machine was made by Letchworth for us in early 1940, and, although not nearly so convenient as this model, has been used quite a lot I believe.

The naval facility in Pensacola, Florida, has a display (small museum) which has one of these fruit machines. The words “I believe” here refer to work carried out in Singapore, later Manila, and later still elsewhere and so not readily accessible to Turing. Yet he was kept informed to some extent.

The admittedly minimal evidence of Turing’s involvement is not restricted to this text. The senior cryptologist John Tiltman (1894–1982), heading the first team working on JN-25, did write up some reminiscences [13] for the internal use of the NSA. These include:

I have no knowledge of higher mathematics and my grasp of probability is instinctive and quite unsound, but I am not too proud to ask for help and, when I have done so, have not often been misled.

Turing’s report shows incidentally that the Bletchley Park mathematicians missed the use of colored background in speeding up the determination of divisibility by three. The aim is to arrange things so that the number of reds is congruent modulo 3 to the number of blues in each sum 5-group. This is somewhat reminiscent of the task of being given a graph drawn on a sphere with three edges meeting at each node, allocating a color (either red or blue) to each node so that the number of red nodes on the boundary of each face is congruent modulo 3 to the number of blue nodes. This task is a variant of the four-color theorem!



Photo by Joseph Maksin.

“Fruit machine” displayed in Pensacola, Florida.

Breaking a Cipher Piece by Piece

Turing’s report [14] discusses in detail the breaking of a cipher piece by piece rather than attempting to get the full solution in one calculation. This is the strategy implicit in the device mentioned above. It uses pre-existing knowledge of the common code 5-groups. The cryptologist would attempt to recover the original code 5-groups by finding the additive for each column. The task of recovering the plain language corresponding to a given code 5-group would be carried out one by one.

Passing by the methods of finding reasonable potential decryptions, the question remains, when should a potential decryption of a column of depth $d = 10$ (say) be accepted? There was considerable urgency at the time. It was accepted that a (hopefully) modest proportion of decryptions would be wrong, but (hopefully) most of these would be corrected when further messages using that part of the additive table turned up. It seems that the clerical staff used simple *scoring systems* such as: “For depths of ten, accept any potential decryption that yields at least three points. Here a point is awarded for each of the one hundred most common code 5-groups appearing in the proposed decryption and for each piece of horizontal evidence obtained.” In this reasoning the occasional duplicating GAT in a column is not disregarded but instead contributes to the calculated score.

A typical piece of “horizontal” evidence arises when the previous column has been decrypted with the common code 5-group 12345 being found. It is known that the common code 5-group 45678 often follows 12345 in signals. Hence a potential decryption in which 45678 occurs immediately to the right of 12345 is more likely to be correct.

One could argue that a better scoring system would award three points for any decrypted code 5-group in the most common twenty, two for any decrypted code group in the next twenty, one for common code 5-groups from forty-one to one hundred, and two for strong horizontal evidence. The word *weight* was used for a number of points in such a system. The threshold “at least three points” would then need adjustment. Any proposed scoring system for depths of (say) ten could be tested on the top ten GATs in columns with (say) sixteen or more GATs for which the correct decryption is known with high reliability.

Turing may well have sought rationality behind such scoring systems in 1940 and 1941, eventually producing the extremely important use ([11] and [14]) of Bayesian methods in cryptology. Of course any reconstruction of the thought processes that resulted in [14] is totally speculative. Quite independent work on sequential analysis was going on elsewhere. For example, Abraham Wald’s 1945 paper [15] describes work carried out in 1943 and contains (page 121) the remarkable paragraph:

Because of the substantial savings in the expected number of observations effected by the sequential probability ratio test, and because of the simplicity of this test in practical applications, the National Defense Research Committee considered these developments sufficiently useful for the war effort to make it desirable to keep these results out of the reach of the enemy, at least for a certain period of time. The author was, therefore, requested to submit his report in a restricted report which was dated September 1943. In this report the sequential probability ratio test is devised and its mathematical theory is developed.

The above discussion disregards the matter of getting started on a new JN-25 system. Here analysis of the initial traffic cannot be carried out piece by piece. One method is to accumulate depths which have unique decryptions and use them to get information on the common code 5-groups. It is in fact possible to use about seventy columns of depths at least thirteen to get an initial impression of what are the common code 5-groups. This depends upon the frequencies of occurrence being reasonably close to what happened historically. The details are not given here. Upgrading the statistics as more and more columns are decrypted must have been an essential part of the process.

Bayesian Methods in Decrypting JN-25 Columns

In this section K is the set of 33,334 scannable 5-groups. Hypothesis T is “the potential decryption

is incorrect,” and so the τ_k are all equal; indeed $\tau_k = 1/33334$ for all k . For the one hundred (or thereabouts) most frequently occurring code 5-groups k , the frequency σ_k is taken to be that obtained from decryptions already made. For other scannable 5-groups k the observed frequency would be a less reliable statistic. It was found easiest to just take $\sigma_k = 1/33334$ for such k : at least this avoided the need to calculate with negative weights.

General reference needs to be made to Edward Simpson’s 2010 account [11] of work carried out at Bletchley Park in 1943–1945 decrypting columns of JN-25 with depths as low as six. In essence it used the above method of exploiting the available data.

The anonymous NARA archive RG0457, entry A1 9032, box 578, file 1391 of March 1945 gives information on the success in attacking various JN-25 systems. Code book B was used in conjunction with additive table 7 from August 1, 1941, to December 3, 1941, that is, in the four months leading up to the raid on the Pearl Harbor Naval and Air Force facilities. It is noted that this combination (JN-25B7) received quite heavy use. Joint work between the American naval unit “Cast” in the Philippines and the British unit FECB in Singapore managed to recover 35,761 additives out of 50,000. The report notes that some of the 35,761 would be incorrect. The combination JN-25B8 (December 4, 1941, to May 27, 1942) had been attacked by the unit at Hawaii as well, and so 47,340 additives had been recovered.

Hall Weights

The Hall weights originate in the observation that, if the *characteristic* $\chi(abcde)$ of the 5-group $abcde$ is defined to be $a+b+c+d+e$ interpreted modulo 10, then the proportions q_j of scannable 5-groups with characteristic j are far from equal. Indeed, careful calculation reveals that $q_9 = q_6 = 925/33334$, $q_2 = q_3 = 1780/33334$, $q_5 = q_0 = 3247/33334$, $q_8 = q_7 = 4840/33334$, $q_1 = q_4 = 5875/33334$. It is far from clear why Hall or anyone else thought that this was worth examining.

The real-valued function $j \mapsto q_j$ defined on the cyclic group of order 10 necessarily has a 10-term expansion in terms of sines and cosines. The functional equation $q_j = q_{5-j}$ implies that five of these terms are zero. Simple calculation yields the following, which is correct to five decimal places:

$$\begin{aligned} q_j \approx & .10000 - .00007 \cos(2\pi j/5) \\ & - .00250 \cos(4\pi j/5) - .00001 \sin(\pi j/5) \\ & + .07808 \sin(3\pi j/5). \end{aligned}$$

The approximate formula $q_j \approx .100 + .078 \sin(3\pi j/5)$ is too attractive to be left out of this account.

Suppose d is reasonably large, say $d > 16$; \mathbf{y}_k , $1 \leq k \leq d$, are randomly chosen scannable 5-groups; and \mathbf{a} is a randomly selected 5-group. Then the distribution of values of the $\chi(\mathbf{y}_k + \mathbf{a})$ may be calculated and expanded in terms of sines and cosines. The coefficients of $\cos(3\pi j/5)$ and $\sin(3\pi j/5)$ may then be used to indicate the most likely value(s) of $\chi(\mathbf{a})$. One can use a table of values of the inverse tangent function to assist in decryption!

The formula $\chi(\mathbf{x} + \mathbf{a}) - \chi(\mathbf{y} + \mathbf{a}) = \chi(\mathbf{x}) - \chi(\mathbf{y})$ motivates the calculation of the probability σ_k of the difference $\chi(\mathbf{x}) - \chi(\mathbf{y})$ being k as \mathbf{x} and \mathbf{y} vary over the $33,334^2$ possible pairs (\mathbf{x}, \mathbf{y}) . These are rational numbers with denominator $33,334^2$ given as the sums $\sum_j q_j q_{k+j}$. The functional equation $\sigma_k = \sigma_{-k}$ is then implied by the earlier $q_n = q_{5-n}$. The values of σ_k are then given to six decimal places in the second column of either table below. In the previous notation S is the hypothesis that two intercepts are in alignment, while T is the hypothesis that they are not. The set K is now the set of ten digits and $\tau_k = 1/10$ for all k in the above logarithmic Bayes formula.

k= 0	0.130510	2.31288	2
1, 9	0.090556	-0.86162	-1
2, 8	0.075352	-2.45808	-2
3, 7	0.124667	1.91503	2
4, 6	0.109393	0.77980	1
5	0.069553	-3.15368	-3

The third column in this table gives the Hall weights $\log_\beta(10\sigma_k)$ in half decibans (so with $\beta = \sqrt[20]{10}$), while the fourth gives rounded values of these. These roundings lose quite a lot of precision.

k=0	0.130510	30.0009	30
1, 9	0.090556	-11.1762	-11
2, 8	0.075352	-31.8843	-32
3, 7	0.124667	24.8403	25
4, 6	0.109393	10.1148	10
5	0.069553	-40.9070	-41

In this table β is taken to be $\exp(3/338)$. The third column in the right-hand table gives instead $(338/3)\log(10\sigma_k)$, and the rounded values are given in the fourth column. Much less precision is lost. The choice $\beta = \exp(3/338)$ may be more aesthetic than historical.

Now suppose we are trying to test “the correctness of the relative setting of two messages using only the property of divisibility by three of the code 5-groups.” So here the two messages are written out on successive lines of a form, one directly below the other. There are two hypotheses: S being that the relative setting is correct and T being that it is incorrect. If S holds, then the probability that $\chi((\mathbf{x} + \mathbf{a}) - (\mathbf{y} + \mathbf{a})) = \chi(\mathbf{x}) - \chi(\mathbf{y}) = k$ is σ_k ,

while otherwise—that is, if T holds—it is just $1/10$. At one stage in 1944 it was possible to work out the page part of the current JN-25 indicators but not the line or column part. Thus we now assume that the two messages which are being tested for correct alignment were encrypted starting on the same page of the table of additives. As there was a bias towards starting on the left half of the page and also a bias towards starting on the top half, the initial p_0 in the formula is about $2/100$ rather than $1/100$. Thus the logarithmic prior term is about $(338/3)\log((1/50)/(49/50)) \approx -438$, and so the Hall weight formula has the totally surprising Diophantine approximation

$$(338/3)\log(p_N/(1-p_N)) \\ \approx -438 + 30n_0 - 11(n_1 + n_9) - 32(n_2 + n_8) \\ + 25(n_3 + n_7) + 10(n_4 + n_6) - 41n_5.$$

In practice the staff working with this formula would be given just a threshold, that is, a minimum acceptable value for the expression $30n_0 + \dots - 41n_5$.

The initial deficit of -438 looks somewhat daunting, but the last paragraph glosses over the true situation. The aim is not to set two JN-25 messages in alignment, but rather at least six messages and hopefully at least seventeen if the decryption process is ever to get started. Another circumstance would be the discovery of two signals with “double hits”, that is, the same pair of GATs occurring in each separated by the same number of other GATs. The Copperhead I device searched for double hits, which would make the “correctness of the relative setting” much more likely. This is not the place to develop a detailed account of the theory.

The operators handling JN-25 encryption in WW2 were instructed to *tail*, that is, to choose the starting point for the first signal in a new additive table randomly and then start each subsequent encryption immediately after the previous one finished. However, not all of them read the instructions. Once detected, this practice helped the cryptologists both with breaking indicator encryption systems and with getting long concatenations of intercepts to put in depth.

The reader seeking a challenge may wish to work out the appropriate modifications of these calculations if, instead of using only multiples of three, the I.J.N. had used only multiples of nine or multiples of eleven.

The Historical Significance

This note has avoided much historical detail about JN-25. For example, the 1945 report HW 43/34 on the system JN-25L53 in the British National Archives has over one hundred pages

and includes a glossary (of jargon). The authors were J. W. S. Cassels and E. H. Simpson. It has also slurred over the difference between Hall weights and the associated Shinn weights. However, much of the more important mathematical aspects are mentioned above.

The decryption and decoding of JN-25B in 1941–1942 undoubtedly turned around the naval war in the Pacific. Decryption of Enigma was extremely useful in the air battle over Britain and later in the Battle of the Atlantic. Also, the 1944 invasion of Normandy needed confirmation from high-level encrypted teleprinter traffic that the deception activities had in fact succeeded. Turing’s work on Bayesian methods in cryptology permeated all of these activities.

Another well-known “insurance” discovery of the era did pay off handsomely. In February to April 1940 at Bletchley Park the talented mathematics student John Herivel developed a technique to recover likely settings of the Enigma encryption machine then used by the German Army and Air Force. This was not needed while an unsound indicator encryption practice was in use but came into its own in May 1940. The “bombe” device, designed by Turing and Gordon Welchman following an earlier Polish version, took over four months later. Meanwhile the Battle of Britain had to be fought.

The “insurance policy” of Hall weights became “useful” in 1944, and by then the U.S.N. had a massive preponderance on, under, and over the Pacific Ocean. Getting back into JN-25 without reading the indicators was very slow work. In general, JN-25 was much less productive as a source of intelligence in 1944–1945. However, Hall weights were an elegant method that did help in detecting alignments. Hall was justified in calling them a “significant contribution”.

The Recordsearch facility of the National Archives of Australia may be used to locate and read online a report entitled *Japanese Naval Order of Battle* compiled in June 1944 by the Joint Intelligence Center Pacific Ocean Area, a predecessor of the NSA based in Hawaii. This document contains around ninety-five pages of information assembled by the center, mostly from intercepted radio communications.

Acknowledgment

This work depends much on a program of researching the communications intelligence aspects of the Pacific War jointly with John Mack.

References

- [1] C. H. O’D. ALEXANDER, *Cryptologic History of the German Naval Enigma*, British National Archives HW 25/7, GC&CS report, 1945.

- [2] J. BURROUGHS, D. LIEBERMAN, and J. REEDS, The secret life of Andrew Gleason, *Notices of the American Mathematical Society* 56 (November 2009), 1239–1243.
- [3] C. CHRISTENSEN, U.S. Naval cryptologic mathematicians during World War II, *Cryptologia* 35 (3) (2011), 267–276.
- [4] PETER DONOVAN, The flaw in the JN-25 series of ciphers, *Cryptologia* 28 (4) (2004), 325–340.
- [5] PETER DUREN, RICHARD ASKEY, and UTA MERZBACH, *A Century of Mathematics in America*, Vol. 1, American Mathematical Society, Providence, RI, 1989.
- [6] I. JACK GOOD, A. M. Turing’s statistical work in World War II, *Biometrika* 66 (1979), no. 2, 393–396.
- [7] ———, Turing’s anticipation of empirical Bayes in connection with the cryptanalysis of the naval Enigma, *Journal of Statistical Computation and Simulation* 66 (2) (2000), 101–111.
- [8] I. JACK GOOD, DONALD MICHIE, and GEOFFREY TIMMS, *General Report on Tunny*, British National Archives HW 25/4, GC&CS report, 1945.
- [9] ANDREW HODGES, *Alan Turing: The Enigma*, Burnett, 1983.
- [10] RICHARD RUGGLES and H. BRODIE, An empirical approach to economic intelligence in WW2, *Journal of the American Statistical Association* 42 (March 1947), 72–91.
- [11] EDWARD SIMPSON, Bayes at Bletchley Park, *Significance* 7 (2) (2010), 76–80.
- [12] ———, *History of the Fleet General Purpose System (JN-25) Cryptographic Party*, British National Archives HW 8/149, GC&CS report, 1945.
- [13] JOHN TILTMAN, *Reminiscences*, N.A.R.A. RG0457, entry A1 9032, box 1417, file 4632.
- [14] ALAN TURING, *The Applications of Probability to Cryptology*, British National Archives HW 25/37, GC&CS report, 1941.
- [15] ABRAHAM WALD, Sequential tests of statistical hypotheses, *Annals of Mathematical Statistics* 16 (2) (1945), 117–186.
- [16] S. ZABELL, Commentary on Alan M. Turing: The applications of probability to cryptography, *Cryptologia* 36 (3) (2012), 191–214.

About the Cover

Low-level cryptography

The image on the cover was loosely suggested by Peter Donovan's article in this issue, which refers to the cryptanalysis of Japanese naval communications by Americans, British, and Australians during World War II. The cover displays the *wabun* telegraphic code for the Japanese syllabary known as *katakana*, in which a large number of communications were transmitted. Other protocols were also used. Standard Morse code was used to transmit numerals, either as groups of length four or five digits taken from a code book, or as the transmission of characters through Chinese telegraphic code. In addition, sometimes the Roman alphabet was used to transcribe *katakana*. Altogether, an impressively complicated collection of conventions.

Difficulties in cryptanalysis of Japanese communications began with the difficulties of the language itself, and the Japanese military deceived themselves into thinking this would make their communications especially secure. Layers of complexity were piled on top of this. Next up was the difficulty in the low-level interpretation of the messages intercepted, since many messages, especially in the early days of interception, were transmitted in *wabun* and others used Roman transcription. It was just after the First World War that the Americans started training operators to interpret Japanese telegraphic transmissions, but at first on a rather haphazard basis. A readable account of the history of this work can be found in *The Silent War* at

<http://corregidor.org/crypto/chs.whitlock/whitlock.htm>

The author, Duane Whitlock, was one of the U. S. Navy code group evacuated from the Phillipines during the invasion of 1942.

Later on, as Donovan says, the most secure systems sent messages as groups of five decimal digits. According to Alan Stripp in *Code Breakers in the Far East*, this was transmitted in standard Morse code according to the translation

0	1	2	3	4	5	6	7	8	9
O	N	Z	S	M	A	T	R	W	V

The systems used by the Japanese to encrypt high-level messages were extremely sophisticated, and if used correctly should have been impossible to break. Much of the Allies' success was through traffic analysis, which did not depend on reading messages, but just on keeping track of where messages originated and to whom they were sent.

The most secure system, JN-25, was encoded in a process of two steps. In the first, a code book was used to translate pieces of the message into groups of five digits. This sequence was written down in a (virtual) line. Then a sequence of additives were written underneath these, and on a third line were written the "false sums" of the first two lines in which decimal carry was ignored. A typical (if totally imaginary) sequence might be as follows:

message	submarine	departure	Honolulu
code groups	98721	13671	76542
additives	35678	17896	46781
transmitted	23399	20467	12223

In early versions of JN-25, each of the code book groups of five digits had the property that the sum of their digits was divisible by three. The purpose of this was presumably to make errors in transmission evident—again in American terminology, as a kind of "garble check".

This requirement limited the number of code groups to 33,334, and for mathematical reasons it made cryptanalysis much easier than it should have been. (Later versions did not have this feature, and this did succeed in foiling Allied techniques.) The additives were taken from an additive book, published and distributed separately from the code book. Each page of this book contained a grid of 5-digit groups, produced by some process supposed to be random. After writing down the message in code groups, the operator would open a page of the additive book, choose a position in the grid, and start writing down successive entries from the additive book underneath. He then recorded his starting place in the additive book in a preliminary part of the final message called the "indicator", using a separate enciphering scheme.

The Allies' tasks were formidable: to build up the code and the additive books over long stretches of time, and then to read the indicators of individual messages. At first sight the first two problems seem almost impossible to solve, but as with Allies' reading of German transmissions, these tasks were made easier by the fact that early implementations were simpler than later ones, and by frequent bad decisions by both operators and code-makers. In particular, changes in the code book were not simultaneous with changes in additives, so that "divide and conquer" was operable.

A valuable analysis of some of the cryptanalysis of Japanese communications can be found in Chapter VI of *Machine Cryptography and Modern Cryptanalysis* by Cipher Deavours and Louis Kruh. It specializes in the machines used for diplomatic messages, but includes also useful observations about the nature of the Japanese language and the problems it posed for telegraphic communication.

The technical literature on JN-25 is sparse. The most detailed coverage is in some *Cryptologia* articles by Peter Donovan, particularly the one he includes in his reference list. There are also some forthcoming articles by Chris Christensen on the history of machinery developed by Americans for the cryptanalysis of Japanese codes.

One could wish for more, especially since famous mathematicians such as Andrew Gleason and Marshall Hall took part in the war effort. It is not clear, unfortunately, if any relevant documentation remains extant.

—Bill Casselman
Graphics Editor
(notices-covers@ams.org)

Viewing “Mathematics for Teaching” as a Form of Applied Mathematics: Implications for the Mathematical Preparation of Teachers

Andreas J. Stylianides and Gabriel J. Stylianides

Introduction

The profound implications of teachers’ mathematical knowledge for the quality of the learning opportunities that teachers can offer to their students (e.g., [2]) justifies, at least in part, the growing research focus on teachers’ mathematical knowledge. This research has given rise to the notion of *Mathematics for Teaching* (MfT) [3], [4], which describes the body of mathematics that is important for teachers to know in order to be able to successfully manage the mathematical demands of their professional practice, i.e., teaching mathematics to children. This is contrasted, for example, with the mathematics that is important for other professionals such as engineers and physicists

Andreas Stylianides lectures mathematics education at the University of Cambridge, UK. His email address is as899@cam.ac.uk.

Gabriel Stylianides lectures mathematics education at the University of Oxford, UK. His email address is gabriel.stylianides@education.ox.ac.uk.

The present article draws on an article that we published in a general education research journal [1]. Parts of that article are reused herein with permission (license number: 2963601258532). The research underpinning the articles was supported by funds from the Spencer Foundation (grant numbers 200700100 and 200800104). We thank James Sandefur and three reviewers for their useful comments on earlier versions of the present article.

DOI: <http://dx.doi.org/10.1090/noti1087>

whose work also imposes specific mathematical demands. Of course there is overlap between the mathematics that is important to different workplaces. Yet there are also certain mathematical ideas or ways of knowing and knowing how to use these ideas that are more relevant to one workplace than to another.

In this article we discuss a conceptualization whereby MfT is thought of as a form of applied mathematics, and we probe the implications of this conceptualization for the mathematical preparation of teachers. We also relate our discussion of MfT as a form of applied mathematics to how Hyman Bass and Zalman Usiskin used the notion of “applied mathematics” to think about mathematics education or the mathematical preparation of teachers.

Exemplifying Knowledge of Mathematics for Teaching

We begin with a classroom scenario that we use to exemplify elements of knowledge of MfT in the particular domain of proof.

Classroom scenario:

A seventh-grade class was reviewing methods for finding a fraction between any two given fractions that are not equivalent and can be located on the positive part of the number line. At one point during the lesson, a student in the class, Mark, announced

proudly his discovery of the following general method for finding a fraction between any two such fractions:

To find the numerator of a fraction that lies between any two given fractions on the number line, you simply add the numerators of the two given fractions. To find the denominator, you simply add their denominators.

Mark illustrated his method with an example, which is shown in Figure 1. He also clarified that his method gives one out of many possible fractions between any two given (positive and nonequivalent) fractions.

The other students in the class were amazed with the method, tested it with lots of examples, and saw that it worked in every case they checked. Then many students became convinced that Mark's method works for any pair of fractions. One of them, Jane, asked the teacher:

Can we use this method every time we need to find a fraction between two given positive fractions?

The teacher found herself in a difficult situation: this was the first time that she had seen the method and was not sure how to respond to Jane's question.

A major mathematical issue that arose for the teacher in the scenario was whether it would be mathematically appropriate for the students in the class to use Mark's method to find a fraction between any two given positive and nonequivalent fractions. The teacher was seeing this method, which draws on the mediant property of positive fractions, for the first time. The teacher's mathematical knowledge could shape the course of action she would follow in the classroom scenario, which in turn would influence students' opportunities to learn mathematics. Consider, for example, the following two possibilities that originate from two different elements of knowledge that the teacher could possess.

Possibility 1:

A possible element of the teacher's mathematical knowledge (misconception): If a general method is found to work for many different cases (a proper subset of all possible cases), then the method can be accepted as correct.

→ *Course of action:* The teacher considers Mark's method to be correct and says to Jane and the rest of the class that they can use the method every time they need to find a fraction between two given positive and nonequivalent fractions.

→ *Students' opportunities to learn mathematics:* The students add a new method to their "toolkit" (which happens to be correct), but they are led to develop or continue to hold the same misconception as their teacher.

Possibility 2:

An alternative possible element of the teacher's mathematical knowledge (sound conception): Unless a general method is proved to work for all possible cases, the method cannot be accepted as correct.

→ *Course of action:* The teacher says to Jane and the rest of the class that even though Mark's method worked in all the cases they checked, there are infinitely many pairs of fractions and so the examination of some of these pairs offers no guarantee that the method will work for all possible cases. Also, the teacher invites the students to join her in thinking more about the method to see whether they can prove that the method works for all possible cases.

→ *Students' opportunities to learn mathematics:* The students are exposed to the mathematically sound idea that the confirming evidence offered by some cases is not enough to establish the correctness of a general method. Also, the students engage with their teacher in an exploration that can potentially lead to the development of a proof for the method. If a proof is developed, the students can add the method to their "toolkit"; otherwise, the class would treat the method as a conjecture.

Prior research (e.g., [5], [6]) shows that many teachers have the misconception described in possibility 1, namely, that examination of a proper subset of all the possible cases constitutes a proof of a general method. Prior research shows further that many students of all levels of education have the same misconception (see [7] for a review of some of this research). Possibility 1 illustrates how a teacher's misconception can generate or reinforce the same misconception among students, while possibility 2 illustrates how a sound conception could allow a teacher to offer to students learning opportunities to develop the same sound conception. The sound conception in possibility 2 is "fundamental" [2] in the sense that it can apply to the mathematical work of all students (including young children) and contains the rudiments of more advanced mathematical issues (notably, what counts as evidence in mathematics).

Given the important implications that possession by the teacher of this sound conception could have for students' opportunities to learn

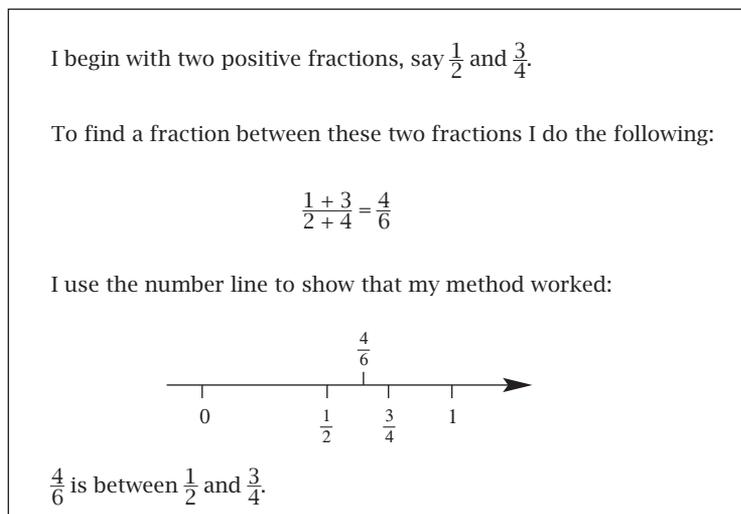


Figure 1. A student's illustration of a method for finding a fraction between two given positive and nonequivalent fractions.

mathematics, we can consider the conception to be an element of knowledge of MfT [8]. Note that we do not suggest that knowledge of the mediant property of positive fractions should also be an element of knowledge of MfT. Although knowledge of this property would likely help the teacher deal with the particular classroom scenario, it is not the kind of “fundamental” knowledge that could have high currency in the work of mathematics teaching.

Of course the element of mathematical knowledge in possibility 2 is important for effective functioning not only in teaching but also in other workplaces. Thus, this element is not unique to knowledge of MfT. A related element that is more relevant to teaching than to other workplaces that use mathematics is knowledge of an actual proof of Mark's method that would be not only (a) mathematically valid but also (b) pedagogically appropriate for use with seventh-graders. Indeed, a physicist or an engineer would likely be concerned only with the mathematical validity of the proof, while a teacher would have to consider also issues such as students' prior knowledge and whether, for example, an algebraic proof would be accessible to them. Later we will revisit the classroom scenario, and we will discuss different possible proofs that could meet both requirements.

Our previous discussion illustrates the point that a teacher's mathematical knowledge cannot generally function in isolation from pedagogical considerations and, by implication, university mathematics courses for prospective teachers cannot lose sight of the domain of application of the targeted knowledge (i.e., mathematics teaching).

This should not be interpreted as a suggestion to compromise the mathematical focus of mathematics courses for prospective teachers. On the contrary, we are strong believers that the focus in these courses should remain on mathematics. Our interest is in how to best promote prospective teachers' learning of mathematics in these courses, and, in this regard, we suggest that at least part of prospective teachers' learning experiences should be contextualized in pedagogical situations, thereby fostering connections with the domain of application of the intended learning.

Conceptualizing Mathematics for Teaching as a Form of Applied Mathematics

Hyman Bass and Zalman Usiskin both used the notion of “applied mathematics” in discussing, respectively, “mathematics education” and “teachers' mathematics”. Hung-Hsi Wu also discussed relevant ideas, though he used the notion of “mathematical engineering” instead of “applied mathematics”. Below we briefly present the views of these researchers and use them to situate our proposal in this article to view MfT as a form of applied mathematics.

Bass [9] suggested that we view mathematics education as a form of applied mathematics: “[Mathematics education] is a domain of professional work that makes fundamental use of highly specialized kinds of mathematical knowledge, and in that sense it can... be usefully viewed as a kind of applied mathematics” (p. 418).¹ Wu [10] expressed a somewhat similar idea when he argued that “mathematics education is mathematical engineering, in the sense that it is the customization of basic mathematical principles to meet the needs of teachers and students” (p. 1678). In his view, the customization of mathematics needs to happen before the mathematics can be applied in the work of teaching. It seems to us that Wu's notion of engineering relates primarily to curriculum development, whereas Bass's notion of applied mathematics is concerned mainly with the practice of teaching and its mathematical demands.

Zalman Usiskin [11], [12] has also discussed the notion of applied mathematics, but, contrary to Bass [9], he has done so in the context of what he calls “teachers' mathematics”. Usiskin [11] discusses eight aspects under “teachers' mathematics”: “(a) ways of explaining and representing ideas new to students, (b) alternate definitions and their consequences, (c) why concepts arose and how they

¹Although this quotation is dated 2005, Bass has discussed the idea of viewing mathematics education as a form of applied mathematics in public talks since the 1990s. Wu [10] notes, for example, that Bass lectured on this idea in 1996.

have changed over time, (d) the wide range of applications of the mathematical ideas being taught, (e) alternate ways of approaching problems with and without calculator and computer technology, (f) extensions and generalizations of problems and proofs, (g) how ideas studied in school relate to ideas students may encounter in later mathematics study, and (h) responses to questions that learners have about what they are learning” (p. 3). Although Usiskin’s notion of “teachers’ mathematics” is certainly not unrelated to the notion of MfT as we described it earlier in this article, the connections between Usiskin’s “teachers’ mathematics” and pedagogy are mainly curricular and not so much about teaching and its mathematical demands, as is the case in MfT. For example, the list (a)–(h) of aspects of “teachers’ mathematics” includes only one item, (h), that specifically refers to teaching.

In thinking about the mathematical preparation of teachers, we were inspired by Bass’s use of “applied mathematics”.² Yet, given that mathematics education in general and the work of mathematics teaching in particular make use of specialized kinds of knowledge from several other fields in addition to mathematics (psychology, sociology, etc.), we propose to use the characterization “form of applied mathematics” in reference to the mathematical component of teachers’ work (i.e., MfT) rather than to mathematics education in general, as Bass used it. Traditionally, the term “applied mathematics” has been associated with the use of mathematical knowledge in particular domains of professional work, such as those that relate to engineering and physics. Our use of this term for the domain of professional work that relates to mathematics teaching aims to extend rather than change its traditional meaning.

Our proposal to conceptualize MfT as a form of applied mathematics is partly motivated by the fact that the conceptualization has two important implications for the mathematical preparation of teachers. These implications, which we describe next, are aligned with existing research in this area.

First, the conceptualization implies that the mathematical preparation of teachers should take seriously into account the idea that “there is a specificity to the mathematics that teachers need to know and know how to use” ([13], p. 271) as compared to the mathematics that other professional users of mathematics need to know and know how to use. This point was illustrated earlier when we talked about mathematical knowledge needed to develop a proof of Mark’s method that would also be accessible to seventh-graders: knowledge of

such a “pedagogically situated” proof would be crucial for the teacher in the classroom scenario but not so much for a physicist or an engineer who may have an interest in the same method.

Second, the conceptualization implies that the mathematical preparation of teachers should aim to “create opportunities for learning subject matter that would enable teachers not only to know, but to learn to use what they know in the varied contexts of [their] practice” ([3], p. 99). In other words, the conceptualization underscores the importance of a “pedagogically functional mathematical knowledge” (ibid., p. 95) which can support teachers to successfully address mathematical issues that arise in their work, such as mathematical evaluation of a novel student method or the generation of a “pedagogically situated” proof, as illustrated in our discussion of the classroom scenario.

To recap, the conceptualization of MfT as a form of applied mathematics necessitates that mathematics courses for prospective teachers design opportunities for prospective teachers to learn and be able to use mathematical knowledge from the perspective of an adult who is specifically preparing to become a teacher of mathematics. But how might such learning opportunities be designed? Next we discuss a special kind of mathematics task that we call *Pedagogy-Related mathematics tasks* (P-R mathematics tasks), which we used in our courses with prospective teachers to support their learning of MfT. We do not suggest that P-R mathematics tasks are the only or the best kinds of tasks for promoting learning of MfT. Yet, we claim that P-R mathematics tasks can support productive learning opportunities for prospective teachers to develop the mathematical knowledge that they need for their work and that such tasks should not be overlooked in the mathematical preparation of teachers.

Pedagogy-Related Mathematics Tasks: A Vehicle to Promoting Knowledge of Mathematics for Teaching

In this section we discuss the notion of P-R mathematics tasks as a vehicle to promoting knowledge of MfT. Specifically, we discuss two main features of P-R mathematics tasks that collectively distinguish P-R mathematics tasks from other kinds of mathematics tasks.

As an example of a P-R mathematics task, consider the following question in relation to the classroom scenario described earlier:

What would be a *mathematically* appropriate way in which the teacher could respond to Jane’s question about whether the class could use Mark’s method every time they had to find a fraction between two given, nonequivalent positive fractions?

²Only recently did we learn about Usiskin’s use of “applied mathematics”. We thank the anonymous referee who brought this work to our attention.

Given two fractions $\frac{a}{b}$ and $\frac{c}{d}$ (where $a, b, c, d > 0$ and $\frac{a}{b} < \frac{c}{d}$), we want to prove that:

$$\frac{a}{b} < \frac{a+c}{b+d} < \frac{c}{d}.$$

Beginning from the known relationship $\frac{a}{b} < \frac{c}{d}$, we can derive the following:

$$ad < bc \Rightarrow ab + ad < ab + bc \Rightarrow a(b+d) < b(a+c) \Rightarrow \frac{a}{b} < \frac{a+c}{b+d}. \quad (*)$$

Beginning again from the known relationship $\frac{a}{b} < \frac{c}{d}$, we can derive the following:

$$ad < bc \Rightarrow ad + cd < bc + cd \Rightarrow d(a+c) < c(b+d) \Rightarrow \frac{a+c}{b+d} < \frac{c}{d}. \quad (**)$$

The inequality we wanted to prove follows from (*) and (**).

Figure 2. An algebraic proof of a general method for finding a fraction between two given positive and nonequivalent fractions.

We will henceforth refer to this task as the *Fractions Task*. A solution to the Fractions Task would build on the “course of action” that we discussed earlier under possibility 2, which is the desirable possibility. According to this course of action, the teacher would engage the class in the discussion of a proof that would not only be valid but also accessible to the group of seventh-graders.

Feature 1: A mathematical focus

P-R mathematics tasks have a mathematical focus that relates to one or more mathematical ideas that theory, research, or practice suggested are important for teachers to know. The mathematical focus is intended to engage prospective teachers in mathematical activity. In the Fractions Task, the mathematical focus is the mathematical evaluation of Mark’s method, which can be expressed algebraically as follows:

Given two fractions $\frac{a}{b}$ and $\frac{c}{d}$ (where $a, b, c, d > 0$ and $\frac{a}{b} < \frac{c}{d}$), $\frac{a}{b} < \frac{a+c}{b+d} < \frac{c}{d}$.

Feature 2: A substantial pedagogical context

In addition to the mathematical focus, a P-R mathematics task has a substantial pedagogical context that is an integral part of the task and essential for its solution. The pedagogical context situates prospective teachers’ mathematical activity in a particular teaching scenario and helps prospective teachers engage with the mathematics from the perspective of a teacher.

In the Fractions Task the pedagogical context describes the teacher’s need to formulate a response to Jane’s question about whether the class could use Mark’s method when asked to find a

fraction between two positive and nonequivalent fractions. According to this context, the event happened in a seventh-grade class, which allows the solvers of the task (prospective teachers) to make certain assumptions about what the students in the class might know or be able to understand. Thus a solution to the task must not only satisfy mathematical considerations but also needs to take into account pedagogical considerations. Next we discuss four points related to feature 2 of P-R mathematics tasks.

First, the pedagogical context in which a P-R mathematics task is situated determines to a great extent what counts as an acceptable/appropriate solution to the task, because it provides (or suggests) a set of conditions a possible solution to the task needs to satisfy. In the Fractions Task, for example, an algebraic proof of Mark’s method like the one in Figure 2, though mathematically valid, would likely not be within the conceptual reach of students in a seventh-grade class. A proof can only be useful to students if it is understandable to them. It is up to the teacher to decide whether, given students’ prior knowledge and any national curricular expectations, it would be sensible to engage the class in the development of a different proof that could be more accessible to students.

A potential proof of the inequality $\frac{a}{b} < \frac{a+c}{b+d} < \frac{c}{d}$ that invokes an argument from physics would likely have stronger explanatory power and be more accessible to students than the algebraic proof. Consider, for example, the distance-time graph in Figure 3, with the fractions $\frac{a}{b}$, $\frac{c}{d}$, and $\frac{a+c}{b+d}$ representing respectively the following speeds: the constant speed for covering distance a in time b , the constant speed for covering an additional distance c in time d , and the average speed for covering the entire distance $(a+c)$ in time $(b+d)$. The smaller the fraction the smaller the speed, and so the fact that $\frac{a}{b}$ is smaller than $\frac{c}{d}$ implies that the constant speed for covering distance a is smaller than the constant speed for covering distance c ; this is illustrated by the smaller slope of OP as compared to the slope of PQ in the figure. The average speed for covering the entire distance $(a+c)$ in time $(b+d)$ should be: (1) bigger than $\frac{a}{b}$, because, otherwise, a smaller distance than $(a+c)$ would be covered in time $(b+d)$; and (2) smaller than $\frac{c}{d}$, because, otherwise, distance $(a+c)$ would be covered in less time than $(b+d)$. Thus it follows that $\frac{a}{b} < \frac{a+c}{b+d} < \frac{c}{d}$.

Another possible argument for the inequality $\frac{a}{b} < \frac{a+c}{b+d} < \frac{c}{d}$ that could possibly be more accessible to students than the algebraic proof might consider that the fractions $\frac{a}{b}$ and $\frac{c}{d}$ represent ratios, say the ratios of the number of a student’s correct answers in tests 1 and 2 over the number of questions in each test ($\frac{a}{b}$ and $\frac{c}{d}$, respectively). The fact that $\frac{a}{b}$ is

smaller than $\frac{c}{d}$ implies that the ratio of the number of correct answers over the number of questions in test 2 was bigger than the corresponding ratio in test 1. After applying reasoning similar to the one in the context of the “distance-time” graph here, one can conclude that the ratio of the total number of the student’s correct answers in the two tests over the total number of questions in the two tests (i.e., $\frac{a+c}{b+d}$) has to be bigger than the ratio in test 1 (i.e., $\frac{a}{b}$) and smaller than the ratio in test 2 (i.e., $\frac{c}{d}$).

Second, it is hard to describe precisely the pedagogical context of a P-R mathematics task: given the complexities of any classroom situation, it is impractical (perhaps impossible) to describe all the parameters of the situation that can be relevant to the task’s solution. This lack of specificity of the pedagogical context is potentially useful for university instructors implementing P-R mathematics tasks with their prospective teachers. Specifically, instructors can use the endemic ambiguity surrounding the conditions of a pedagogical context to vary some of its conditions in order to engage prospective teachers in related mathematical activities. Consider, for example, the pedagogical context of the Fractions Task, which does not specify whether the class would be able to produce an algebraic proof like the one in Figure 2. An instructor could exploit this ambiguity to engage prospective teachers in the development of other arguments that are likely to be more accessible to students, such as the arguments we discussed earlier. Each of these alternative arguments is based on different assumptions about the level of students’ knowledge, and it is important to make this explicit in the proposed mathematical solutions to the task.

Third, the pedagogical context of a P-R mathematics task has the potential to motivate prospective teachers’ engagement in the task by helping them see why the mathematical ideas in the task are, or can be, important for their future work as teachers of mathematics. According to Harel [14], “[s]tudents are most likely to learn when they see a need for what we intend to teach them, where by ‘need’ is meant intellectual need, as opposed to social or economic need” (p. 501; the excerpt in the original was in italics). In the case of prospective teachers, a “need” for learning mathematics may be defined in terms of developing mathematical knowledge that they need for teaching, i.e., knowledge of MfT. By helping prospective teachers see a need for the ideas they are being taught in mathematics courses for prospective teachers, it is more likely that they will get interested in learning these ideas. This is particularly important for mathematical ideas that prospective teachers tend to consider difficult or “advanced” for the

level of the students they will be teaching, such as the notion of proof for pre-high school students.

Fourth, the design and implementation of P-R mathematics tasks require some pedagogical knowledge by instructors of mathematics courses for prospective teachers. For example, the design of the Fractions Task used knowledge about a common student misconception in the domain of proof and considered a possible link between this student misconception and a teacher’s evaluation of, and response to, a novel student method. The pedagogical demands imposed by the design of P-R mathematics tasks on the instructors’ knowledge can create challenges for those who may have limited background in pedagogy or familiarity with the school mathematics curriculum. Similar challenges could emerge also for instructors during the implementation of P-R mathematics tasks with prospective teachers, especially in relation to the question of what kinds of variations an instructor could make to the pedagogical context of a task without compromising the task’s realistic nature. We return to these issues in the last section of the article.

Exemplifying the Use of P-R Mathematics Tasks in a Mathematics Course for Prospective Elementary Teachers

This section is organized in two parts. In the first part we provide a brief description of major features of a mathematics course for prospective elementary teachers that we developed to promote MfT as a form of applied mathematics. Given the importance we attribute to P-R mathematics tasks in thinking about MfT as a form of applied mathematics, P-R mathematics tasks had a prominent place in the course. Yet P-R mathematics tasks were not the only kinds of tasks we used in the course. Another kind was what we call *typical mathematics tasks*, which embody only feature 1 of P-R mathematics tasks. Advantages of typical mathematics tasks are that they allow for a faster pace during university sessions than P-R mathematics tasks do and do not require any pedagogical knowledge from the instructor.

In the second part we illustrate the use of P-R mathematics tasks in the course by discussing the implementation of a task sequence, which includes both a typical and a P-R mathematics task. We developed this and other task sequences in a four-year study that used *design experiment methodology* [15]. The design experiment included five research cycles of implementation, analysis, and refinement of different task sequences in the course. In this article we discuss the implementation of one task sequence from the last research cycle of the design experiment. The last research cycle was conducted in two sections of the course

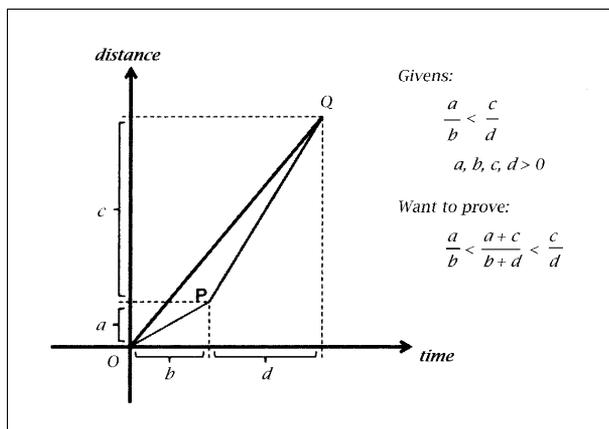


Figure 3. A distance-time graph that can be elaborated on in a potential proof of a general method for finding a fraction between two given positive and nonequivalent fractions.

with a total of thirty-nine prospective elementary teachers and the second author as the instructor. The data come from the implementation of the task sequence in one of the sections.

General Description of the Course

This three-credit undergraduate mathematics course was prerequisite for admission to the master's-level elementary teaching certification program at a large American state university. Contrary to what usually happens with mathematics courses for prospective elementary teachers in North America [16], the course was offered by the Department of Education rather than by the Department of Mathematics. Yet this did not make any difference to the fact that this was a *mathematics course*.³ The students in the course pursued undergraduate majors in different fields of study and tended to have weak mathematical backgrounds (for many of them this was the first mathematics course since high school). Also, given that the students were not yet in the teaching certification program, they had limited or no background in pedagogy.

The course was the only mathematics course specified in the admission requirements for the teaching certification program. It covered a wide range of mathematical topics in different mathematical domains (arithmetic, algebra, number theory, geometry, and measurement) and was intended to improve prospective teachers' understanding of key mathematical concepts and procedures in those topics. In addition to mathematical topics, the course emphasized the following three

³The first two research cycles of the design experiment took place at another large American state university where the course was offered through the mathematics department.

mathematical practices: (a) reasoning-and-proving (i.e., making mathematical generalizations and formulating arguments for or against these generalizations, with particular attention to the use of definitions), (b) problem solving, and (c) making connections between different forms of representation (algebraic, pictorial, etc.). With these three practices, which we treated as strands that underpinned prospective teachers' mathematical work, we aimed to also help prospective teachers appreciate what it means to "do" mathematics through engaging them with more authentic mathematical experiences, not merely helping them learn (or relearn) mathematical concepts and procedures.

One aspect of the course's approach to promote MfT, which is the most relevant to our purposes in this article (other features are discussed in [17] and [18]), was the use of both typical and P-R mathematics tasks in carefully designed task sequences. A common task sequence began with a typical mathematics task that set the stage for a P-R mathematics task. The typical mathematics task allowed prospective teachers to work on a mathematical idea from an adult's standpoint. The P-R mathematics task, which followed the typical task, introduced a pedagogical context that prospective teachers had to consider in their mathematical work, thus engaging prospective teachers in mathematical work from a teacher's standpoint. To address feature 2 of P-R mathematics tasks concerning situating prospective teachers' mathematical work in a pedagogical context, we used a wide range of classroom scenarios based on actual classroom records: videos or written descriptions of classroom episodes in elementary classrooms, artifacts of elementary students' mathematical work, excerpts from elementary mathematics textbooks, etc. When actual classroom records were unavailable, we used fictional records that were nevertheless realistic.

An Example of a Task Sequence and Its Implementation in the Course

The task sequence aimed to promote prospective teachers' knowledge about a possible relation between the notions of area and perimeter of rectangles. Central to this exploration were also ideas of mathematical generalization and proof by counterexample. The sequence included a typical mathematics task (question 1) followed by a P-R mathematics task (question 2):

Imagine that one of your students comes to class very excited. She tells you that she has figured out a theory that you never told the class. She explains that she has discovered that as the perimeter of a rectangle increases, the area also increases.

She shows you the work in Figure 4 below to prove what she is doing:

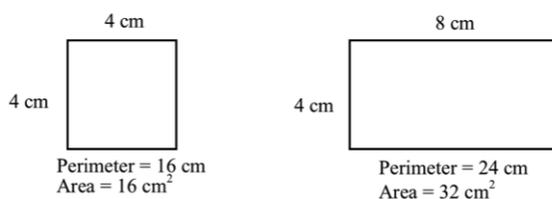


Figure 4.

1. Evaluate mathematically the student statement (underlined).
2. How would you respond to this student?

The task sequence was an adaptation of tasks that were originally developed by Ball [19] and subsequently used by Ma [2].

Although question 1 refers to a student statement, it is a typical mathematics task, because the prompt asks prospective teachers to mathematically evaluate the statement without asking or expecting them to take into account the fact that the statement was produced by a student. Question 2, on the other hand, is a P-R mathematics task, because it introduces a pedagogical consideration that prospective teachers need to take into account in their mathematical work. Although not explicitly mentioned in the task, it was understood in the teacher education class that answers to prompts like the one in question 2 should not focus on pedagogical issues (e.g., “I’d teach again the notion of perimeter and area...”), but should rather focus on the underlying mathematical issues by appropriately considering the relevant pedagogical context.

The *mathematical focus* of this P-R mathematics task is to evaluate mathematically the underlined statement, which is essentially what the prospective teachers were asked to do in question 1. The *pedagogical context* of the task concerns the teacher’s responsibility to respond to the student who produced the statement. An appropriate response to question 1 could say that the statement is false and provide a counterexample to refute it. However, an appropriate response to question 2 would need to go beyond that. Consideration also of the pedagogical context suggests that it would be useful for the student’s learning if the teacher not only refuted the student’s statement (by providing a counterexample) but also helped her understand why the statement is false and explore the conditions under which the statement would be true. This additional work, though pedagogically situated, is deeply mathematical in nature and is

the kind of work that we argue deserves more attention in mathematics courses for prospective teachers.

The prospective teachers worked on the two questions first individually and then in groups of four or five. Later on there was a whole-class discussion, which began with the instructor (Stylianides) asking representatives from different small groups to report their work on the task, beginning with question 1 (all prospective teacher names are pseudonyms).

- Andria:* We [the members of her small group] said that it [the student statement] was mathematically sound, because as you increase the size of the figure, the area is going to increase as well.
- Tiffany:* We [the members of her small group] agreed. We thought the same, because as the sides are getting bigger...[inaudible]
- Stylianides:* Does anybody disagree? [No group expressed a disagreement.]
- Evans:* I agree. [Evans was in a different small group than Andria and Tiffany.]
- Stylianides:* And how would you respond to the student?
- Melissa:* I think it’s true, but they haven’t proved it for all numbers, so it’s not really a proof.
- Andria:* I think that you don’t have to try every number [she seems to refer to every possible case in the domain of the statement] to be able to prove it, because if the student can explain why it works like we just did, like if you increase the length, then the area increases. [pause] [...]
- Meredith:* I’d say that it’s an interesting idea, and I’d see if they can explain why it works.

As illustrated by the above transcript, all small groups thought that the student statement was true, but at the same time they seemed to realize that the evidence that the student provided for her claim was not a proof (see, e.g., Melissa’s comment). As a result, the prospective teachers started to think about how to prove the statement and how to respond to the student. For example, Andria and Meredith pointed out that the student needed to prove/explain why the area of a rectangle increases as its perimeter increases, with Andria appearing to believe that she already had a proof. However, the instructor knew that the statement was false. As the representative of the mathematical community in the classroom, he probed the prospective teachers to check more cases to see whether they could come up with an example in which the student

statement was false. After a few minutes, all small groups found at least one counterexample to the statement and concluded that the statement was false. We note that earlier in the course the prospective teachers had opportunities to discuss the idea that one counterexample suffices to refute a general mathematical statement.

The prospective teachers' counterexamples to the student statement made them experience a "cognitive conflict", because at the initial stages of their engagement with the task sequence, they did not expect that a statement that looked so "obvious" to them would turn out to be false. This unexpected discovery motivated prospective teachers' further work on question 2. The instructor decided to give the prospective teachers more time to think in their small groups about question 2. The transcript below is from the whole-class discussion that followed the small-group work.

Natasha: We said that the way that they [the students] are doing it, where they're just increasing the length of one side, it's always going to work for them; but if they try examples where they change the length on both sides, that's the only way it's going to prove that it doesn't work all the time. So you should try examples by changing both sides.

Stylianides: [referring to the class] What do you think about Natasha's response? Does it make sense? [The class nods in agreement.] So what else? What else do you think about this?

Evans: You can kind of ask them to restructure the proof so that it would work.

Stylianides: What do you mean by "restructure the proof"?

Evans: Like once they figure out that it doesn't work for all cases, they could say it's still like... if they saw it and if they revise it like the wording or just add a statement in there that if they can come up with a mathematically correct statement...

Stylianides: Anything else? [No response from the class.] I think both ideas [mentioned earlier] are really important. So when you have something [a statement] that doesn't work, then it's clear that this student would be interested to know more. For example, why it doesn't work or under what conditions does it work, because, obviously, some of the examples that the student checked worked. ...

Natasha and Evans raised two related issues that the teacher in the scenario of the P-R mathematics task could address when responding to the student: (a) why the statement is false (instead of simply showing that the statement is false with a counterexample) and (b) the conditions under which the statement would be true. Based on our planning for the implementation of the task, the instructor would raise these issues anyway, because, as we explained earlier, we considered it mathematically sufficient but pedagogically inconsiderate for a teacher to offer only a counterexample to the student's statement. We considered such a response inadequate in light of the pedagogical context of the task.

It is noteworthy that the two issues were raised not by the instructor but by two prospective teachers, Natasha and Evans, who (like the other prospective teachers in the class) had no teaching experience. It is difficult to say what provoked the contributions of these prospective teachers, but we speculate that the pedagogical context of the P-R mathematics task played a role in this. It is also possible that the P-R mathematics tasks we used earlier in the course had helped the prospective teachers begin to develop pedagogical sensibilities.

Following a summary of the two issues in Evans's contribution, the instructor engaged the prospective teachers in an examination of the conditions under which the student statement would be true. Specifically, he asked the prospective teachers to investigate what happens to the area of a rectangle in each of the following cases where the perimeter of the rectangle increases:

1. One of the two dimensions (length or width) is increased and the other dimension is kept constant.
2. Both dimensions are increased.
3. One of the two dimensions is increased and the other dimension is decreased, so that the amount of increase in one dimension is larger than the amount of decrease in the other.

The prospective teachers produced algebraic and pictorial proofs to show that in the first two cases the area always increases and examples to show that in the third case the area can increase, decrease, or stay the same.

To conclude, our discussion of the implementation of the task sequence exemplified the idea that the application of mathematical knowledge in pedagogical contexts can be different from its application in similar but purely mathematical contexts. Although the typical mathematics task and the P-R mathematics task in the sequence were dealing with the same mathematical ideas, the pedagogical context in which the P-R mathematics

task was embedded shaped what could count as an appropriate mathematical solution to it, thereby supporting the generation of rich mathematical activity in a realistic pedagogical context.

Concluding Remarks

The design, implementation, and solution of P-R mathematics tasks suggest that instructors of university mathematics courses for prospective teachers who may want to use these tasks in their courses need to have not only good mathematical knowledge but also some knowledge of school-related pedagogy (including familiarity with the school mathematics curriculum). For example: What arguments for a true generalization could be accessible to students of different ages? In addition to offering a counterexample, what other mathematical investigations would be pertinent in a pedagogical context where a student proposed a false generalization?

In countries such as the United States where mathematics courses for prospective teachers are typically offered by mathematics departments [16], it may be unrealistic to require or expect that instructors of these courses have good knowledge of pedagogy in addition to their robust mathematical knowledge [20]. However, if certain knowledge of pedagogy is recognized to be useful for teaching MfT to prospective teachers, ways need to be found to support these instructors in their work.

One way could be through textbooks intended for use in mathematics courses for prospective teachers. Textbooks that would be consistent with the conceptualization of MfT as a form of applied mathematics discussed in this article would not only include P-R mathematics tasks (alongside typical and possibly other kinds of mathematics tasks) but would also include the following: (a) the rationale for the design of P-R mathematics tasks and associated target learning goals for prospective teachers, (b) suggestions for implementing the tasks with prospective teachers, and (c) comments about how the tasks relate to school mathematics (e.g., an elaboration on the pedagogical context of the tasks and how this context can shape mathematical solutions).

To conclude, the conceptualization of MfT as a form of applied mathematics highlights the idea that prospective teachers' learning of MfT should not happen in isolation from the context in which teachers will need to apply this knowledge. P-R mathematics tasks can provide a vehicle through which prospective teachers' learning of mathematics can be connected to the teaching practice. On the one hand, these tasks have mathematics at the core of prospective teachers' activity; this is a necessity given that they are

meant for use in mathematics courses. On the other hand, they situate this mathematical activity in a substantial pedagogical context that shapes and influences the activity, thereby ensuring that prospective teachers' learning of mathematics does not lose sight of its domain of application.

References

- [1] G. J. STYLIANIDES and A. J. STYLIANIDES, Mathematics for teaching: A form of applied mathematics, *Teaching and Teacher Education* **26** (2010), pp. 161–172.
- [2] L. MA, *Knowing and Teaching Elementary Mathematics*, Erlbaum, Mahwah, NJ, 1999.
- [3] D. L. BALL and H. BASS, Interweaving content and pedagogy in teaching and learning to teach: Knowing and using mathematics, in *Multiple Perspectives on Mathematics Teaching and Learning* (J. Boaler, ed.), Ablex Publishing, Westport, CT, 2000, pp. 83–104.
- [4] ———, Making mathematics reasonable in school, in *A Research Companion to Principles and Standards for School Mathematics* (J. Kilpatrick, W. G. Martin, and D. Schifter, eds.), National Council of Teachers of Mathematics, Reston, VA, 2003, pp. 27–44.
- [5] M. GOULDING, T. ROWLAND, and P. BARBER, Does it matter? Primary teacher trainees' subject knowledge in mathematics, *British Educational Research Journal* **28** (5) (2002), pp. 689–704.
- [6] W. G. MARTIN and G. HAREL, Proof frames of pre-service elementary teachers, *Journal for Research in Mathematics Education* **20** (1989), pp. 41–51.
- [7] G. HAREL and L. SOWDER, Toward comprehensive perspectives on the learning and teaching of proof, in *Second Handbook of Research on Mathematics Teaching and Learning* (F. K. Lester, ed.), Information Age Publishing, Greenwich, CT, 2007, pp. 805–842.
- [8] A. J. STYLIANIDES and D. L. BALL, Understanding and describing mathematical knowledge for teaching: Knowledge about proof for engaging students in the activity of proving, *Journal of Mathematics Teacher Education* **11** (2008), pp. 307–332.
- [9] H. BASS, Mathematics, mathematicians, and mathematics education, *Bulletin of the American Mathematical Society* **42** (2005), pp. 417–430.
- [10] H. WU, How mathematicians can contribute to K–12 mathematics education, *Proceedings of the International Congress of Mathematicians, Madrid, 2006*, Volume III, European Mathematical Society, Zürich, 2006, pp. 1676–1688.
- [11] Z. USISKIN, *Teachers' Mathematics: A Collection of Content Deserving To Be a Field*, National Summit on the Mathematical Education of Teachers, 2001, (Retrieved January 6, 2012, from http://cbmsweb.org/NationalSummit/wg_speakers.htm).
- [12] Z. USISKIN, A. PERESSINI, E. A. MARCHISOTTO, and D. STANLEY, *Mathematics for High School Teachers: An Advanced Perspective*, Prentice Hall, Upper Saddle River, NJ, 2003.
- [13] J. ADLER and Z. DAVIS, Opening another black box: Research mathematics for teaching in mathematics teacher education, *Journal for Research in Mathematics Education* **37** (2006), pp. 270–296.
- [14] G. HAREL, Two dual assertions: The first on learning and the second on teaching (or vice versa), *American Mathematical Monthly* **105** (1998), pp. 497–507.



Worldwide Search for Talent

City University of Hong Kong is a dynamic, fast-growing university that is pursuing excellence in research and professional education. As a publicly-funded institution, the University is committed to nurturing and developing students' talent and creating applicable knowledge to support social and economic advancement. Currently, the University has six Colleges/Schools. Within the next two years, the University aims to recruit **100 more scholars** from all over the world in various disciplines, including **science, engineering, business, social sciences, humanities, law, creative media, energy, environment**, and other strategic growth areas.

Applications and nominations are invited for:

Chair Professor/Professor/ Associate Professor/Assistant Professor Department of Mathematics [Ref. A/118/49]

Duties : Conduct research in areas of Applied Mathematics including Analysis and Applications, Mathematical Modelling (including biological/physical/financial problems), Scientific Computation and Numerical Analysis, and Probability and Statistics; teach undergraduate and postgraduate courses; supervise research students; and perform any other duties as assigned.

Requirements : A PhD in Mathematics/Applied Mathematics/Statistics with an excellent research record.

Salary and Conditions of Service

Remuneration package will be driven by market competitiveness and individual performance. Excellent fringe benefits include gratuity, leave, medical and dental schemes, and relocation assistance (where applicable). Initial appointment will be made on a fixed-term contract.

Information and Application

Further information on the posts and the University is available at <http://www.cityu.edu.hk>, or from the Human Resources Office, City University of Hong Kong, Tat Chee Avenue, Kowloon Tong, Hong Kong [Email : hrojob@cityu.edu.hk/Fax : (852) 2788 1154 or (852) 3442 0311].

Please send the nomination or application with a current curriculum vitae to Human Resources Office. **Applications and nominations will receive full consideration until the positions are filled** and only shortlisted applicants will be contacted. Please quote the reference number in the application. Shortlisted candidates for the post of Assistant Professor will be requested to arrange for at least 3 reference reports sent directly by their referees to the Department, specifying the position applied for. The University's privacy policy is available on the homepage.

The University also offers a number of visiting positions through its "CityU International Transition Team" scheme for current graduate students, postdoctoral scholars, and for early-stage and established scholars, as described at http://www.cityu.edu.hk/provost/cityu_international_transition.htm.

City University of Hong Kong is an equal opportunity employer and we are committed to the principle of diversity. We encourage applications from all qualified candidates, especially those who will enhance the diversity of our staff.

- [15] P. COBB, J. CONFREY, A. DISESSA, R. LEHRER, and L. SCHAUBLE, Design experiments in educational research, *Educational Researcher* 32 (1) (2003), pp. 9–13.
- [16] B. DAVIS and E. SIMMT, Mathematics-for-teaching: An ongoing investigation of the mathematics that teachers (need to) know, *Educational Studies in Mathematics* 61 (2006), pp. 293–319.
- [17] G. J. STYLIANIDES and A. J. STYLIANIDES, Facilitating the transition from empirical arguments to proof, *Journal for Research in Mathematics Education* 40 (2009), pp. 314–352.
- [18] A. J. STYLIANIDES and G. J. STYLIANIDES, Impacting positively on students' mathematical problem solving beliefs: An instructional intervention of short duration, *Journal of Mathematical Behavior* 33 (2014), pp. 8–29.
- [19] D. L. BALL, Knowledge and reasoning in mathematical pedagogy: Examining what prospective teachers bring to teacher education, unpublished doctoral dissertation, Michigan State University, East Lansing, MI, 1988.
- [20] J. O. MASINGILA, D. E. OLANOFF, and D. K. KWAKA, Who teaches mathematics content courses for prospective elementary teachers in the United States? Results of a national survey, *Journal of Mathematics Teacher Education* 15 (2012), pp. 347–358.

Access and Accessibility for the London Mathematical Society Journals

Susan Hezlet

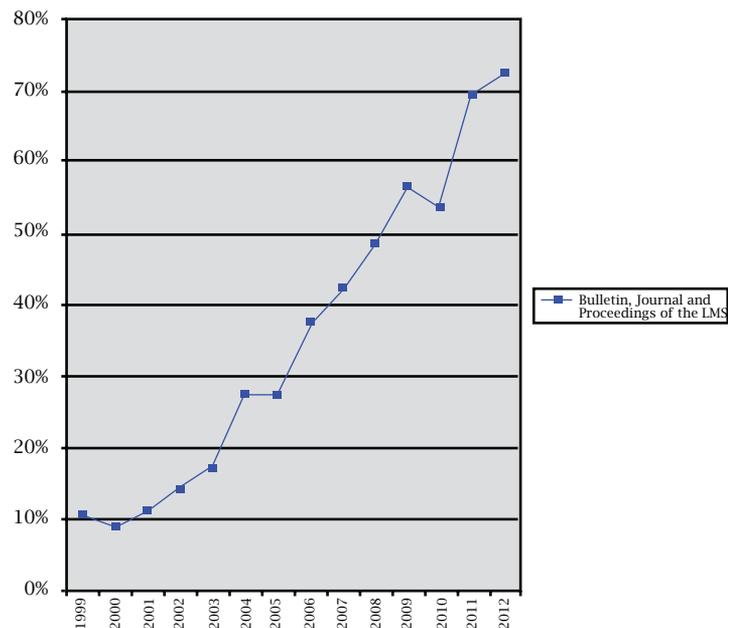
The title of this article, inspired by *Sense and Sensibility*, is set to highlight the distinction between what may be easily *accessible*, for example, freely available to the reader in some version or other, and what is *accessed* or downloaded and read from our journals' websites. At the London Mathematical Society (LMS) we have been gathering usage data on the full-text downloads from which we can see the papers that are read most frequently and if the presence of a preprint version on the arXiv has an effect on the usage of the final published version. In the UK we are undergoing a change in funders' policies that is driving a move towards paid open access. I will describe how the Society is responding to the government policy, with the aim of providing a balanced mixture of access policies that support both authors and readers.

Why should we be interested in usage data and the effect of the arXiv? We use the analysis to inform our decisions on what to make *accessible* through our publishing policies for the journals. We want to open up access as far as possible while not undermining the income that pays for the costs of production and supports the activities of the Society. The costs of production include the cost of managing the refereeing of papers, that is, providing staff to support the authors, referees, and editors from submission to decision and to reduce time spent waiting for referee reports where possible. Then there is the cost of copyediting, typesetting, and proofing, a service appreciated by the

Susan Hezlet is publisher at the London Mathematical Society. Her email address is susan.hezlet@lms.ac.uk. Members of the Editorial Board for Scripta Manent are: Jon Borwein, Thierry Bouche, John Ewing, Andrew Odlyzko, and Ann Okerson.

DOI: <http://dx.doi.org/10.1090/noti1085>

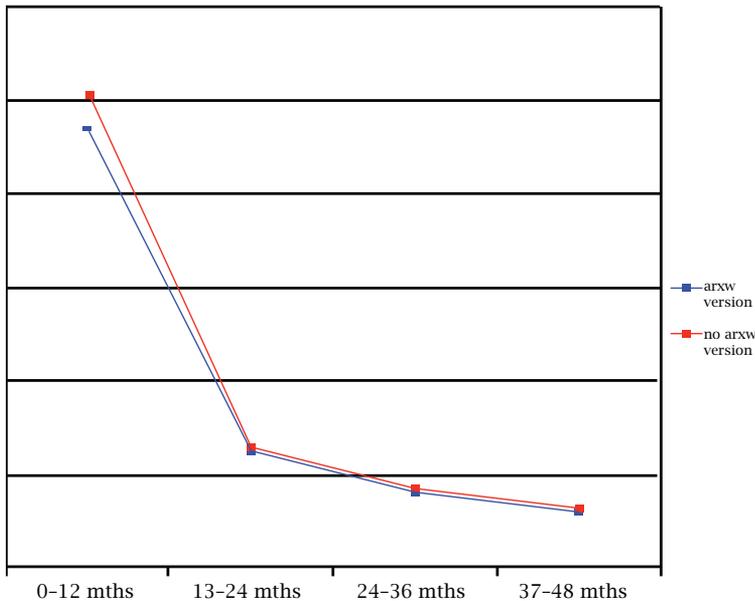
Percentage of published articles that have a version on the arXiv



Graph 1. Percentage of published articles that have a version on the arXiv.

majority of our authors whose first language is not English. Another cost is the sustainable preservation of the older articles in a form that is regularly upgraded to take account of new developments in electronic media.

The obvious question for a publisher to ask is if the presence of the arXiv is a threat to published journals. At the LMS we have been tracking the growth in the percentage of our published papers that have a version on the arXiv for almost fifteen years, and the results are given in graph 1. The



Graph 2. Average number of full text downloads per period, all papers, *Bulletin*, *Journal*, and *Proceedings of the LMS*.

Bulletin, *Journal* and *Proceedings* are general journals, and the average growth across all of mathematics is slower than for those subject areas whose mathematicians were “early adopters”, such as the algebraic geometers.

There have been accounts from theoretical particle physics of a serious decline in readership of published journals where almost all of the articles are available in preprint form on the arXiv.

At the LMS we decided to see if we could find a similar result by identifying those papers published in the *Bulletin*, *Journal* and *Proceedings* that have an arXiv version and comparing that group of journal articles with the rest, i.e., those articles where there is no arXiv version. The results are shown in graph 2.

During the first twelve months of publication,¹ there is a small and clear distinction between the two lines, showing that papers not on the arXiv (the red line) are downloaded more frequently on average than those that have a preprint version on the arXiv (the blue line). This effect quickly tails off in subsequent years, and over all the years we have measured, the tiny difference shown in graph 2 cannot be seen as a threat to our journals. This result came as a welcome surprise, and a similar pattern is seen for our other journals.

It might be true that, if the arXiv had never existed, published research articles in mathematics would be more widely read, but the arXiv is a reality and it is pointless to speculate on its nonexistence.

¹The date of publication is the date on which the online version of the paper is published. The online version is now the final “version of record” and is not posted until after all production work is completed.

For me as a publisher, it is a reassuring confirmation that published papers are read regardless of their “pre-life” on the arXiv and there is a value to the long-term preservation and storage of the mathematical literature in an “organized” form, i.e., as journals, where the Society has a duty to look after the published record.

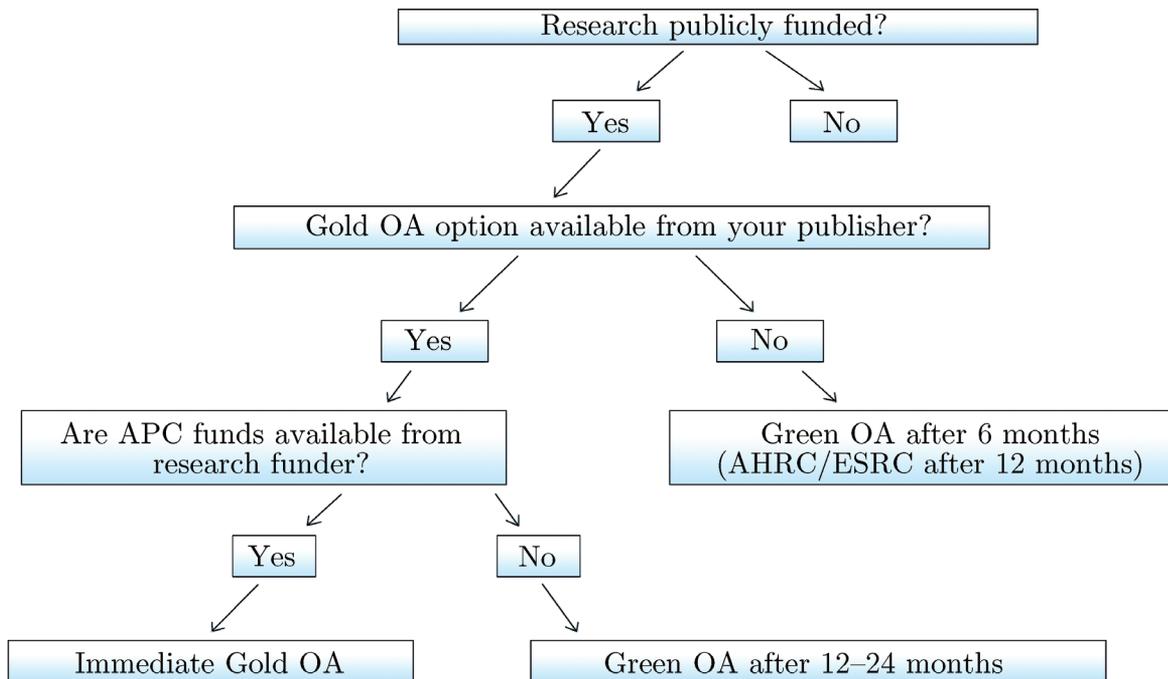
To give an idea of the scale of the data, we looked at 1,332 articles, of which 562 did not have a version on the arXiv. The search for each arXiv version was a painstaking manual job and there will be some human errors, but this works in both directions: misidentifying a preprint version through two papers having similar titles and failing to recognize the preprint version because there has been a substantial change in the title.

One of the reasons for the significantly higher number of downloads in the first twelve months of publication is that we give free access to all the papers in these journals for the first six months (this is called a “reverse moving wall”). This policy has been in place for ten years now, and there is no evidence to suggest it affects a library’s decision to subscribe to the journal. I also looked at usage data for two journals that do not offer the reverse moving wall, and while there is higher usage in the first year of publication, which then tails off in subsequent years, it is only about half of the usage we see in graph 2.

The reason we adopted the reverse moving wall is because we wanted to encourage early reading and citing of the papers while, at the same time, recognizing the value of the older papers. Mathematics truly is a long-lived subject. All of our journals that have been published for more than twenty years have cited half-lives greater than ten years.² In 2012 the *Proceedings of the LMS* had a cited half-life of thirty-three years. We also have preliminary data that the usage half-life of the *Proceedings* is over ten years. For both the usage and the citation data, it appears that several famous old papers are dominant, for example, those by Maxwell, Kelvin, Turing, and Hodge.

However, we may have to close early access in the face of being required to make other parts of the journal freely available under new open access policies driven by changes in UK government policy. Over the last year we have had to review our publishing policies across all our journals following the decision of the UK Department of Business and Industry to adopt a radical policy for publicly funded research, summarized in the flowchart on the next page.

²The cited half-life is measured by taking all the citations made in a single year (e.g., 2012) to any papers published in a journal in any year of publication dating back to the journal’s first volume (e.g 1865 for the *Proceedings*.) The “half-life” year is the year where the median point is found.



I won't go into the details of this chart, the full explanation for which can be found on the Research Council's UK website.³ My intention in showing it is to give an idea of the increasingly complex world in which mathematical researchers are finding themselves, particularly where there are coauthors from several countries, some of whom may be working under conflicting policies.

The Society has been active in defending the uniqueness of mathematics research and its expression through published journals, and while government statements supported the idea that special cases could be made, recognizing that "one size does not fit all," nothing has been done in practice. Mathematics as just one of the subjects covered by the UK Engineering and Physical Sciences Research Council (EPSRC) has to follow the same conditions and embargo periods as any other subject within this wide group, regardless of the presence of the arXiv or unique features such as long citation and usage half-lives.

Although we are a British-based society, more of our authors are from the USA than the UK; last year we had authors from forty-four countries contributing to the 280 articles published in the LMS journals. This is the point at which we set aside the question of "is open access a good or bad thing?" Instead we ask, "have we provided all the options to ensure that a mathematician *from any country* can submit a paper to our journals and find a place that fits his or her funder's requirements while retaining our high standards for acceptance

of a paper regardless of funding?" We have to balance the authors' needs with accessibility for our readers, ensuring their libraries get value for their subscriptions. Where there is no money for subscriptions, free access is subsidized through our developing countries initiative, and the presence of preprint versions on the arXiv provides a sustainable "green" alternative access.

We recognize that, for green open access, some people would like the final published version (the "version of record") to be freely available. Setting an embargo period to match the citation half-life of our journals would be unacceptable to some, but six or twelve months embargo periods are far too short, and there is a danger that such a policy would quickly lead to cancellations of subscriptions. We have evidence for this from the case of the *Annals of Mathematics*, which lost over one third of its subscriptions in five years when it moved to a green open access model. The distinguishing feature for the *Annals* was that it was the final published versions on the journal's website that were freely available, leading librarians to question paying subscriptions for online access to something freely available. From the scant evidence we have, it seems that the danger does not lie in the arXiv version because these are preprints and "disorganized" in comparison with hosting the free versions on the publisher's own website. I believe there would be a threat to the subscription base if we were required to deposit the final published version and not just the author's accepted manuscript. I should be clear that no one is asking this of our published papers; I have seen several summaries describing the development of

³<http://www.rcuk.ac.uk/research/Pages/outputs.aspx>

Rise Above the Ordinary



A career at NSA is no ordinary job. It's a profession dedicated to identifying and defending against threats to our nation. It's a dynamic career filled with challenging and highly rewarding work that you can't do anywhere else but NSA.

You, too, can rise above the ordinary. Whether it's producing valuable foreign intelligence or preventing foreign adversaries from accessing sensitive or classified national security information, you can help protect the nation by putting your intelligence to work.

NSA offers a variety of career fields, paid internships, co-op and scholarship opportunities.

Learn more about NSA and how your career can make a difference for us all.

KNOWINGMATTERS

Excellent Career Opportunities for Experts in the Following:

- Number Theory
- Probability Theory
- Group Theory
- Finite Field Theory
- Combinatorics
- Linear Algebra

>> **Plus** other opportunities

WHERE INTELLIGENCE GOES TO WORK®



NSA

www.NSA.gov/Careers

APPLY TODAY



U.S. citizenship is required. NSA is an Equal Opportunity Employer.

government polices around the world, and so far they only require deposit of the author manuscript after an embargo period. However, the policies are frequently badly worded and imprecise—and changing all the time!

Our response to this situation is to develop the following policies, which we hope cover all the bases for both readers and authors. There are three main options that apply to our core journals (the *Bulletin*, *Journal*, and *Proceedings*, and now the *Transactions*). We hope these will cover everything a mathematician may be required to do.

1) If an author would like to make his article permanently available in final published form, he can apply to his funder or university for the funds to pay the hybrid open access fee of the *Bulletin*, *Journal*, or *Proceedings*. Mathematicians who are awarded grants from EPSRC are first expected to follow this route. If there is no money left for the payment of the Author Payment Charges (APCs), then the authors may take the green route. Since the introduction of the UK policy, we have seen several universities (for example, Imperial College and Warwick) paying the hybrid fees.

2) A few funders have said they will not pay fees for hybrid journals, preferring only to fund pure open access journals. As a result, we have launched a new journal, the *Transactions of the LMS*, which is a gold open access journal. Note that this is not a “transfer journal” and the editor will not consider papers rejected by other LMS journals. We have several papers currently under review and expect to publish the first papers this year.

For further information on the open access options and the launch of the *Transactions*, see <http://www.lms.ac.uk/sites/lms.ac.uk/files/Publications/TLMS-Announcement.pdf>, which explains the background of the decision to launch the journal and how it fits in with our other journals.

Our Editorial Advisory Board now looks after papers submitted to the *Bulletin*, *Journal*, *Proceedings*, and *Transactions* and ensures that the same high standards are applied to all four journals.

3) Authors in any of these journals are free to post their preprint versions, up to the final accepted version, on the arXiv and in any repository that they are required to do so. This has been the case for many years.

In this article I have described in some detail what the LMS is doing about open access, and I think have fairly reflected the reasons why we have adopted these policies and gone so far as to launch a new open access journal. However, the views expressed here are my own and shouldn't be taken to represent the membership or the Council of the LMS. After all, with over two thousand members, the range of their views should cover every possible opinion on publishing.

Undiluted Hocus-Pocus

Reviewed by Andy Magid

Undiluted Hocus-Pocus: The Autobiography of Martin Gardner

Martin Gardner

Princeton University Press, 2013

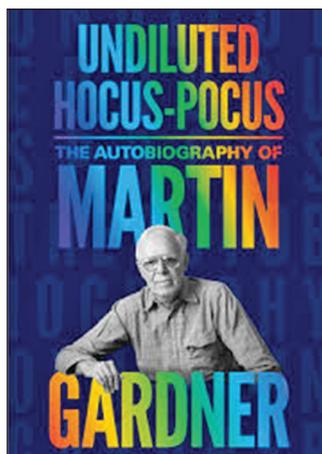
US\$24.95, 288 pages

ISBN-13: 978-0691159911

At one time, algebraists used to entertain themselves with the pseudotrivia question: who is the most important ring theorist from Alabama? “Pseudo” because the point was not to test the interrogee’s knowledge of Cotton State mathematics, but to surprise them with the answer, namely, Nathan Jacobson. That it should be a surprise carried more than a whiff of Yankee chauvinism; anyone familiar with the Midwestern U.S. small town merchants of the 1940s and 1950s who were born in Poland and raised in the American South would have instantly recognized from Professor Jacobson’s speech patterns that he shared that biography. And the algebra community being the size it is, anyone who could have been surprised by the answer was surprised long ago, although there is a similar question still making the rounds—who is the best group theorist from Arkansas?—that reeks of the same chauvinism.

Algebraists annoyed at being asked the Jacobson question too many times began to respond with the question, who is the second most important ring theorist from Alabama? which is a cute riposte but finesses a more fundamental point. Is there any reason we should care to know that Jacobson was from Alabama? Or, for that matter, know any biographical trivia about any mathematical figure?

Martin Gardner, the author and mathematics columnist who died in 2010, was educated in Tulsa, Oklahoma, where he was born in 1914, thereby be-



coming one of two possible answers to the trivia question, who is the most important nonfiction writer from Tulsa? The other possible answer is the historian Daniel Boorstin, who was also born in 1914 but arrived in Tulsa as an infant. Both men graduated from Tulsa Central High School, although Boorstin,

something of a prodigy, seems to have graduated at age fifteen before Gardner entered. I do not know if they ever met. Incidentally, even though I met these men only briefly and then near the end of their lives, I spoke to them enough to know that you couldn’t detect anything in their speech patterns suggesting a Tulsa biography, not even in the telltale second person plural.

There’s also the academic historian John Hope Franklin, who graduated from Tulsa’s Booker T. Washington High School. Franklin was known more as a scholar than as a writer, although his 1947 book *From Slavery to Freedom* has sold millions of copies. He was born two days after the end of 1914, which makes him almost a coeval of Gardner and Boorstin; again, I don’t know if Franklin ever met Gardner or Boorstin.

Gardner’s impact on mathematics in America was profound, especially in the 1960s and 1970s, when he wrote his widely popular column “Mathematical Games” for *Scientific American*. I was a fan, beginning as a teenager, and loved reading the columns, especially those in narrative form featuring the Dr. Matrix character. I also remember with pleasure reading in Gardner’s first collection of those columns, *The Scientific American Book of Mathematical Puzzles and Diversions*, the

Andy Magid is George Lynn Cross Professor of Mathematics Emeritus at the University of Oklahoma. His email address is amagid@ou.edu.

DOI: <http://dx.doi.org/10.1090/noti1091>

dedication to Gardner's teacher at Tulsa Central High School, being an Oklahoma high school student myself at the time. I also have to say that, with the possible exception of some word ladders, I can't recall ever solving any of the problems in Gardner's column. This is no insult to Gardner—I also never built any of the apparati described in “The Amateur Scientist”, the wonderful *Scientific American* companion column by C. L. Strong—but rather a testimony to his skills as a writer and the pleasure his writing gave the reader. I suppose, between the ends of the spectrum of readers like me, who never solved any problems and readers, if any, for whom only the problems and not Gardner's writing mattered fell the vast majority of readers who made Gardner's column the most popular feature of *Scientific American* in its day.

Let's agree that, whether he was a mathematician or not, Martin Gardner wrote about mathematical puzzles in an entertaining way that entranced a wide audience well beyond professional mathematicians and advanced students of mathematics. Even when mathematics is admired by the general public, as it was in post-Sputnik America, the gap between what the public thinks mathematics is and what mathematicians understand mathematics to be is vast. What Martin Gardner accomplished was to bridge that gap.

Here's an illustration. The following two problems are, in my judgment, about equal in intellectual content. The first comes from Gardner's first collection of columns mentioned above. The second is an exercise in commutative algebra.

1. A young man lives in Manhattan near a subway express station. He has two girlfriends, one in Brooklyn, one in the Bronx. To visit the girl in Brooklyn, he takes a train on the downtown side of the platform; to visit the girl in the Bronx he takes a train on the uptown side of the same platform. Since he likes both girls equally well, he simply takes the first train that comes along. In this way he lets chance determine whether he rides to the Bronx or to Brooklyn. The young man reaches the subway platform at a random moment each Saturday afternoon. Brooklyn and Bronx trains arrive at the station equally often—every ten minutes. Yet he finds himself spending most of his time with the girl in Brooklyn; in fact, on the average he goes there nine times out of ten. Can you think of a good reason why the odds so heavily favor Brooklyn?

2. The commutative ring S is an algebra over the commutative ring R . The ring R has no nontrivial idempotents, and S is finitely generated as an R module. Can S have infinitely many idempotents?

One needs to understand some basic arithmetic and have some notion of random and average to solve problem one, but beyond that no special knowledge is required. I suspect that even the one specialized detail that Gardner puts in (the uptown/downtown choice from the same central

platform is apparently a feature of express stops; hence the protagonist is said to live near such a station) was unnecessary for most of his readers. On the other hand, almost all the words in problem 2 are used in a specialized mathematical sense. Even if it were possible to present definition chains of all the terminology involved, we would expect years of study before a typical layperson would be comfortable tackling that problem. I hope those readers familiar with the terminology will agree with me, and I invite the rest to take my word for it, that the two problems are roughly the same sort of intellectual, or mathematical, challenge.

Month after month Martin Gardner's column presented and discussed intellectual recreations that were on the level of what mathematicians thought about and yet were accessible to people without advanced mathematical training. He called these recreations—properly—mathematics. The discipline has had no finer exponent.

To further establish my Gardner fan credentials before we turn to Gardner's new book, I also recall reading in high school with much satisfaction two other excellent Gardner books of the period, *Logic Machines and Diagrams* and *Fads and Fallacies in the Name of Science*. Both of these, by the way, could well have been collections of articles, although they were in fact unified projects; Gardner just seems to write that way naturally. His other great style is being the annotator, as he is in his most popular book, *The Annotated Alice in Wonderland*. To illustrate its popularity and to keep Gardner's mathematician fan base in perspective, it's well to recall that since its initial release in 1960, the number of copies of *The Annotated Alice* sold is about twenty times the number of mathematicians in or joining the profession from then until now.

So how did Tulsa schoolboy Martin Gardner become the popular and admired writer on mathematics and other topics? *Undiluted Hocus-Pocus: The Autobiography of Martin Gardner* tells the story. Like everything Gardner ever wrote, it is entertaining, informative, witty, deft, and a joy to read, or so this fan assesses. Mathematicians need to be aware that the role that mathematics, or the writing of the “Mathematical Games” columns, plays in Gardner's story of his life is brief. Readers also need to be aware that Gardner is concerned with philosophical ideas, including theological ones. In his preface, quoting Lenny Bruce, Gardner identifies himself with people leaving churches and going back to God. In his prologue, quoting himself from his 2007 *Notices* book review [“Do loops explain consciousness?: Review of *I Am a Strange Loop*”, August 2007], Gardner identifies himself as a mystic, i.e., one who is convinced that “no philosopher or scientist living today has the foggiest notion of how consciousness, and its

inseparable companion free will, emerge, as they surely do, from a material brain.”

Gardner has previously spoken to the mathematical community about how he came to write “Mathematical Games” in an interview with Allyn Jackson in the *Notices* (June/July 2005) and in an interview with Donald Albers of the Mathematical Association of America, which is included in the MAA’s CD *Martin Gardner’s Mathematical Games: The entire collection of his Scientific American columns* (the disc also includes a biographical essay on Gardner by Peter Renz). As Gardner recounts in *Undiluted Hocus-Pocus*, a friend of his showed him a hexaflexagon, he decided to do an article on it that he sold to *Scientific American*, the response to the article was such that the publisher asked Gardner to do a monthly column, and “Mathematical Games” was born. This account, by the way, occupies the first two pages of Gardner’s chapter 15 (of twenty-one), which is entitled “Scientific American”. Gardner tells us that writing the column for twenty-five years “was one of the greatest joys of [Gardner’s] life,” and that “one of the pleasures in writing the column is that it introduced [Gardner] to so many top mathematicians,” among whom he mentions Solomon Golomb, John Conway, Raymond Smullyan, Roger Penrose, and Donald Knuth (in chapter 15), and Ron Graham and Persi Diaconis in chapter 17, which is entitled “Math and Magic Friends”. These chapter titles are not rigid boundaries. Chapter 15 includes an account of Gardner’s relationship with Isaac Asimov, and chapter 17 recounts his relationships with Salvador Dali and Vladimir Nabokov. As this last bit of name-dropping makes clear, Gardner’s long career as a Chicago- (where he attended the University of Chicago) and New York-based writer brought him in contact with a smorgasbord of top-tier intellectual celebrities. Of course he was one himself—or would have been had his proverbial public shyness not kept him from certain spotlights. Here is an example (not mentioned in *Undiluted Hocus-Pocus*): according to Gardner’s son James, Gardner declined an invitation from Stanley Kubrick to attend the premiere of *2001: A Space Odyssey* on the grounds that he didn’t have a tuxedo. On the other hand, Gardner must have been a wonderful small group social companion, as the heartfelt Foreword by Persi Diaconis and Afterword by James Randi for this book make clear.

Except for the sections noted in the preceding paragraph, however, most of Gardner’s autobiography, and life, was not about mathematics. The reader will learn about Tulsa in the 1920s from the perspective of a bright and athletic schoolboy. And, it must be said, a privileged one: the family home on South Owasso Street was in a pretty tony area (it’s still tony). Gardner tells that the third floor of the house was servants’ quarters. Although Gardner doesn’t mention household

staff, the house my late mother-in-law grew up in a mile north on Owasso, in a less ritzy area, also had servants’ quarters in the rear. However, by the 1920s their domestic help were commuters, not live-in. (Although I never heard them mention him, my mother-in-law and her sisters were the right age to have passed Gardner in the halls of Horace Mann Junior High and Tulsa Central High.) The reader will also learn about the University of Chicago of the 1930s from the perspective of an intelligent undergraduate with a deep interest in philosophy and the philosophy of religion, about Navy life in World War II aboard a destroyer escort, and about living the life of a writer in the Greenwich Village of the 1950s.

What the reader will also hear about, but not enough, is the role that performing magic tricks played in Gardner’s life. Anyone who has ever traveled with, say, mothers of small children or people who keep kosher know how these folks can make contact with others of their kind almost instantly in strange venues while the rest of us are still struggling to meet the local population. Gardner hints that the same type of radar connects magicians, and many of the pivotal events of his life seem to hinge on a connection made by magicians. (The friend who showed Gardner the hexaflexagon, for example, was a fellow magic enthusiast. So are Diaconis and Randi.) Like followers of twelve-step programs (another group who make instant connections in new places), magicians apparently also gather regularly to trade tricks and gossip. Gardner seems to have spent many hours in such gatherings, presumably with pleasure and involvement, but he doesn’t share much of this with his readers.

Gardner makes clear in this book, as he did in his MAA and *Notices* interviews mentioned earlier, that he considers his book *The Whys of a Philosophical Scrivener* his deepest work. It is an important book, which unfortunately seems not to have reached the audience he sought for it. Perhaps the format (each chapter is framed as a question “Why I am not a ...”, where the blank is replaced by various philosophical systems) makes it look like a collection of discrete pieces in the style used for *Fads and Fallacies* or *Logic Machines and Diagrams*. It is not: it is a sustained account of Gardner’s thinking leading up to his “mysterian” position.

Although various chapters of *Undiluted Hocus-Pocus* could be read in isolation, the book is a sustained account of Martin Gardner’s eventful life. Despite the caveats noted above about the role magic played in that life, it is a remarkably open account for the publicly shy Gardner, perhaps that being one of the reasons it is posthumous. Gardner believed in God and an afterlife. He tells us in his last pages that this is not grounded in the “head”, which he is using as a metonym for rational inference, but in the “heart”, which he

uses as a metonym for direct emotional perception. Gardner says:

As for God and an afterlife, our head tells us both are illusions. An Old Testament psalm (14:1), Unamuno reminds us, does not say “The fool hath said in his *head* there is not God.” God is a hope only of the heart.

In the King James translation of Psalm 14 that Unamuno is referencing, the italicized word is rendered heart, which is indeed the literal translation of the Hebrew word in question. On the other hand, the biblical writers understood that organ to be the location of the intellect, not the emotions, which is why a modern translation, such as the

Jewish Publication Society’s of 1982, renders the verse “The benighted man thinks....” Could Martin Gardner, the master annotator and occasional pseudonymous prankster, not know this? This reviewer, an afterlife skeptic, is willing to suspend disbelief long enough to wonder if in some form or other Gardner is watching to see how many readers catch this “glitch”. Plus of course I wonder if there are other glitches Gardner has planted that I’ve missed. For example, about that express subway station: are there any stops in New York where trains go in two directions from a central platform?

In keeping with the prankster tradition, I confess that the Arkansas group theorists’ query above is also a trick question. There’s a three-way tie for first (some say two-way).

Donoho Awarded 2013 Shaw Prize



David L. Donoho

The Shaw Foundation has awarded the 2013 Shaw Prize in Mathematical Sciences to DAVID L. DONOHO of Stanford University “for his profound contributions to modern mathematical statistics and in particular the development of optimal algorithms for statistical estimation in the presence of noise and of efficient techniques for sparse representation and recovery in large data sets.” The prize carries a cash award of US\$1 million.

The Shaw Prize in Mathematical Sciences Selection Committee released the following statement about Donoho’s work.

“For more than two decades David Donoho has been a leading figure in mathematical statistics. His introduction of novel mathematical tools and ideas has helped shape both the theoretical and applied sides of modern statistics. His work is characterized by the development of fast computational algorithms together with rigorous mathematical analysis for a wide range of statistical and engineering problems.

“A central problem in statistics is to devise optimal and efficient methods for estimating (possibly nonsmooth) functions based on observed data which has been polluted by (often unknown) noise. Optimality here means that, as the sample size increases, the error in the estimation should decrease as fast as that for an optimal interpolation of the underlying function. The widely used least square regression method is known to be nonoptimal for many classes of functions and noise that are encountered in important applications, for example, nonsmooth functions and non-Gaussian noise. Together with Iain Johnstone, Donoho developed provably almost optimal (that is, up to a factor of a power of the logarithm of the sample size) algorithms for function estimation in wavelet bases. Their ‘soft thresholding’ algorithm is now one of the most widely used algorithms in statistical applications.

“A key theme in Donoho’s research is the recognition and exploitation of the fundamental role of sparsity in function estimation from high-dimensional noisy data. Sparsity here refers to a special property of functions that can be represented by only a small number of appropriately chosen basis vectors. One way to characterize such sparsity is to minimize the L^0 -norm of the coefficients in such representations. Unfortunately, the L^0 -norm is not convex and is highly nonsmooth, making it difficult to develop fast algorithms for

its computation. In addition to pioneering the exploitation of sparsity, Donoho also introduced the computational framework for using the L^1 -norm as a convexification of the L^0 -norm. This has led to an explosion of efficient computational algorithms realizing this sparsity framework which have been used effectively in a wide variety of applications, including image processing, medical imaging, data mining, and data completion.

“A recent and much celebrated development along this sparsity- L^1 theme is Compressed Sensing (a term coined by Donoho). Data compression is widely used nowadays—for example, the JPEG standard for compressing image data. Typically, the data is gathered from sensors (for example, a camera) and the data is then compressed (that is, represented by a much smaller number of coefficients in an appropriate basis, while preserving as much accuracy as possible). Corresponding decompression algorithms are then used to recover the original data. The revolutionary idea in Compressed Sensing is to shortcut this standard approach and to ‘compress while sensing’, that is, to collect a small number of appropriately chosen samples of the data, from which the original data can be recovered (provably exactly under appropriate assumptions) through corresponding decompression algorithms. The key ingredients are again sparsity (most typical in a wavelet basis), use of L^1 -norm for recovery, and the use of random averaging in sensing. Along with Emmanuel Candes and Terence Tao, Donoho is widely credited as one of the pioneers of this exploding area of research, having contributed fundamental ideas, theoretical frameworks, efficient computational algorithms, and novel applications. This is still a thriving area of research with wide applications, but already many stunning results have been obtained (both theoretical and practical).”

David L. Donoho was born in 1957 in Los Angeles, California. He is currently Anne T. and Robert M. Bass Professor of the Humanities and Sciences and professor of statistics at Stanford University. He received his Ph.D. from Harvard University in 1983. From 1984 to 1990 he served on the faculty of the University of California, Berkeley. He has been on the faculty at Stanford since 1990. He received a MacArthur Fellowship in 1991. He is the recipient of the John von Neumann Prize of the Society for Industrial and Applied Mathematics (SIAM) and of the Norbert Wiener Prize in Applied Mathematics of SIAM and the AMS. He is a fellow of the American Academy of Arts and Sciences and of SIAM. He is a foreign associate of the French Academy of Sciences and a member of the National Academy of Sciences.

The Shaw Prize is an international award established to honor individuals who are currently active in their respective fields and who have achieved distinguished and significant advances,

who have made outstanding contributions in culture and the arts, or who have achieved excellence in other domains. The award is dedicated to furthering societal progress, enhancing quality of life, and enriching humanity’s spiritual civilization. Preference is given to individuals whose significant work was recently achieved.

The Shaw Prize consists of three annual awards: the Prize in Astronomy, the Prize in Science and Medicine, and the Prize in Mathematical Sciences. Established under the auspices of Run Run Shaw in November 2002, the prize is managed and administered by the Shaw Prize Foundation based in Hong Kong. Previous recipients of the Shaw Prize in Mathematical Sciences are Maxim Kontsevich (2012), Demetrios Christodoulou and Richard S. Hamilton (2011), Jean Bourgain (2010), Simon K. Donaldson and Clifford H. Taubes (2009), Vladimir Arnold and Ludwig Faddeev (2008), Robert Langlands and Richard Taylor (2007), David Mumford and Wen-Tsun Wu (2006), Andrew Wiles (2005), and Shiing-Shen Chern (2004).

From Shaw Foundation announcements

uses as a metonym for direct emotional perception. Gardner says:

As for God and an afterlife, our head tells us both are illusions. An Old Testament psalm (14:1), Unamuno reminds us, does not say “The fool hath said in his *head* there is not God.” God is a hope only of the heart.

In the King James translation of Psalm 14 that Unamuno is referencing, the italicized word is rendered heart, which is indeed the literal translation of the Hebrew word in question. On the other hand, the biblical writers understood that organ to be the location of the intellect, not the emotions, which is why a modern translation, such as the

Jewish Publication Society’s of 1982, renders the verse “The benighted man thinks....” Could Martin Gardner, the master annotator and occasional pseudonymous prankster, not know this? This reviewer, an afterlife skeptic, is willing to suspend disbelief long enough to wonder if in some form or other Gardner is watching to see how many readers catch this “glitch”. Plus of course I wonder if there are other glitches Gardner has planted that I’ve missed. For example, about that express subway station: are there any stops in New York where trains go in two directions from a central platform?

In keeping with the prankster tradition, I confess that the Arkansas group theorists’ query above is also a trick question. There’s a three-way tie for first (some say two-way).

Donoho Awarded 2013 Shaw Prize



David L. Donoho

The Shaw Foundation has awarded the 2013 Shaw Prize in Mathematical Sciences to DAVID L. DONOHO of Stanford University “for his profound contributions to modern mathematical statistics and in particular the development of optimal algorithms for statistical estimation in the presence of noise and of efficient techniques for sparse representation and recovery in large data sets.” The prize carries a cash award of US\$1 million.

The Shaw Prize in Mathematical Sciences Selection Committee released the following statement about Donoho’s work.

“For more than two decades David Donoho has been a leading figure in mathematical statistics. His introduction of novel mathematical tools and ideas has helped shape both the theoretical and applied sides of modern statistics. His work is characterized by the development of fast computational algorithms together with rigorous mathematical analysis for a wide range of statistical and engineering problems.

“A central problem in statistics is to devise optimal and efficient methods for estimating (possibly nonsmooth) functions based on observed data which has been polluted by (often unknown) noise. Optimality here means that, as the sample size increases, the error in the estimation should decrease as fast as that for an optimal interpolation of the underlying function. The widely used least square regression method is known to be nonoptimal for many classes of functions and noise that are encountered in important applications, for example, nonsmooth functions and non-Gaussian noise. Together with Iain Johnstone, Donoho developed provably almost optimal (that is, up to a factor of a power of the logarithm of the sample size) algorithms for function estimation in wavelet bases. Their ‘soft thresholding’ algorithm is now one of the most widely used algorithms in statistical applications.

“A key theme in Donoho’s research is the recognition and exploitation of the fundamental role of sparsity in function estimation from high-dimensional noisy data. Sparsity here refers to a special property of functions that can be represented by only a small number of appropriately chosen basis vectors. One way to characterize such sparsity is to minimize the L^0 -norm of the coefficients in such representations. Unfortunately, the L^0 -norm is not convex and is highly nonsmooth, making it difficult to develop fast algorithms for

its computation. In addition to pioneering the exploitation of sparsity, Donoho also introduced the computational framework for using the L^1 -norm as a convexification of the L^0 -norm. This has led to an explosion of efficient computational algorithms realizing this sparsity framework which have been used effectively in a wide variety of applications, including image processing, medical imaging, data mining, and data completion.

“A recent and much celebrated development along this sparsity- L^1 theme is Compressed Sensing (a term coined by Donoho). Data compression is widely used nowadays—for example, the JPEG standard for compressing image data. Typically, the data is gathered from sensors (for example, a camera) and the data is then compressed (that is, represented by a much smaller number of coefficients in an appropriate basis, while preserving as much accuracy as possible). Corresponding decompression algorithms are then used to recover the original data. The revolutionary idea in Compressed Sensing is to shortcut this standard approach and to ‘compress while sensing’, that is, to collect a small number of appropriately chosen samples of the data, from which the original data can be recovered (provably exactly under appropriate assumptions) through corresponding decompression algorithms. The key ingredients are again sparsity (most typical in a wavelet basis), use of L^1 -norm for recovery, and the use of random averaging in sensing. Along with Emmanuel Candes and Terence Tao, Donoho is widely credited as one of the pioneers of this exploding area of research, having contributed fundamental ideas, theoretical frameworks, efficient computational algorithms, and novel applications. This is still a thriving area of research with wide applications, but already many stunning results have been obtained (both theoretical and practical).”

David L. Donoho was born in 1957 in Los Angeles, California. He is currently Anne T. and Robert M. Bass Professor of the Humanities and Sciences and professor of statistics at Stanford University. He received his Ph.D. from Harvard University in 1983. From 1984 to 1990 he served on the faculty of the University of California, Berkeley. He has been on the faculty at Stanford since 1990. He received a MacArthur Fellowship in 1991. He is the recipient of the John von Neumann Prize of the Society for Industrial and Applied Mathematics (SIAM) and of the Norbert Wiener Prize in Applied Mathematics of SIAM and the AMS. He is a fellow of the American Academy of Arts and Sciences and of SIAM. He is a foreign associate of the French Academy of Sciences and a member of the National Academy of Sciences.

The Shaw Prize is an international award established to honor individuals who are currently active in their respective fields and who have achieved distinguished and significant advances,

who have made outstanding contributions in culture and the arts, or who have achieved excellence in other domains. The award is dedicated to furthering societal progress, enhancing quality of life, and enriching humanity’s spiritual civilization. Preference is given to individuals whose significant work was recently achieved.

The Shaw Prize consists of three annual awards: the Prize in Astronomy, the Prize in Science and Medicine, and the Prize in Mathematical Sciences. Established under the auspices of Run Run Shaw in November 2002, the prize is managed and administered by the Shaw Prize Foundation based in Hong Kong. Previous recipients of the Shaw Prize in Mathematical Sciences are Maxim Kontsevich (2012), Demetrios Christodoulou and Richard S. Hamilton (2011), Jean Bourgain (2010), Simon K. Donaldson and Clifford H. Taubes (2009), Vladimir Arnold and Ludwig Faddeev (2008), Robert Langlands and Richard Taylor (2007), David Mumford and Wen-Tsun Wu (2006), Andrew Wiles (2005), and Shiing-Shen Chern (2004).

From Shaw Foundation announcements

Writing about Math for the Perplexed and the Traumatized

Steven Strogatz

Introduction

In the summer of 2009 I received an unexpected email from David Shipley, the editor of the op-ed page for the *New York Times*. He invited me to look him up next time I was in the city and said there was something he'd like to discuss.

Over lunch at the Oyster Bar restaurant in Grand Central Station, he asked whether I'd ever have time to write a series about the elements of math aimed at people like him. He said he'd majored in English in college and hadn't studied math since high school. At some point he'd lost his way and given up. Although he could usually do what his math teachers had asked of him, he'd never really seen the point of it. Later in life he'd been puzzled to hear math described as beautiful. Could I convey some of that beauty to his readers, many of whom, he suspected, were as lost he was?

I was thrilled by his proposition. I love math, but even more than that, I love trying to explain it. Here I'd like to touch on a few of the writing challenges that this opportunity entailed, along with the goals I set for myself, and then describe how, by borrowing from three great science writers, I tried to meet those challenges. I'm not sure if any of my suggestions will help other mathematicians who'd like to share their own love of math with the public, but that's my hope.

Three Challenges

One challenge in writing about math is that the subject is inherently abstract. The objects of

Steven Strogatz is the Schurman Professor of Applied Mathematics at Cornell University. His email address is strogatz@cornell.edu.

This essay is adapted, with permission, from a chapter to appear in The Power of Writing, edited by Christiane Donahue, to be published by the University Press of New England on behalf of Dartmouth College Press.

DOI: <http://dx.doi.org/10.1090/noti1086>

mathematics are disembodied ideas, not people or stories or things. Although its simplest concepts, numbers and shapes, aren't too hard for most readers to grasp, math becomes increasingly slippery and ethereal as we move on to formulas and functions, theorems and proofs, derivatives and integrals.

Then there's the matter of the strange symbols and jargon. The uninitiated have no idea how to say something like ϕ . And what on earth is a directrix or, worse yet, a latus rectum?

Finally, attention must be paid to the psychiatric dimensions of the subject. Math is linked in the popular mind with phobia and anxiety. You'd think we were discussing spiders. So anyone hoping to write about math for a wide audience needs to reckon with the reality that math is, for many people, terrifying. Boring. Meaningless. And, in the most florid cases, all of the above.

Three Audiences

After years of listening to people's emotional stories about their experiences with math, I've come to recognize three broad groups into which all of humanity falls (I'm kidding, of course, but not entirely):

1) *The traumatized*: These folks suffered humiliation somewhere along the line, maybe as early as second or third grade when they were subjected to the arcana of borrowing and carrying. Or maybe they hit the wall at long division, word problems, or linear algebra. In any case, for these wounded souls math is now an unhappy memory, a lasting blow to the ego. "I'm just not a math person." "I don't have a head for numbers." "I loved math until I got to (insert tricky math concept here)." Other subjects can inflict the same kind of damage but not to the same degree and not quite so painfully as math does.

2) *The perplexed*: This is David Shipley's camp. For him and his ilk, math left no scars; it merely felt pointless. These are the people who never quite knew what they were doing mathematically, yet they compensated by working hard, following directions, and overcoming failures. A large proportion of successful people fall into this camp—essentially anyone who wasn't a natural at math.

3) *The naturals*: Though it's taboo to admit it, I believe there are some kids who have a feel for math. It makes sense to them and gives them pleasure and satisfaction. They may or may not get good grades; that depends more on how hard they work and how well they play the game of school. But the talent is there. In rare cases, they grow up to become mathematicians. Or they may go into a related field: accounting, engineering, computers, finance, medicine, etc. Or, most likely of all, they never use math again after they join the workforce. Nonetheless, they retain a lifelong affection for it. These are the people who used to read Martin Gardner's "Mathematical Games" column in *Scientific American*. Almost all books, blogs, and magazine articles on "popular math" are directed toward them and them alone.

That's why, as crude as this classification scheme may be, it's useful. It helps us to see that groups 1 and 2—the traumatized and the perplexed—are underserved mathematically. Though David Shipley didn't put it this way, he was asking me to write for them.

The Need for Empathy

Whether I'm teaching a class, tutoring one-on-one, writing for my colleagues in other scientific disciplines, or trying to convey the beauty of math to the wider public, I've learned that explaining math successfully is not mainly about the logic and clarity of the explanation. (Those are necessary but not sufficient.) Explaining math well requires *empathy*. The explainer needs to recognize that there's another person on the receiving end of the explanation. But in our culture of mathematics, an all-too-common approach is to state the assumptions, state the theorems, prove the theorems, and stop. Any questions?

What makes this approach so ineffective is that it answers questions the student hasn't thought to ask. On top of that, it can be exhausting to follow someone else's train of thought. A captive audience of students has no choice, of course; they're forced to listen and yield. That's how we, as math teachers, get in the habit of forgetting to empathize.

If you want someone to follow your mathematical disquisitions voluntarily—or better yet, happily—you have to help him or her love the questions you're asking. This is true for any audience, but especially for the traumatized and the perplexed. *You have to help them love the questions.*

But how?

Three Routes to Mathematical Seduction

For any would-be pop math writer, here are a few surefire techniques.

(1) *Illuminate*. Give the reader a shiver of pleasure by providing an "Aha!" experience.

(2) *Make connections*. Tie the math to something the reader already enjoys.

(3) *Treat the reader like a friend of yours*—a nonmathematical friend. Then you'll instinctively do everything right.

In what follows I'll try to flesh out what I mean by these techniques and show how three giants of science writing—Richard Feynman, Stephen Jay Gould, and Lewis Thomas—served as inspirations to me.

Provide Illumination

Moments of illumination help a reader fall in love with math, especially after struggling in the dark for so long.

The illumination can be purely verbal. In one of my articles I pointed out why fractions like $2/3$ or $1/4$ are called "rational numbers"—they involve ratios of whole numbers. This struck my wife, Carole, as an epiphany. She had always labored under the misimpression that rational numbers were somehow more reasonable than "irrational" numbers, but she could never see what was so flighty or hysterical about the latter. Now she understood. Irrational numbers are simply those that can't be expressed as a ratio of two whole numbers. They're ir-ratio-nal.

Another revelation for her had to do with the word "squared". No teacher had ever bothered to explain that "2 squared" is synonymous with 2 times 2 and "3 squared" with 3 times 3 because collections of that many objects can be arranged in the shape of a square:



On other occasions in the series, I tried to illuminate the reasoning behind mathematical statements that all of us heard in school but that few of us ever really understood, such as why a negative times a negative is a positive or where the formula for the area of a circle comes from.

Make Connections

Math becomes more appealing when it's tied to topics the reader cares about. Sports, music, literature, movies, science, business, law—they're all great sources of math in action. For anyone who likes to get physical, vectors seem a lot more vivid when they're illustrated by samba dance steps or how Roger Federer hits his running forehand down the line. For history buffs the rules for multiplying negative and positive numbers come to life when you show how much sense they can make of the

shifting alliances among European countries in the runup to World War I.

Making the effort to include real-world connections like these sends a message to the reader: Even if you are not primarily interested in math, you are welcome here. This is what the perplexed and the traumatized need to hear. Connection, not alienation.

Be a Friend

Adopting a welcoming tone comes automatically if you picture the reader as a living, breathing, non-mathematical friend of yours. Rather than writing for a generic “intelligent reader”, I imagined a real person when I wrote for the *Times*. It felt right to open the series by mentioning him, to establish an informal, affectionate tone and also to hint at the ideal reader I had in mind:

I have a friend who gets a tremendous kick out of science, even though he’s an artist. Whenever we get together all he wants to do is chat about the latest thing in evolution or quantum mechanics. But when it comes to math, he feels at sea, and it saddens him. The strange symbols keep him out. He says he doesn’t even know how to pronounce them.

In fact, his alienation runs a lot deeper. He’s not sure what mathematicians do all day, or what they mean when they say a proof is elegant. Sometimes we joke that I just should sit him down and teach him everything, starting with $1 + 1 = 2$ and going as far as we can. ([Strogatz], “From Fish to Infinity”)

I found that when thinking about specific tactical decisions in my writing, this orientation—treating the reader as a friend—always suggested what to do. For instance, it nudged me to make the following choices:

- 1) Keep algebraic manipulations to a minimum. My artist friend panics when the math gets too symbolic. The same is true for most of the perplexed and the traumatized. They get turned off by equations and shut down emotionally. It’s much better, where possible, to recast the same mathematical idea pictorially.

- 2) Likewise, avoid sophisticated math symbols. Since most of the target readers won’t know how to pronounce them, they won’t be able to sound them out in their heads, which will tempt them to stop reading.

- 3) Don’t number the diagrams. That gives them a textbook feel, another turn off. And don’t automatically place them at the top or bottom of the page (contrary to what most publishers would do by default). Instead, insist that the diagrams be placed in the text, surrounded by the words they

illustrate. This is a friendly gesture; it saves the reader the trouble of hunting around for the diagram. In the same spirit, I asked my artist, Margy Nelson, to draw the diagrams in a cartoonish style. The hope was that the levity would refresh the reader when the going got tough.

Three Heroes

The strategies I’ve described here are all devices to help an outsider feel welcome. Three superb science writers—Richard Feynman, Stephen Jay Gould, and Lewis Thomas—approach this issue with exceptional flair. They take subjects that many readers would find forbidding—the edifice of modern physics, the vagaries of evolution, and the marvels of biology—and open the door for everyone.

Richard Feynman

What you notice first about Richard Feynman is his voice. He’s conversational, direct, and funny, always plain-spoken, but sometimes surprisingly lyrical. He comes across as a rascal; a playful, mischievous Brooklyn wise guy.

In his celebrated three-volume set of textbooks, *The Feynman Lectures on Physics*, here’s how he opens his chapter on the principle of least action, one of the deepest ideas in all of physics:

When I was in high school, my physics teacher—whose name was Mr. Bader—called me down one day after physics class and said, “You look bored; I want to tell you something interesting.” Then he told me something which I found absolutely fascinating, and have, since then, always found fascinating. Every time the subject comes up, I work on it. In fact, when I began to prepare this lecture I found myself making more analyses on the thing. Instead of worrying about the lecture, I got involved in a new problem. The subject is this—the principle of least action. ([Feynman], Volume II, page 19–1)

With his conversational style, he seems to be saying that physics is hard enough as it is—there’s no need to make it harder by using fancy language or by putting on the formal airs of a textbook writer.

And he revels in telling the truth, especially about what remains unknown. For example, in another chapter he prefaces a discussion of thunderstorms by stressing how little we know about this commonplace phenomenon:

What is going on inside a thunderstorm? We will describe this insofar as it is known. As we get into this marvelous phenomenon of real nature—instead of the idealized spheres

of perfect conductors inside of other spheres that we can solve so neatly—we discover that we don't know very much. Yet it is really quite exciting. Anyone who has been in a thunderstorm has enjoyed it, or has been frightened, or at least has had some emotion. And in those places in nature where we get an emotion, we find that there is generally a corresponding complexity and mystery about it. ([Feynman], Vol. II, page 9-5)

Any student reading this feels reassured. Not only is it okay not to know something, it's exciting, because that's where new science is made—on the border between the known and the unknown. Feynman, one of the greatest physicists of the twentieth century, takes you there as your personal tour guide.

I had Feynman in mind when I wrote about calculus for the *Times* series. Knowing that many readers would quake at the thought of calculus as the Mount Everest of math, I tried to disarm their fears without dismissing them, by casting my dad in the role of everyman, and by mimicking Feynman's affable style:

Long before I knew what calculus was, I sensed there was something special about it. My dad had spoken about it in reverential tones. He hadn't been able to go to college, being a child of the Depression, but somewhere along the line, maybe during his time in the South Pacific repairing B-24 bomber engines, he'd gotten a feel for what calculus could do. Imagine a mechanically controlled bank of anti-aircraft guns automatically firing at an incoming fighter plane. Calculus, he supposed, could be used to tell the guns where to aim.

Every year about a million American students take calculus. But far fewer really understand what the subject is about or could tell you why they were learning it. It's not their fault. There are so many techniques to master and so many new ideas to absorb that the overall framework is easy to miss.

Calculus is the mathematics of change. It describes everything from the spread of epidemics to the zigs and zags of a well-thrown curveball. The subject is gargantuan—and so are its textbooks. Many exceed 1,000 pages and work nicely as doorstops. ([Strogatz], "Change We Can Believe In")

But what I find most inspiring in Feynman's writing, and what I try to emulate in my own work, is his knack for delivering Aha! moments. His explanations, though phrased colloquially, are impeccable. They go straight to the heart of the matter. On almost any topic in any branch of physics, you will not find a more elegant and satisfying explanation than the one Feynman offers. He is the master of illumination.

Stephen Jay Gould

In contrast to Feynman, Stephen Jay Gould is the master of connections. Whereas Feynman lives and breathes for physics and physics alone, Gould links his subject, evolution, to the rest of existence in glorious detail. His essays range over science, history, philosophy, politics, architecture, and all parts of culture, high and low.

Two of his most famous essays draw on principles of evolutionary biology to explain why there are no longer any .400 hitters in baseball and why Mickey Mouse's facial features became progressively less rat-like and more adorably infantile (big eyes, big head, rounded features) over his first fifty years. In other pieces he explains why large animals have relatively thick leg bones, how insects walk up walls, why toddlers aren't hurt when they fall down, why medieval churches changed shape as they got larger, and how the creators of science fiction and horror movies embarrass themselves by overlooking these principles of size and scale when they depict giant ants or tiny people.

One of Gould's signature moves is to hook you with something light and unthreatening—a word, a story, a joke—to ease you into something sophisticated, the real subject of the piece. For instance, in his essay "Senseless signs of history" he introduces a subtle idea in evolutionary biology, that "oddities in current terms are the signs of history," by coming in from the side like so:

Words provide clues about their history when etymology does *not* match current meaning. Thus, we suspect that emoluments were once fees paid to the local miller (from the Latin *molere*, to grind), while disasters must have been blamed upon evil stars.

Evolutionists have always viewed linguistic change as a fertile field for meaningful analogies. Charles Darwin, advocating an evolutionary interpretation for such vestigial structures as the human appendix and the embryonic teeth of whalebone whales, wrote: "Rudimentary organs may be compared with the letters in a word, still retained in the spelling, but become useless in the pronunciation, but which serve as a

clue in seeking for its derivation.” Both organisms and languages evolve...

Darwin reasoned that, if organisms have a history, then ancestral stages should leave remnants behind. Remnants of the past that don’t make sense in present terms—the useless, the odd, the peculiar, the incongruous—are the signs of history. They supply proof that the world was not made in its present form. ([Gould], Chapter 2, pp. 27-29)

I tried a similar sideways approach in the opening paragraphs of my column about group theory:

My wife and I have different sleeping styles—and our mattress shows it. She hoards the pillows, thrashes around all night long, and barely dents the mattress, while I lie on my back, mummy-like, molding a cavernous depression into my side of the bed.

Bed manufacturers recommend flipping your mattress periodically, probably with people like me in mind. But what’s the best system? How exactly are you supposed to flip it to get the most even wear out of it?

Brian Hayes explores this problem in the title essay of his recent book, “Group Theory in the Bedroom.” Double entendres aside, the “group” in question here is a collection of mathematical actions—all the possible ways you could flip, rotate or overturn the mattress so that it still fits neatly on the bed frame.

By looking into mattress math in some detail, I hope to give you a feeling for group theory more generally. It’s one of the most versatile parts of mathematics. It underlies everything from the choreography of contra dancing and the fundamental laws of particle physics, to the mosaics of the Alhambra.... ([Strogatz], “Group Think”)

Unlike Feynman, however, Gould does not talk to you. He lectures at you. I never feel that he’s my friend, and I wouldn’t want to be stuck with him on a long car ride.

Lewis Thomas

My dream companion would be Lewis Thomas. He’s funny and sunny, the most amiable science writer I’ve ever read. It’s not that he doesn’t see the world as it is, warts and all. It’s that, for him, even the warts are wonderful:

Warts are wonderful structures. They can appear overnight on any part of the skin, like mushrooms on a damp lawn, full grown and splendid in the complexity of their architecture. Viewed in stained sections under a microscope, they are the most specialized of cellular arrangements, constructed as though for a purpose. They sit there like herded mounds of dense, impenetrable horn, impregnable, designed for defense against the world outside....

The strangest thing about warts is that they tend to go away. Fully grown, nothing in the body has so much the look of toughness and permanence as a wart, and yet, inexplicably and often very abruptly, they come to the end of their lives and vanish without a trace.

And they can be made to go away by something that can only be called thinking, or something like thinking. This is a special property of warts which is absolutely astonishing, more of a surprise than cloning or recombinant DNA or endorphin or acupuncture or anything else currently attracting attention in the press. It is one of the great mystifications of science: warts can be ordered off the skin by hypnotic suggestion. ([Thomas], “On Warts”, p. 61)

This is the delight of Lewis Thomas. He sees the universe in a grain of sand or, in his case, in a wart.

He’s also, for my money, the best stylist of all science writers. His sentences have a lilt and a rhythm and a snap to them. So do his words and his paragraphs. He’s graceful at every scale, from punctuation to paragraph. Read this passage out loud to hear what I mean:

The capacity to blunder slightly is the real marvel of DNA. Without this special attribute, we would still be anaerobic bacteria and there would be no music. Viewed individually, one by one, each of the mutations that have brought us along represents a random, totally spontaneous accident, but it is no accident at all that mutations occur; the molecule of DNA was ordained from the beginning to make small mistakes.

If we had been doing it, we would have found some way to correct this, and evolution would have been stopped in its tracks. Imagine the consternation of human scientists, successfully engaged in the letter-perfect replication

of prokaryotes, nonnucleated cells like bacteria, when nucleated cells suddenly turned up. Think of the agitated commissions assembled to explain the scandalous proliferation of trilobites all over the place, the mass firings, the withdrawal of tenure. ([Thomas], “The Wonderful Mistake”, p. 23)

I especially love his surprising juxtapositions. Sometimes they come in staccato bursts, like a prizefighter throwing a combination: “The capacity to blunder slightly is the real marvel of DNA. Without this special attribute, we would still be anaerobic bacteria and there would be no music.” Bang, bang, bang, boom!

I was hoping to achieve a similar effect, in muted form, in this opening to a piece about differential geometry:

The most familiar ideas of geometry were inspired by an ancient vision—a vision of the world as flat. From parallel lines that never meet, to the Pythagorean theorem discussed in last week’s column, these are eternal truths about an imaginary place, the two-dimensional landscape of plane geometry. ([Strogatz], “Think Globally”)

Saying something nice about flat-earth thinking and juxtaposing eternal truths and imaginary places was my attempt (pale as it may have been) to play with the reader’s expectations in the manner of Lewis Thomas.

Although Feynman, Gould, and Thomas use different tactics, it seems to me that they’ve all converged on the same secret, the key to communicating difficult technical subjects to the masses. Clear writing? Sure. Beautiful explanations? Of course. But none of that is enough.

The real secret is empathy. These heroes of science writing help us love the questions they’re asking. They do whatever it takes to make us feel at home in a strange land.

Epilogue

My *New York Times* series “The Elements of Math” debuted on January 31, 2010. The response from readers far surpassed what I could have dreamed of. For fifteen straight weeks, the columns attracted hundreds of comments and climbed the list of most emailed articles, occasionally reaching #1. Here are a few sample reactions to the first column:

- Thank you thank you thank you! I’ve been waiting for you all my adult life. I’ve always felt I am colour-blinded for math; perhaps this time around I’ll finally be able to make friends with it....

- We, the innumerate, thank you.

- Great! I am a math phobic, an artist, but very curious to learn again in a new way. I am excited!

- This is exciting! I’m an English teacher, but also a science enthusiast. I’ve always, however, been hobbled by my poor math skills. What a testament to the survival of intellect, that a column about mathematics could generate buzz and (at this writing) almost 500 positive and encouraging comments. I look forward to this. Thank you.

My favorite reaction, though, came from my neighbor Lauren, a photographer. She said that reading my series made her *want* to like math.

Not quite what I was shooting for, but hey, it’s a start.

Bibliography

[Feynman] RICHARD P. FEYNMAN, ROBERT B. LEIGHTON, and MATTHEW SANDS, *The Feynman Lectures on Physics*, Addison-Wesley, 1964.

[Gould] STEPHEN JAY GOULD, *The Panda’s Thumb: More Reflections in Natural History*, W.W. Norton & Company, 1980.

[Strogatz] STEVEN STROGATZ, The Elements of Math, *The New York Times*, 2010. Available online at http://topics.nytimes.com/top/opinion/series/steven_strogatz_on_the_elements_of_math/index.html and in slightly modified form in Steven Strogatz, *The Joy of x : A Guided Tour of Math, from One to Infinity*, Houghton Mifflin Harcourt, 2012.

[Thomas] LEWIS THOMAS, *The Medusa and the Snail: More Notes of a Biology Watcher*, Bantam Books, 1980.

How Well Are Secondary Mathematics Teacher Education Programs Aligned with the Recommendations Made in *MET II*?

*Jill Newton, Yukiko Maeda, Vivian Alexander,
and Sharon L. Senk*

Introduction

For many years the mathematics community has been concerned with how best to prepare school mathematics teachers [1], [2], [3]; the most recent set of recommendations for the mathematical preparation of teachers appeared in *The Mathematical Education of Teachers II* [*MET II*, 4]. As noted by Ferrini-Mundy and Graham [5], over the years questions have been raised, not just about the nature and extent of the mathematics courses required

Jill Newton is assistant professor of mathematics education at Purdue University. Her email address is jnewton@purdue.edu.

Yukiko Maeda is assistant professor of education psychology and research methods at Purdue University. Her email address is ymaeda@purdue.edu.

Vivian Alexander is a graduate research assistant at Purdue University. His email address is vaalexand@purdue.edu.

Sharon L. Senk is professor of mathematics and mathematics education at Michigan State University. Her email address is senk@msu.edu.

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

DOI: <http://dx.doi.org/10.1090/noti1089>

by teacher education programs, but also about the integration of mathematics and pedagogy, and who should have a voice in making decisions about the preparation of mathematics teachers.

Until recently, little research has been done that examined the requirements of mathematics teacher education programs or the effects of these requirements [6], [7]. In this article, we report results from a national survey of secondary mathematics teacher education programs. The survey investigated a number of questions related to the preparation of secondary mathematics teachers and several reports are in progress.¹ Specifically, we address the question: How do current secondary mathematics teacher education program course requirements align with the recommendations described in *MET II* [4]? In particular, we report on the extent to which current teacher education program course requirements are aligned with

¹*The Preparing to Teach Algebra Project is a three-year Collaborative Project at Michigan State University and Purdue University, funded through NSF's REESE program (MSU 1109256, Sharon L. Senk, PI; Purdue 1109239, Jill Newton, PI, Yukiko Maeda, Co-PI). Any opinions, findings, and conclusions or recommendations expressed in this article are those of the authors and do not necessarily reflect the views of the National Science Foundation.*

parts ii and iii of *MET II*'s Recommendation 2 (i.e., the course recommendations for middle and high school mathematics teachers).

Recommendation 2. Coursework that allows time to engage in reasoning, explaining, and making sense of the mathematics that prospective teachers will teach is needed to produce well-positioned beginning teachers. Although the quality of mathematical preparation is more important than the quantity, the following recommendations are made for the amount of mathematics coursework for prospective teachers...

ii. Prospective middle grades (5–8) teachers of mathematics should be required to complete at least twenty-four semester-hours of mathematics that include at least fifteen semester-hours on fundamental ideas of school mathematics appropriate for middle grades teachers.

iii. Prospective high school teachers of mathematics should be required to complete the equivalent of an undergraduate major in mathematics that includes three courses with a primary focus on high school mathematics from an advanced viewpoint. [4, pp. 17–18]

Procedures

In November 2012 we sent, via email, a survey link to contacts at 400 secondary school mathematics teacher education programs in the United States; the sample was stratified based on the institutions' Carnegie classification (i.e., Bachelor's, Master's, or Doctoral). In some institutions, contacts were in mathematics departments; at others, they were in departments or colleges of education.

Two questions from the survey asked about the type and size of the programs offered at the institution. One asked if the program(s) offered were middle grades only, high school only, or combined middle school and high school. Another asked which type of program (in cases where there were multiple programs) graduated the largest number of pre-service secondary mathematics teachers; detailed data were collected only for the institution's program graduating the largest number of pre-service teachers. The survey also asked questions about three categories of courses that are related to the *MET II* recommendations: (a) mathematics courses (e.g., Linear Algebra), (b) mathematics courses primarily designed for teachers (e.g., Algebra for Teachers), and (c) mathematics education courses (e.g., Teaching Middle School Mathematics). For each category, respondents were asked to select required courses from a given list, to name any additional courses in each category, and to state the total number of courses and credits for each course type. We received valid responses from one hundred thirty-one programs in forty-two states. These programs produced from one to fifty-one graduates per year during the last three years, with a mean of nine graduates and a median

of five graduates per year; seventy-five percent of the programs awarded a Bachelor's degree. Among eighty programs that provided responses to the questions about specific course requirements, two were middle grades only, sixteen were high school only, and sixty-two were combined middle and high school programs.

Results

Middle Grades Recommendations

For the analysis reported in this section, we used the data from sixty-four programs (two middle grades only and sixty-two combined middle and high school programs) to examine alignment with *MET II*'s recommendations for middle grades programs. All sixty-four programs that reportedly prepare middle grades only or middle and high school teachers together in their largest program met *MET II*'s recommendation of at least twenty-four required semester-hours of mathematics. On average these programs required thirty-six semester-hours of mathematics courses at the level of pre-calculus or higher.

Mathematics for teachers. None of the programs reported requiring *MET II*'s recommended fifteen semester-hours of courses designed for middle grades teachers. The maximum number of required credits reported by any program was twelve semester-hours (four programs) and the average number of required credits of this type was three. Most commonly required in this category were Geometry for Teachers (thirteen programs), Statistics and Probability for Teachers (four programs), Algebra for Teachers (three programs), and Capstone Course for Teachers (fifteen programs). *MET II* also recommended six semester-hours related to Number and Operations; however, such courses were almost nonexistent in the programs responding to our survey.

Additional mathematics courses. *MET II* called for at least nine semester-hours of other mathematics courses "carefully selected from mathematics or statistics department offerings that are both useful and accessible to undergraduates in the institution's middle-level teacher education program" (*MET II*, p. 47). All sixty-four programs met this requirement of nine additional credits of advanced mathematics. Specifically, *MET II* recommended that these other mathematics courses should be selected from among introductory statistics, calculus, number theory, discrete mathematics, history of mathematics, and modeling. Table 1 indicates the percentage of programs that required each of these courses. Most programs that prepare middle school teachers required them to take calculus, statistics, and discrete mathematics. However, few required them to take the other three courses recommended by *MET II*.

Middle grades methods courses. *MET II* recommended two middle grades-focused methods

Table 1. Mathematics Courses Recommended in MET II for Middle School Teachers that Are Required in Programs Preparing Middle Grades Teachers

Course	Number of Programs	Percentage of Programs ($n=64$)
Calculus	63	98%
Probability and Statistics	58	91%
Discrete Mathematics	45	70%
Number Theory	22	34%
History of Mathematics	12	19%
Mathematical Modeling	9	14%

courses for programs preparing middle grades mathematics teachers. Although the average number of mathematics methods courses per program was 1.8, only sixteen (twenty-five percent) of the programs required a course whose title indicated explicitly that it was for middle grades and no program reported requiring two such courses.

High School Recommendations

For the analysis reported in this section, we used the data from seventy-eight programs (sixteen high school only and sixty-two combined middle and high school programs) to examine alignment with *MET II*'s recommendations for high school programs.

Specific mathematics courses. *MET II* recommended three specific mathematics courses or sequences of courses for programs preparing high school mathematics teachers: (a) a three-course calculus sequence, (b) an introductory statistics course, and (3) an introductory linear algebra course. Of the seventy-eight programs that reportedly prepare high school teachers in their largest program, sixty-three (81 percent) required a three-course calculus sequence; the mean number of calculus courses across the programs was 2.8. Sixty-nine programs (88 percent) required at least one probability and/or statistics course; it is not possible to separate the statistics courses from

the probability courses given the combined course title offered for selection in the survey. Almost all programs ($n=76$, 97 percent) required students to take at least one linear algebra course.

Other advanced mathematics courses. *MET II* recommended eighteen additional semester-hours of advanced mathematics beyond the calculus, probability and statistics, and linear algebra courses, including three courses (nine semester hours) focused explicitly on high school mathematics from an advanced standpoint. All programs satisfied the additional eighteen-hour requirement for advanced mathematics. Table 2 summarizes the frequency (in decreasing order) of these courses, including any courses represented in at least five programs.

Several programs reported that they offered special sections of mathematics courses for teachers; most common was a section of geometry designed for teachers required by thirteen programs (17 percent). Other courses with special sections for teachers included linear algebra, abstract algebra, discrete mathematics, probability and statistics, and reasoning and proof. Only eight programs (10 percent) reported meeting the nine semester-hours of high school mathematics from an advanced perspective.

Table 2. Advanced Mathematics Courses Required in Programs Preparing High School Teachers

Course	Number of Programs	Percentage of Programs ($n=78$)
Geometry	70	90%
Abstract Algebra	61	78%
Discrete Mathematics	52	67%
Reasoning and Proof	47	60%
Mathematics Capstone Course	36	46%
Differential Equations	27	35%
Number Theory	24	31%
Real Analysis	23	29%
History of Mathematics	14	18%
Mathematical Modeling	12	15%

Mathematics methods courses. *MET II* recommended methods courses focused on instructional strategies for high school mathematics rather than generic instructional methods. Almost all programs ($n=74$, 95 percent) required at least one mathematics-specific methods course; the mean number of mathematics methods courses per program was 1.8.

Summary and Discussion

This study provides data from a national survey sample about course requirements in contemporary secondary mathematics teacher preparation programs. In general, teacher preparation programs for middle school and/or high school met the recommendations of the mathematics community described in *MET II* for the number of hours of mathematics required. However, programs that prepared teachers for middle grades did not typically require students to take the number theory, history of mathematics, or mathematical modeling courses suggested by *MET II*; and both the middle school and the high school preparation programs generally failed to meet the recommended number of courses and/or semester-hours for courses designed for teachers to study K–12 school mathematics from an advanced perspective.

The small number of programs meeting the recommendations for mathematics courses designed for teachers to study school mathematics from an advanced perspective is disappointing, given that the earlier version of *MET* [3], published more than a decade ago also called for such courses. If those involved in secondary mathematics teacher education programs are committed to the goal of assisting future mathematics teachers to better understand school mathematics, much more work needs to be done toward creating and staffing such courses. Several challenges likely prevent development in this area. First, programs preparing small numbers of secondary mathematics teachers each year are challenged to justify staffing courses, particularly sections to serve only pre-service teachers. Second, not enough information has been shared or research conducted about such courses in order to better understand their effect on future teachers' content knowledge and mathematical knowledge for teaching.

Although the data used for this analysis proved useful for the goals of the study, several limitations are worth mentioning. First, much of the data used in the middle grades and high school analyses were, in fact, the same data because sixty-two of the seventy-eight programs prepare both middle and high school teachers. In fact, only two of the sixty-four programs examined in the middle grades program analysis were “middle grades only” programs. Therefore, sixty-two “combined middle and high school” programs were analyzed through two distinct, but closely related, sets of *MET II*

recommendations. Given that a large percentage of secondary mathematics programs are preparing teachers to teach both middle and high school mathematics, it seems that special consideration must be given to the unique demands of teaching the mathematics topics required at different levels; these differences must be given attention during program design and course development. Second, we cannot make claims about middle grades teacher education programs, in general, from our data because many middle grades mathematics teachers are not graduating from secondary mathematics teacher education programs; rather, many of them are prepared in elementary education programs.

References

- [1] Committee on the Undergraduate Program in Mathematics, Panel on Teacher Training, (1971). Recommendations on course content for the training of teachers of mathematics, in *A compendium of CUPM recommendations: Studies discussions and recommendations by the Committee on the Undergraduate Program in Mathematics of the Mathematical Association of America*, (pp. 158–202), Washington, DC: Mathematical Association of America.
- [2] Committee on the Undergraduate Program in Mathematics, Panel on Teacher Training, (1983), *Recommendations on the mathematical preparation of teachers*, Washington, DC: Mathematical Association of America.
- [3] Conference Board of the Mathematical Sciences. (2001). *The Mathematical Education of Teachers*, Providence, RI, and Washington, DC: American Mathematical Society and Mathematical Association of America.
- [4] Conference Board of the Mathematical Sciences, (2012), *The Mathematical Education of Teachers II*, Providence, RI, and Washington, DC: American Mathematical Society and Mathematical Association of America.
- [5] J. Ferrini-Mundy and K. Graham, *The education of mathematics teachers in the United States in the decades following World War II: Goals, programs, and practices*, in J. Kilpatrick and G. Stanic (eds.), *History of Mathematics Education*, National Council of Teachers of Mathematics, 2002.
- [6] National Mathematics Advisory Panel, (2008), *Foundations for success: The final report of the national mathematics advisory panel*, Washington, DC: U.S. Department of Education.
- [7] National Research Council, (2010), *Preparing teachers: Building evidence for sound policy*, Washington, DC: National Academy Press.

Mathematics People

Guth Awarded 2013 Salem Prize

LAWRENCE GUTH of the Massachusetts Institute of Technology has been awarded the 2013 Salem Prize for his “major contributions to geometry and combinatorics. His brilliant insights led to the solution of old problems and the introduction of powerful new techniques,” according to the prize citation. The prize, in memory of Raphael Salem, is awarded yearly to young researchers for outstanding contributions to the field of analysis.

Previous winners of the Salem Prize include: N. Varopoulos, R. Hunt, Y. Meyer, C. Fefferman, T. Korner, E. M. Nikišin, H. Montgomery, W. Beckner, M. R. Herman, S. B. Bočkarëv, B. E. Dahlberg, G. Pisier, S. Pichorides, P. Jones, A. B. Aleksandrov, J. Bourgain, C. Kenig, T. Wolff, N. G. Makarov, G. David, J. L. Journé, A. L. Vol’berg, J.-C. Yoccoz, S. V. Konyagin, C. McMullen, M. Shishikura, S. Treil, K. Astala, H. Eliasson, M. Lacey, C. Thiele, T. Wooley, F. Nazarov, T. Tao, O. Schramm, S. Smirnov, X. Tolsa, E. Lindenstrauss, K. Soundararajan, B. Green, A. Avila, S. Petermichl, A. Venkatesh, B. Klartag, A. Naor, N. Anantharaman, D. Zhan, and J. Dubedat.

The prize committee consisted of J. Bourgain, C. Fefferman, P. Jones, N. Nikolski, G. Pisier, P. Sarnak, and J.-C. Yoccoz.

—*Salem Prize Committee announcement*

Kamran Awarded 2014 CRM-Fields-PIMS Prize

NIKY KAMRAN of McGill University has been awarded the CRM-Fields-PIMS Prize for 2014 for his work in analysis and differential geometry. His work is in the theory of exterior differential systems and Lie theory, a central area of the geometric analysis of systems of partial differential equations, and the mathematical analysis of general relativity. According to the prize citation, his work on exterior differential systems “has its roots in the foundational insight of E. Cartan, which describes local geometrical objects in terms of systems of differential forms which are invariant under diffeomorphisms and other infinite dimensional Lie (pseudo)group actions. Professor Kamran’s principal contributions have been in the theory of existence of solutions and the classification of infinite dimensional symmetries. His publications on isotropy subgroups of transitive analytic Lie pseudogroups of

infinite type are definitive, and involve global elements, such as the cohomology of certain differential complexes, and local, which for example include Malgrange’s estimates arising from his proof of the Cartan-Kähler theorem.”

The CRM-Fields-PIMS Prize recognizes exceptional achievement in the area of mathematical sciences. It is awarded by the Centre de Recherches Mathématiques (CRM), the Fields Institute, and the Pacific Institute for Mathematical Sciences (PIMS).

—*From a CRM announcement*

ICMI Klein and Freudenthal Medals Awarded

MICHÈLE ARTIGUE of Université Paris Diderot has been awarded the 2013 Felix Klein Medal of the International Commission on Mathematical Instruction (ICMI) “in recognition of her more than thirty years of sustained, consistent, and outstanding lifetime achievements in mathematics education research and development.” According to the prize citation, “she has been a leading figure in developing and strengthening new directions of research inquiry in areas as diverse as advanced mathematical thinking, the role of technological tools in the teaching and learning of mathematics, institutional considerations in the professional development of teachers, the articulation of didactical theory and methodology, and the networking of theoretical frameworks in mathematics education research.”

FREDERICK K. S. LEUNG of the University of Hong Kong has been awarded the 2013 Hans Freudenthal Medal of the ICMI “in recognition of his research in comparative studies of mathematics education and on the influence of culture on mathematics teaching and learning.” According to the prize citation, “his groundbreaking work, for which he is internationally known, is the utilization of the perspective of the Confucian Heritage Culture to explain the superior mathematics achievement of East Asian students in international studies.”

The Klein Medal honors lifetime achievement in mathematics education research. The Freudenthal Medal recognizes a major cumulative program of research.

—*From ICMI announcements*

Boyd Receives IEEE Control Systems Award

STEPHEN P. BOYD of Stanford University has been named the recipient of the 2013 Control Systems Award of the Institute of Electrical and Electronics Engineers (IEEE). According to the prize citation, “Stephen P. Boyd’s vision that convex optimization methods can transform the theory and practice of control system analysis and design has led to one of the most important developments in the field over the last twenty-five years. Working with other researchers, Boyd developed a new style of research in control that combines advanced mathematical concepts with effective numerical computation, using a formal reduction process of a control problem to a convex optimization problem. Convex optimization problems are readily and reliably solved numerically, so the reduction gives a theoretical and practical solution of the original problem. No one is considered to have done more to articulate, develop, systematize, advance, and popularize the role of convex optimization than Dr. Boyd. He has helped to develop many of the basic computational techniques, showed how to apply them to problems in systems and control, and illuminated the powerful connections to essential concepts in other disciplines, such as computational mathematics, statistics, machine learning, finance, circuit design, networking, and signal processing.”

—From an IEEE announcement

Fox and Yun Awarded 2013 Packard Fellowships

JACOB FOX of the Massachusetts Institute of Technology and ZHIWEI YUN of Stanford University have been awarded Packard Fellowships by the David and Lucile Packard Foundation, which provides young scientists early in their careers with flexible funding and the freedom to take risks and explore new frontiers in their fields of study. Fox works on developing powerful techniques to solve problems concerning large networks; his research is at the interface between combinatorics and computer science, geometry, analysis, and number theory. Yun’s research project focuses on the interaction between algebraic geometry, number theory, and representation theory of groups. He looks for ways to apply methods from one of these areas to solve problems in another. These problems are closely related to the conjectures of Langlands. They will receive grants of US\$875,000 each over five years to pursue their research.

—From a Packard Foundation announcement

2013 Rosenthal Prize Awarded

The 2013 Rosenthal Prize for Innovation in Math Teaching has been awarded to TRANG VU, a teacher at La Jolla

High School in La Jolla, California. BRENT FERGUSON, who teaches at the Lawrenceville School in Lawrenceville, New Jersey, was selected as runner-up. Trang was awarded a cash prize of US\$25,000, and Brent received a prize of US\$10,000. The annual Rosenthal Prize for Innovation in Math Teaching is designed to recognize and promote hands-on math teaching in the upper elementary and middle school classrooms.

—National Museum of Mathematics announcement

Prizes of the Math Society of Japan

The Mathematical Society of Japan (MSJ) has awarded the following prizes for 2013.

The 2013 Autumn Prize has been awarded to MASATO TSUJII of Kyosho University for his outstanding contributions to functional analytic methods in ergodic theory of differentiable dynamical systems. The Autumn Prize is awarded without age restriction to people who have made exceptional contributions in their fields of research.

The 2013 Analysis Prizes have been awarded to YOSHIHIRO TONEGAWA of Hokkaido University for the study of regularity theory for surface evolution equations, to YASUO WATATANI of Kyushu University for research on operator algebras from the multidirectional viewpoint and its applications, and to TOSHIRO WATANABE of the University of Aizu for profound studies of distributional properties of Lévy processes.

The 2013 Geometry Prizes have been awarded to TOSHITAKE KOHNO of the University of Tokyo for work in geometric representation theory for quantum groups and to KATSUTOSHI YAMANOI of the Tokyo Institute of Technology for the affirmative solution of the Gol’dberg-Mues conjecture.

The 2013 Takebe Katahiro Prizes have been awarded to BENOÎT COLLINS of Tohoku University for his work in free probability and its applications, to TAKEHIKO YASUDA of Osaka University for work in motivic integration and singularities, and to KENTARO NAGAO of Nagoya University for work in Donaldson-Thomas theory and cluster algebras. The prize is given to young researchers who have obtained outstanding results.

The 2013 Takebe Katahiro Prizes for Encouragement of Young Researchers have been awarded to the following: NAO HAMAMUKI of the University of Tokyo for work in analysis on Hamilton-Jacobi equations with its applications to crystal growth phenomena, to HIROMU TANAKA of Kyoto University for work in minimal model theory in positive characteristic, to HAJIME KANEKO of Nihon University for work in Diophantine approximation of algebraic numbers and a conjecture of Emile Borel, to YOH TANIMOTO of the University of Tokyo for work in operator algebraic methods in two-dimensional quantum field theory, to HISASHI KASUYA of Tokyo Institute of Technology for work in topology and geometry of solvmanifolds, and to Kenta Ozeki of the National Institute of Informatics and JST-ERATO for work in Hamiltonicity of graphs. The prize

is intended for young mathematicians who are deemed to have begun promising careers in research by obtaining significant results.

The Journal of the Mathematical Society of Japan Outstanding Paper Prizes for 2013 have been awarded to NOBUAKI YAGITA of the College of Education, Ibaraki University, for the paper “Chow rings of nonabelian p -groups of order p^3 ”, **64**, No. 2, 2012, pp. 507–531; and to GOPAL PRASAD of the University of Michigan and SAI-KEE YEUNG of Purdue University for their paper “Nonexistence of arithmetic fake compact Hermitian symmetric spaces of type other than A_n ($n \leq 4$)”, **64**, No. 3, 2012, pp. 683–731.

—From MSJ announcements

Rhodes Scholars Announced

The Rhodes Trust has named its scholars for 2014. Among them are three students who work in the mathematical sciences.

LINDSAY E. LEE of Oak Ridge, Tennessee, is a senior at the University of Tennessee, Knoxville, where she majors in mathematics and Spanish. She has done research at the National Institute of Mathematical and Biological Synthesis, at Vanderbilt Medical Center, and at the Oak Ridge National Laboratory. She has also served as the president of the Dean’s Student Advisory Council, as opinion columnist at the student newspaper, as a volunteer for the homeless, and in a children’s hospital. She has studied in Barcelona and Tokyo. Diagnosed with muscular dystrophy at age three, Lindsay is a passionate and highly successful advocate for disability issues locally, nationally, and globally. She plans to use her mathematical modeling expertise for analysis of successful health policy grounded in health care equality for all. Lindsay plans to do the M.Phil. in comparative social policy at Oxford.

JOHN MIKHAEL of Dallas, Texas, is a 2013 graduate of the Massachusetts Institute of Technology, where he majored in mathematics and where he is continuing his research in cognitive neuroscience. Of Lebanese as well as U.S. citizenship, his research focuses on the algorithms that underlie our ability to perform functions such as language and social perception. John has also worked as a tutor and lecturer in math, physics, and biology in summers in Syria and Lebanon and has been active as a peer health advocate and in interfaith relations. At Oxford, he plans to continue his research on the brain with a D.Phil. in neuroscience.

CALLA GLAVIN of Birmingham, Michigan, is a senior at the U. S. Military Academy, where she majors in mathematical sciences. Calla is Cadet Brigade Headquarters Company Commander, founding editor and editor-in-chief of the *Past in Review* student newspaper, and president of the society of women engineers. She is also goalkeeper for the army women’s lacrosse team and a Big Brother Big Sister mentor. As a student researcher at the disease biophysics group at Harvard University she has developed a mathematical model for a novel method of nanofiber formation for use in wound healing, and at the Los

Alamos National Laboratories she worked on algal bio-fuels. She intends to do the M.Sc. in applied statistics at Oxford.

—From a Rhodes Trust announcement

AAAS Fellows Chosen

The following mathematical scientists have been elected fellows of the Section on Mathematics of the American Association for the Advancement of Science (AAAS): STEVEN F. ASHBY, Pacific Northwest National Laboratory; CHRISTIAN BORGS, Microsoft Research; ROBERT P. LIPTON, Louisiana State University; DAVID C. MANDERSCHIED, The Ohio State University; QING NIE, University of California Irvine; PHILIP PROTTER, Columbia University; and SHMUEL WEINBERGER, University of Chicago.

—From an AAAS announcement

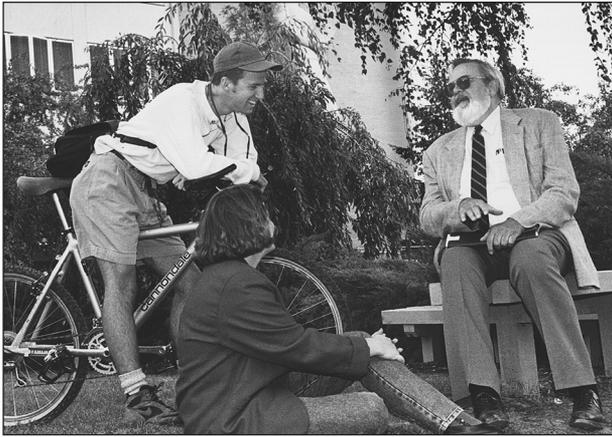
Donald W. Bushaw (1926–2012)

DONALD W. BUSHAW, a long-time faculty member at Washington State University, died in Portland, Oregon, on January 15, 2012. Born in Anacortes, Washington, on May 5, 1926, he attended Washington State as an undergraduate and went on to earn his Ph.D. at Princeton University in 1952, under the supervision of Solomon Lefschetz. He returned to Washington State where he remained, with the exception of a visiting appointment in 1972–73 at the Jagiellonian University in Krakow, for the remainder of his career. His dissertation appeared in the *Annals of Mathematics Studies*, no. 41, 1958, and has been cited as “the starting point of the modern development of optimal control theory.” Later Don returned to his roots in topology by writing a text, *Elements of General Topology* (Wiley, 1963), and after that he coauthored a text on mathematical economics. At Washington State he supervised seventeen Ph.D. dissertations.

Don was clearly a mathematician with broad mathematical interests, and his expertise outside mathematics was also astonishingly broad. He is reputed to have been fluent in French, German, Italian, Polish, Russian, and Chinese, but it didn’t stop there. Over a three-year period he visited Switzerland three times in order to learn Romansch, the least-used of that country’s four languages. And he regularly translated works from Chinese and Russian. Further, he actively collected materials in the Native-American languages in the Pacific Northwest, specifically Chinook in its various forms. He was also interested in modern poetry. This led one of his colleagues in WSU’s English Department to say that “if Don was not such a gentleman, we would have killed him a long time ago, because you always had the feeling he knew more about your area than you.”

A man of imposing presence, Don became an important figure on his campus: one-time chair of the Mathematics Department, on two occasions Acting Director

Photo courtesy of Washington State University News Service.



Donald Bushaw and students.

of Libraries at WSU, and Vice Provost for Instruction. He received various awards on his own campus as well as the MAA's Certificate of Meritorious Service in 1996. Between 1970 and 1973 he served on the MAA's national Board of Governors and on influential committees: the Committee on the Undergraduate Program in Mathematics (CUPM), which he chaired (1973-75), the CUPM Subcommittee on Quantitative Literacy (1989-95), and the AMS-MAA-SIAM Committee on Preparation for College Teaching. In addition, he was on the Board of Editors of the *College Mathematics Journal* for a record-breaking term—1984-99. Well known as a speaker and panelist for numerous sectional, regional, and national meetings of the AMS and the MAA,

he is also remembered for one of his more impressive appearances, an MAA meeting at Central Washington University in Ellensburg, WA, where, to an understandably small audience, he spoke only a few weeks after the eruption of nearby Mt. St. Helens in 1980. His topic was "Minimal complexities, maximal confusion, and mean people".

Bushaw's year in Krakow may have contributed to his strong interest in Polish mathematics—he was an honorary member of the Polish Mathematical Society—and, in particular, in the work of that wildly eccentric mathematician-philosopher-inventor-astronomer-lawyer, J. M. Hoene-Wroński, who inspired Bushaw to write a historical paper "Wroński's Canons of Logarithms" in *Mathematics Magazine* in 1983. Wroński's name is known to every student of elementary differential equations. Bushaw may have been drawn to him because both he and Wroński were polymaths. But the comparison ends there. Bushaw writes, in his colorful way, that Wroński was "brilliant, erudite, industrious, versatile, and ambitious," but also that he "had a difficult personality, and has been accused, not without plausibility, of arrogance, charlatanry, paranoia, and other blemishes of character. Thomas Muir [the scholar who named the Wrońskian for Wroński] called his style 'exhaustingly wearisome'." By contrast the words arrogance, charlatanry, and paranoia could never have applied to Don.

He is survived by his wife, Sylvia, and four children: Amy, Bruce, Gordon, and Margaret.

—Gerald L. Alexanderson and Kenneth A. Ross

Mathematics Opportunities

Call for Nominations for Prizes of the Academy of Sciences for the Developing World

The Academy of Sciences for the Developing World (TWAS) prizes are awarded to individual scientists in developing countries in recognition of outstanding contributions to knowledge in eight fields of science.

Eight awards are given each year in the fields of mathematics, medical sciences, biology, chemistry, physics, agricultural sciences, earth sciences, and engineering sciences. Each award consists of a prize of US\$15,000 and a plaque. Candidates for the awards must be scientists who have been working and living in a developing country for at least ten years.

The deadline for nominations for the 2014 prizes is **February 28, 2014**. Nomination forms should be sent to: TWAS Prizes, International Centre for Theoretical Physics (ICTP) Campus, Strada Costiera 11, 1-34151 Trieste, Italy; phone: 39 040 2240 387 fax: 39 040 2240 7387/7662;

email: prizes@twas.org. Further information is available on the World Wide Web at <http://www.twas.org/>.

—From a TWAS announcement

Call for Nominations for Graham Wright Award

The Canadian Mathematical Society (CMS) is seeking nominations for the 2014 Graham Wright Award for Distinguished Service. This award recognizes individuals who have made sustained and significant contributions to the Canadian mathematical community and, in particular, to the Canadian Mathematical Society. Nominations should include a reasonably detailed rationale and be submitted by **March 31, 2014**, to gwaward@cms.math.ca. For more information see the website <http://cms.math.ca/Prizes/dis-nom>.

—From a CMS announcement

Project NExT 2014–2015

Project NExT (New Experiences in Teaching) is a professional development program for new and recent Ph.D.'s in the mathematical sciences (including pure and applied mathematics, statistics, operations research, and mathematics education). It addresses all aspects of an academic career: improving the teaching and learning of mathematics, engaging in research and scholarship, and participating in professional activities. It also provides the participants with a network of peers and mentors as they assume these responsibilities. In 2014 about eighty faculty members from colleges and universities throughout the country will be selected to participate in a workshop preceding the Mathematical Association of America (MAA) summer meeting, in activities during the summer MAA meetings in 2014 and 2015 and the Joint Mathematics Meetings in January 2015, and in an electronic discussion network. Faculty for whom the 2014–2015 academic year

will be the first or second year of full-time teaching (post-Ph.D.) at the college or university level are invited to apply to become Project NExT Fellows.

Applications are invited for the 2014–2015 fellowship year, the twenty-first year of Project NExT. The deadline for applications is **April 11, 2014**. For more information, see the Project NExT website, <http://archives.math.utk.edu/projnext/> or contact Aparna Higgins, Director, at Aparna.Higgins@dayton.edu.

Project NExT is a program of the MAA. It receives major funding from the Mary P. Dolciani Halloran Foundation and additional funding from the Educational Advancement Foundation, the American Mathematical Society, the National Council of Teachers of Mathematics, the American Statistical Association, the American Institute of Mathematics, the Association for Symbolic Logic, W. H. Freeman Publishing Company, MAA Sections, and the Mathematical Association of America.

—Aparna Higgins, Director

For Your Information

Mathematics Awareness Month 2014: Mathematics, Magic, and Mystery

From magic squares and Möbius bands to magical card tricks and illusions, mysterious phenomena with elegant “Aha!” explanations have permeated mathematics for centuries. Such brain-teasing challenges promote creative and rational thinking, attract a wide range of people to the subject, and often inspire serious mathematical research.

The theme of Mathematics Awareness Month 2014, Mathematics, Magic, and Mystery, echoes the title of a 1956 book by renowned math popularizer Martin Gardner, whose extensive writings introduced the public to hexaflexagons, polyominoes, John Conway’s “Game of Life”, Penrose tiles, the Mandelbrot set, and much more. For more than half a century Gardner inspired enthusiasts of all ages to engage deeply with mathematics, and many of his readers chose to pursue it as a career. The year 2014 marks the centennial of Gardner’s birth.

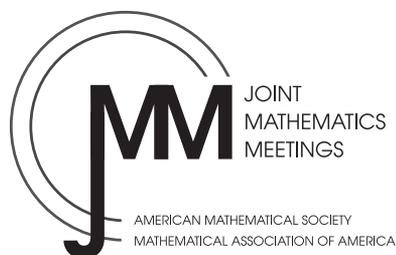
The Mathematics Awareness Month website will feature thirty magical and mysterious topics—a new one will be unveiled each day in April 2014. Contributors will include professional mathematicians and magicians of the highest caliber. Each topic will be introduced by a short video and will include supporting materials at various levels of mathematical sophistication. Mathematics departments at the secondary and college levels will find a month full of interesting activities to use in their programs.

Mathematics Awareness Month is sponsored each year by the Joint Policy Board for Mathematics (American Mathematical Society, American Statistical Society, Mathematical Association of America, and Society for Industrial and Applied Mathematics) to recognize the importance of mathematics through written materials and an accompanying poster which highlight mathematical developments and applications in a particular area.

—Joint Policy Board for Mathematics

Inside the AMS

From the AMS Public Awareness Office



Selected Highlights of the 2014 Joint Mathematics Meetings. See the JMM Blog for postings by Adriana Salerno, Tyler Clark, and Anna Haensch at <http://blogs.ams.org/jmm2014/>;

use hashtag #JMM14 on Twitter; see AMS Facebook, <https://www.facebook.com/amermathsoc>, and YouTube, <http://www.youtube.com/amermathsoc/>, for postings about sessions and events.

2014 National Who Wants to be a Mathematician. See results of the national contest held at JMM at <http://www.ams.org/wwtbam/jmm2014>.

AMS at the USA Science & Engineering Festival. The AMS will host a booth at the 2014 USASEF in Washington, DC, April 25–27. Susan Wildstrom will lead the curve stitching (“Pushing the Envelope”) activity for visitors of all ages. All are welcome to this free event to advance STEM education and inspire the next generation of scientists and engineers. <http://www.usasciencefestival.org/>.

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

Deaths of AMS Members

IRVING ADLER, of Bennington, Vermont, died on September 22, 2012. Born on April 27, 1913, he was a member of the Society for 52 years.

RAYMOND G. AYOUB, professor, Pennsylvania State University, died on January 5, 2013. Born on January 2, 1923, he was a member of the Society for 63 years.

FELICE D. BATEMAN, of Urbana, Illinois, died on February 4, 2013. Born on September 2, 1922, she was a member of the Society for 41 years.

EGBERT BRIESKORN, professor, University of Bonn, died on July 11, 2013. Born on July 7, 1936, he was a member of the Society for 49 years.

ROBERT WALLACE BROWN, of Tualatin, Oregon, died on November 26, 2013. Born on May 20, 1925, he was a member of the Society for 58 years.

THOMAS PATRICK CAHILL, of Brooklyn, New York, died on July 17, 2011. Born on April 4, 1945, he was a member of the Society for 37 years.

ALAN CANDIOTTI, professor, Drew University, died on August 19, 2013. Born on February 8, 1947, he was a member of the Society for 41 years.

CHONG-YUN CHAO, professor, University of Pittsburgh, died on August 26, 2011. Born on July 5, 1930, he was a member of the Society for 54 years.

GERALD P. DINNEEN, of Lexington, Massachusetts, died on May 30, 2012. Born on October 23, 1924, he was a member of the Society for 64 years.

JULIEN DOUCET, of Alexandria, Louisiana, died on January 8, 2012. Born on August 26, 1948, he was a member of the Society for 23 years.

MARC FONTAINE, of Houston, Texas, died on January 24, 2013. Born on March 27, 1926, he was a member of the Society for 58 years.

ABOLGHASSEM GHAFFARI, of Sherman Oaks, California, died on November 5, 2013. Born on June 15, 1907, he was a member of the Society for 62 years.

RICHARD P. GOSSELIN, of Amherst, Massachusetts, died on October 1, 2012. Born on June 29, 1921, he was a member of the Society for 60 years.

DENIS A. HIGGS, of Toronto, Canada, died on February 25, 2011. Born on May 6, 1932, he was a member of the Society for 41 years.

DANIEL M. KAN, of Newton Highlands, Massachusetts, died on August 4, 2013. Born on August 4, 1927, he was a member of the Society for 52 years.

JOHN E. KIMBER, of Pittsburg, California, died on January 18, 2013. Born on August 5, 1925, he was a member of the Society for 59 years.

WILLIAM W. KUHN, of Columbia, South Carolina, died on October 24, 2013. Born on July 22, 1938, he was a member of the Society for 47 years.

WILLIAM G. LEAVITT, of Lincoln, Nebraska, died on August 1, 2013. Born on March 9, 1916, he was a member of the Society for 73 years.

MORAY S. MACPHAIL, of Ontario, Canada, died on August 12, 2013. Born on May 27, 1912, he was a member of the Society for 74 years.

GEORGE DOUGLAS MATTHEWS, of Indianapolis, Indiana, died on July 20, 2013. Born on November 15, 1951, he was a member of the Society for 23 years.

TREVOR J. MCMINN, of Reno, Nevada, died on November 4, 2013. Born on January 23, 1921, he was a member of the Society for 58 years.

RAY MINES, professor, New Mexico State University, died on February 1, 2013. Born on July 22, 1938, he was a member of the Society for 49 years.

ZBIGNIEW OPALKA, of Harvard, Massachusetts, died on June 10, 2013. Born on June 10, 1954, he was a member of the Society for 7 years.

FREDRIC GRANT PETERSON, of Orem, Utah, died on August 15, 2013. Born on January 6, 1939, he was a member of the Society for 40 years.

MARY E. RUDIN, professor, University of Wisconsin, died on March 18, 2013. Born on December 7, 1924, she was a member of the Society for 64 years.

LELAND SAPIRO, of Huntington Beach, California, died on October 8, 2013. Born on April 14, 1924, he was a member of the Society for 24 years.

JOSEF SCHMID, of Vorarlberg, Austria, died on June 27, 2013. Born on May 31, 1925, he was a member of the Society for 56 years.

RICHARD G. SEGERS, of Mendham, New Jersey, died on April 30, 2013. Born on July 4, 1928, he was a member of the Society for 57 years.

MARIA W. STEINBERG, professor, University of California Los Angeles, died on July 7, 2013. Born on August 19, 1919, she was a member of the Society for 65 years.

LOUIS SUCHESTON, of Clearwater, Florida, died on June 5, 2013. Born on February 9, 1926, he was a member of the Society for 55 years.

JAMES E. WARD, of Brunswick, Maine, died on November 11, 2013. Born on September 20, 1939, he was a member of the Society for 47 years.

JAN C. WILLEMS, of Belgium, died on August 31, 2013. Born on September 18, 1939, he was a member of the Society for 13 years.

G. KENNETH WILLIAMS, of Franklin, Tennessee, died on July 11, 2013. Born on July 8, 1932, he was a member of the Society for 52 years.

Classified Advertisements

MARYLAND

JOHNS HOPKINS UNIVERSITY
Department of Applied Mathematics
and Statistics
Department of Mathematics
Bloomberg Distinguished Professor

Johns Hopkins University invites applications for a Bloomberg Distinguished Professorship in the area of the Mathematical Foundations of Data Intensive Computation and Inference. This position is one of 50 new Bloomberg Distinguished Professorships designated for outstanding scholars at the associate or full professor rank who carry out interdisciplinary research and teaching in areas identified for significant growth at the university. The position will include

joint tenure in the Department of Applied Mathematics and Statistics in the Whiting School of Engineering and the Department of Mathematics in the Krieger School of Arts and Sciences. The holder of this Bloomberg Distinguished Professorship will participate in the research and teaching activities of both departments and would devote 50% of his/her effort to each department. Applicants should possess distinguished records of achievement in research and teaching in areas of mathematics and statistics applicable to the representation and analysis of large data sets. Applicants should submit a cover letter, curriculum vitae and a list of publications to bdp.mathdata@jhu.edu. Review of applications will begin on February 28, 2014, and will

continue until the position is filled. Johns Hopkins University is committed to enhancing the diversity of its faculty and encourages applications from women and minorities. The Johns Hopkins University is an Affirmative Action/Equal Opportunity Employer.

000017

WISCONSIN

THE MILWAUKEE SCHOOL OF
ENGINEERING
Full-time Faculty
Mathematics Department

The Milwaukee School of Engineering invites applications for two full-time mathematics faculty positions

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 2014 rate is \$3.50 per word with a minimum two-line headline. 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: April 2014 issue-January 30, 2014; May 2014 issue-March 3, 2014; June/July 2014 issue-

April 29, 2014; August 2014 issue-May 29, 2014; September 2014 issue-June 30, 2014; October 2014 issue-July 29, 2014.

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 1373 (vol. 44).

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 classifieds@ams.org. AMS location for express delivery packages is 201 Charles Street, Providence, Rhode Island 02904. Advertisers will be billed upon publication.

starting in Fall 2014. The department has just launched programs in Actuarial Science and Operations Research, and we are looking for the candidates to have a strong background in one or both of these areas. Candidates should also be prepared to teach the standard mathematics courses in the first two years of the undergraduate curriculum. Candidates should possess an appropriate doctoral degree and related experience. Salary and rank will be commensurate with experience. An institution that also offers degrees in engineering, engineering technology, business, nursing, mathematics and technical communication, MSOE is located on the beautiful east side of downtown Milwaukee, just blocks from Lake Michigan and within easy walking distance of the city's highly acclaimed fine arts and entertainment venues. With approximately 2,400 full-time students, our campus maintains an intimate, small-town atmosphere. The review of candidates will begin immediately and continue until the positions are filled. To apply, please submit a file within the resumé section of the application which includes: 1) a detailed resumé; 2) a letter of interest; 3) evidence of successful teaching; and 4) three professional references. Please visit our website at: <http://www.msoe.edu/hr/> for additional information including requirements and the application process, or <http://www.milwaukeejobs.com/apply.asp?jid=5642529> to apply. MSOE is an Equal Opportunity/Affirmative Action Employer.

000016

NEW YORK

SAMPLING PUBLISHING Journal and Books

Sampling Theory in Signal and Image Processing, ISSN-6429- online, three issues a year, \$102.00 for institutions, \$54.00 for individuals. Contact: jerria12@yahoo.com.

Jerri books: *Intro to Integral Equations with Applications*, \$60.95; its *Student's Solutions Manual*, \$16.75; *Advances in the Gibbs Phenomenon*, \$60.75; *Intro To Wavelets*, \$60.75 plus S & H; its *Student's Solutions Manual*, with M. Kamada, \$16.75, plus S & H.

(\$10.00 in the U.S., \$15.00 abroad). No S & H for solutions manuals ordered with their books.

Contact: The Computer Guys, telephone 315-265-3866, or cguys@twcny.com, jerria12@yahoo.com.

000014

INDIA

TIFR- CENTRE FOR APPLICABLE MATHEMATICS Bangalore

TIFR-CAM is actively seeking applications from strong mathematics researchers. This Centre has a long tradition of research in Differential Equations and Analysis. In the past few years, the Centre has diversified its interests to include mathematical biology, stochastic analysis, differential geometry and ergodic theory, inverse problems and scientific computing. TIFR-CAM also runs a well-structured integrated Ph.D program that attracts bright students.

Positions available. Postdoctoral position; faculty position.

All positions compulsorily carry teaching responsibilities. Applicants should provide:

A letter of intent

A complete and up-to-date CV

A list of referees (at least three)

Applications and enquiries should be directed to jobs@math.tifrbng.res.in. For more details, see the webpage <http://math.tifrbng.res.in>.

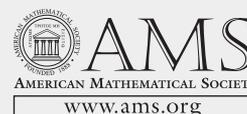
000015



Please make sure
that the *AMS Notices*
and *Bulletin* find their
new home.



- Email your new address to us: amsmem@ams.org
- or make the change yourself online at: www.ams.org/cml-update
- or send the information to:
Member and Customer Services:
American Mathematical Society
201 Charles Street
Providence, RI 02904-2294 USA
Phone: (800) 321-4267
(US & Canada)
(401) 455-4000 (Worldwide)



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 smf@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

February 28, 2014: Nominations for 2014 TWAS Prize. See "Mathematics Opportunities" in this issue.

February 28, 2014: Applications for Second Heidelberg Laureate Forum. See www.heidelberg-laureate-forum.org.

February 28, 2014: Applications for George Washington University Summer Program for Women in Mathematics (SPWM). Contact the director, Murli M. Gupta; email: mmg@gwu.edu; telephone: 202-994-4857; or visit the program's website at <http://www.gwu.edu/~spwm/>.

March 3, 2014: Applications for the EDGE for Women Summer Program. See the website <http://www.edgeforwomen.org/>.

March 10, 2014: Nominations for the second Stephen Smale Prize. See http://focm-society.org/smale_prize.php.

March 15, 2014: Nominations for PIMS Education Prize. See the website <http://www.pims.math.ca/pims-glance/prizes-awards>.

March 31, 2014: Nominations for 2014 Graham Wright Award for Distinguished Service of the Canadian Mathematical Society. See "Mathematics Opportunities" in this issue.

March 31, 2014: Nominations for Achievement in Information-Based Complexity Prize. Nominations may be sent to Joseph Traub, email: traub@cs.columbia.edu. See http://www.cs.columbia.edu/~traub/html/ibc_prize.html.

Where to Find It

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

AMS Bylaws—November 2013, p. 1358

AMS Email Addresses—February 2014, p. 199

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

AMS Officers 2012 and 2013 Updates—May 2013, p. 646

AMS Officers and Committee Members—October 2012, p. 1290

Contact Information for Mathematical Institutes—August 2013, p. 629

Conference Board of the Mathematical Sciences—September 2013, p. 1067

IMU Executive Committee—December 2011, p. 1606

Information for Notices Authors—June/July 2013, p. 776

National Science Board—January 2014, p. 82

NRC Board on Mathematical Sciences and Their Applications—March 2014, p. 305

NSF Mathematical and Physical Sciences Advisory Committee—February 2014, p. 202

Program Officers for Federal Funding Agencies—October 2013, p. 1188 (DoD, DoE); December 2012, p. 1585 (NSF Mathematics Education)

Program Officers for NSF Division of Mathematical Sciences—November 2013, p. 1352

March 31, 2014: Applications for AMS-Simons Travel Grants. See www.ams.org/programs/travel-grants/AMS-SimonsTG or contact Steven Ferrucci, email: ams-simons@ams.org; telephone: 800-321-4267, ext. 4113.

April 11, 2014: Applications for 2014–2015 Project NEXt Fellowships. See “Mathematics Opportunities” in this issue.

April 15, 2014: Applications for fall 2014 semester of Math in Moscow. See <http://www.mccme.ru/mathinmoscow> or contact: Math in Moscow, P.O. Box 524, Wynnwood, PA 19096; fax: +7095-291-65-01; email: mim@mccme.ru. Information and application forms for the AMS scholarships are available on the AMS website at <http://www.ams.org/programs/travel-grants/mimoscow> or contact: Math in Moscow Program, Membership and Programs Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294; email: student-serv@ams.org.

May 1, 2014: Applications for May review for National Academies Research Associateship Programs. See the website 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.

May 1, 2014: Applications for AWM Travel Grants and Mathematics Education Research Travel Grants. See <https://sites.google.com/site/awmmath/programs/travel-grants>; telephone: 703-934-0163; email: awm@awm-math.org; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

August 1, 2014: Applications for August review for National Academies Research Associateship Programs. See the website 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.

October 1, 2014: Applications for AWM Travel Grants and Mathematics Education Research Travel Grants. See <https://sites.google.com/site/awmmath/programs/travel-grants>; telephone: 703-934-0163; email: awm@awm-math.org; or contact Association for Women in Mathematics, 11240 Waples Mill Road, Suite 200, Fairfax, VA 22030.

November 1, 2014: Applications for November review for National Academies Research Associateship Programs. See the website 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.

Board on Mathematical Sciences and Their Applications, National Research Council

The Board on Mathematical Sciences and Their Applications (BMSA) was established in November 1984 to lead activities in the mathematical sciences at the National Research Council (NRC). The mission of BMSA is to support and promote the quality and health of the mathematical sciences and their benefits to the nation. Following are the current BMSA members.

Douglas N. Arnold, University of Minnesota

Gerald G. Brown, Naval Postgraduate School

L. Anthony Cox Jr., Cox Associates, Inc.

Constantine Gatsonis, Brown University

Mark L. Green, University of California Los Angeles

Darryll Hendricks, UBS Investment Bank

Bryna Kra, Northwestern University

Andrew W. Lo, Massachusetts Institute of Technology Sloan School of Management

David Maier, Portland State University

William A. Massey, Princeton University

Juan C. Meza, University of California Merced

John W. Morgan, Stony Brook University

Claudia Neuhauser, University of Minnesota

Fred S. Roberts, Rutgers University

Donald Saari, Chair, University of California Irvine

Carl P. Simon, University of Michigan

Katepalli Sreenivasan, New York University

Eva Tardos, Cornell University

The postal address for BMSA is: Board on Mathematical Sciences and Their Applications, National Academy of Sciences, Room K974, 500 Fifth Street, NW, Washington, DC 20001; telephone: 202-334-2421; fax: 202-334-2422; email: bms@nas.edu; website: http://sites.nationalacademies.org/DEPS/BMSA/DEPS_047709.

Book List

The Book List highlights recent books that have mathematical themes and are aimed at a broad audience potentially including mathematicians, students, and the general public. 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.

Algorithms Unlocked, by Thomas H. Cormen. MIT Press, March 2013. ISBN-13: 978-02625-188-02.

**Alan M. Turing: Centenary Edition*, by Sara Turing. Cambridge University Press, April 2012. ISBN-13: 978-11070-205-80.

**Alan Turing: His Work and Impact*, edited by S. Barry Cooper and J. van Leeuwen. Elsevier, May 2013. ISBN-13: 978-01238-698-07.

**Alan Turing: The Enigma, The Centenary Edition*, by Andrew Hodges. Princeton University Press, May 2012. ISBN-13: 978-06911-556-47.

An Accidental Statistician: The Life and Memories of George E. P. Box, by George E. P. Box. Wiley, April 2013. ISBN-13: 978-1-118-40088-3.

Assessing the Reliability of Complex Models: Mathematical and Statistical Foundations of Verification, Validation, and Uncertainty Quantification, by the National Research

Council. National Academies Press, 2012. ISBN-13: 978-0-309-25634-6.

A Cabinet of Mathematical Curiosities at Teachers College: David Eugene Smith's Collection, by Diane R. Murray. Docent Press, November 2013. ISBN-13: 978-0-9887449-1-2.

A Calculus of Ideas: A Mathematical Study of Human Thought, by Ulf Grenander. World Scientific, September 2012. ISBN-13: 978-98143-831-89. (Reviewed January 2014.)

Charles S. Peirce on the Logic of Number, by Paul Shields. Docent Press, October 2012. ISBN-13: 978-0-9837004-7-0.

Classic Problems of Probability, by Prakash Gorroochurn. Wiley, May 2012. ISBN-13: 978-1-1180-6325-5. (Reviewed November 2013.)

Computability: Turing, Gödel, Church, and Beyond, edited by B. Jack Copeland, Carl J. Posy, and Oron Shagrir. MIT Press, June 2013. ISBN-13: 978-02620-189-99.

Conflict in History, Measuring Symmetry, Thermodynamic Modeling and Other Work, by Dennis Glenn Collins. Author House, November 2011. ISBN-13: 978-1-4670-7641-8.

The Continuity Debate: Dedekind, Cantor, du Bois-Reymond, and Peirce on Continuity and Infinitesimals, by Benjamin Lee Buckley. Docent Press, December 2012. ISBN-13: 978-0-9837004-8-7.

The Crest of the Peacock: Non-European Roots of Mathematics, by George Gheverghese Joseph. Third edition. Princeton University Press, October 2010. ISBN-13: 978-0-691-13526-7. (Reviewed December 2013.)

Decoding the Heavens: A 2,000-Year-Old Computer—and the Century-Long Search to Discover Its Secrets, by Jo Marchant. Da Capo Press, February 2009. ISBN-13: 978-03068-174-27. (Reviewed June/July 2013.)

Do I Count?: Stories from Mathematics, by Günter Ziegler (translation of *Darf ich Zahlen?: Geschichte aus der Mathematik*, Piper Verlag, 2010). CRC Press/A K Peters, July 2013. ISBN-13: 978-1466564916

Figures of Thought: A Literary Appreciation of Maxwell's Treatise on Electricity and Magnetism, by Thomas K. Simpson. Green Lion Press, February 2006.

ISBN-13: 978-18880-093-16. (Reviewed October 2013.)

Fueling Innovation and Discovery: The Mathematical Sciences in the 21st Century, by the National Research Council. National Academies Press, 2012. ISBN-13: 978-0-309-25473-1.

Girls Get Curves: Geometry Takes Shape, by Danica McKellar. Plume, July 2013. ISBN-13: 978-04522-987-43.

The Gödelian Puzzle Book: Puzzles, Paradoxes and Proofs, by Raymond M. Smullyan. Dover Publications, August 2013. ISBN-13: 978-04864-970-51.

The Golden Ticket: P, NP, and the Search for the Impossible, by Lance Fortnow. Princeton University Press, March 2013. ISBN-13: 978-06911-564-91.

Good Math: A Geek's Guide to the Beauty of Numbers, Logic, and Computation, by Mark C. Chu-Carroll. Pragmatic Bookshelf, July 2013. ISBN-13: 978-19377-853-38.

Google's PageRank and Beyond: The Science of Search Engine Rankings, by Amy Langville and Carl Meyer. Princeton University Press, February 2012. ISBN-13: 978-06911-526-60.

Gösta Mittag-Leffler: A Man of Conviction, by Arild Stubhaug (translated by Tiina Nunnally). Springer, November 2010. ISBN-13: 978-36421-167-11. (Reviewed September 2013.)

Heavenly Mathematics: The Forgotten Art of Spherical Trigonometry, by Glen Van Brummelen. Princeton University Press, December 2012. ISBN-13: 978-06911-489-22.

How to Study As a Mathematics Major, by Lara Alcock. Oxford University Press, March 2013. ISBN-13: 978-0199661312.

Ibn al-Haytham's Theory of Conics, Geometrical Constructions and Practical Geometry, by Roshdi Rashed. Routledge, February 2013. ISBN-13: 978-0-415-58215-5.

If A, Then B: How the World Discovered Logic, by Michael Shenefelt and Heidi White. Columbia University Press, June 2013. ISBN-13: 978-02311-610-53.

Imagined Civilizations: China, the West, and Their First Encounter, by Roger Hart. Johns Hopkins University Press, July 2013. ISBN-13: 978-14214-060-60.

Invisible in the Storm: The Role of Mathematics in Understanding Weather, by Ian Roulstone and John Norbury. Princeton University Press, February 2013. ISBN-13: 978-06911-527-21. (Reviewed September 2013.)

Levels of Infinity: Selected Writings on Mathematics and Philosophy, by Hermann Weyl. Edited by Peter Pesic. Dover Publications, February 2013. ISBN-13: 978-0486489032.

The Logician and the Engineer: How George Boole and Claude Shannon Created the Information Age, by Paul J. Nahin. Princeton University Press, October 2012. ISBN-13: 978-06911-510-07. (Reviewed October 2013.)

Magnificent Mistakes in Mathematics, by Alfred S. Posamentier and Ingmar Lehmann. Prometheus Books, August 2013. ISBN-13: 978-16161-474-71.

Manifold Mirrors: The Crossing Paths of the Arts and Mathematics, by Felipe Cucker. Cambridge University Press, June 2013. ISBN-13: 978-05217-287-68.

The Math Book: From Pythagoras to the 57th Dimension, 250 Milestones in the History of Mathematics, by Clifford A. Pickover. Sterling, February, 2012. ISBN-13: 978-14027-882-91.

**Math in 100 Key Breakthroughs*, by Richard Elwes. Quercus, December 2013. ISBN-13: 978-16236-505-44.

**Math in Minutes: 200 Key Concepts Explained in an Instant*, by Paul Glendinning. Quercus, September 2013. ISBN-13: 978-16236-500-87.

Math Is Murder, by Robert C. Brigham. iUniverse, March, 2012. ISBN-13 978-14697-972-81.

Math on Trial: How Numbers Get Used and Abused in the Courtroom, by Leila Schneps and Coralie Colmez. Basic Books, March 2013. ISBN-13: 978-04650-329-21. (Reviewed August 2013.)

A Mathematician Comes of Age, by Steven G. Krantz. Mathematical Association of America, December 2011. ISBN-13: 978-08838-557-82.

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. (Reviewed April 2013.)

Mathematics in Nineteenth-Century America: The Bowditch

Generation, by Todd Timmons. Docent Press, July 2013. ISBN-13: 978-0-9887449-3-6.

Mathematics in Victorian Britain, by Raymond Flood, Adrian Rice, and Robin Wilson. Oxford University Press, October 2011. ISBN-13: 978-019-960139-4.

Mathematics under the Microscope: Notes on Cognitive Aspects of Mathematical Practice, by Alexandre V. Borovik. AMS, January 2010. ISBN-13: 978-0-8218-4761-9.

Maverick Genius: The Pioneering Odyssey of Freeman Dyson, by Phillip F. Schewe. Thomas Dunne Books, February 2013. ISBN-13: 978-03126-423-58.

Meaning in Mathematics, edited by John Polkinghorne. Oxford University Press, July 2011. ISBN-13: 978-01996-050-57. (Reviewed May 2013.)

My Brief History, by Stephen Hawking. Bantam Dell, September 2013. ISBN-13: 978-03455-352-83.

Naming Infinity: A True Story of Religious Mysticism and Mathematical Creativity, by Loren Graham and Jean-Michel Kantor. Belknap Press of Harvard University Press, March 2009. ISBN-13: 978-06740-329-34. (Reviewed January 2014.)

The New York Times Book of Mathematics: More Than 100 Years of Writing by the Numbers, edited by Gina Kolata. Sterling, June 2013. ISBN-13: 978-14027-932-26.

The Noether Theorems: Invariance and Conservation Laws in the Twentieth Century, by Yvette Kosmann-Schwarzbach. Springer, December 2010. ISBN-13: 978-03878-786-76. (Reviewed August 2013.)

Our Mathematical Universe: My Quest for the Ultimate Nature of Reality, by Max Tegmark. Knopf, January 2014. ISBN-13: 978-03075-998-03.

The Outer Limits of Reason: What Science, Mathematics, and Logic Cannot Tell Us, by Noson S. Yanofsky. MIT Press, August 2013. ISBN-13: 978-02620-193-54.

Peirce's Logic of Continuity: A Conceptual and Mathematical Approach, by Fernando Zalamea. Docent Press, December 2012. ISBN-13: 978-0-9837004-9-4.

Perfect Mechanics: Instrument Makers at the Royal Society of London in the Eighteenth Century, by Richard

Sorrenson. Docent Press, September 2013. ISBN-13: 978-0-9887449-2-9.

Probably Approximately Correct: Nature's Algorithms for Learning and Prospering in a Complex World, by Leslie Valiant. Basic Books, June 2013. ISBN-13: 978-04650-327-16.

Relations between Logic and Mathematics in the Work of Benjamin and Charles S. Peirce, by Allison Walsh. Docent Press, October 2012. ISBN-13: 978-0-9837004-6-3.

Seduced by Logic: Emilie Du Châtelet, Mary Somerville and the Newtonian Revolution, by Robyn Arianrhod. Oxford University Press, September 2012. ISBN-13: 978-01999-316-13. (Reviewed June/July 2013.)

The Simpsons and Their Mathematical Secrets, by Simon Singh. Bloomsbury, October 2013. ISBN: 978-14088-353-02.

Sources in the Development of Mathematics: Series and Products from the Fifteenth to the Twenty-first Century, by Ranjan Roy. Cambridge University Press, June 2011. ISBN-13: 978-05211-147-07. (Reviewed November 2013.)

Strange Attractors (comic book), by Charles Soule, Greg Scott, and Robert Saywitz. Archaia Entertainment, May 2013. ISBN-13: 978-19363-936-26.

Symmetry: A Very Short Introduction, by Ian Stewart. Oxford University Press, July 2013. ISBN-13: 978-01996-519-86.

A Tale of Two Fractals, by A. A. Kirillov. Birkhäuser, May 2013. ISBN-13: 978-08176-838-18.

Théorème vivant, by Cédric Villani (in French). Grasset et Fasquelle, August 2012. ISBN-13: 978-2246798828. (Reviewed February 2014.)

Thinking in Numbers: On Life, Love, Meaning, and Math, by Daniel Tammet. Little, Brown and Company, July 2013. ISBN-13: 978-03161-873-74.

Turbulent Times in Mathematics: The Life of J. C. Fields and the History of the Fields Medal, by Elaine McKinnon Riehm and Frances Hoffman. AMS, November 2011. ISBN-13: 978-0-8218-6914-7.

**Turing: Pioneer of the Information Age*, by Jack Copeland. Oxford

University Press, January 2013. ISBN-13: 978-01996-397-93.

Turing's Cathedral: The Origins of the Digital Universe, by George Dyson. Pantheon/Vintage, December 2012. ISBN-13: 978-14000-759-97.

**Undiluted Hocus-Pocus: The Autobiography of Martin Gardner*. Princeton University Press, September 2013. ISBN-13: 978-06911-599-11. (Reviewed in this issue.)

Visions of Infinity: The Great Mathematical Problems, by Ian Stewart. Basic Books, March 2013. ISBN-13: 978-04650-224-03.

William Fogg Osgood at Harvard: Agent of a Transformation of Mathematics in the United States, by Diann R. Porter. Docent Press, November 2013. ISBN-13: 978-0-9887449-4-3.

Leroy P. Steele Prizes

Call for Nominations

The selection committee for these prizes requests nominations for consideration for the 2015 awards. Further information about the prizes can be found in the November 2013 *Notices*, pp. 1372–1377 (also available at <http://www.ams.org/profession/prizes-awards/ams-prizes/steele-prize>).

Three Leroy P. Steele Prizes are awarded each year in the following categories: (1) the Steele Prize for Lifetime Achievement: 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) the Steele Prize for Mathematical Exposition: for a book or substantial survey or expository-research paper; and (3) the Steele Prize for Seminal Contribution to Research: 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 2015 the prize for Seminal Contribution to Research will be awarded for a paper in algebra.

Nomination with supporting information should be submitted to www.ams.org/profession/prizes-awards/nominations. Include a short description of the work that is the basis of the nomination, including complete bibliographic citations. A curriculum vitae should be included. Nominations for the Steele Prizes for Lifetime Achievement and for Mathematical Exposition will remain active and receive consideration for three consecutive years. Those who prefer to submit by regular mail may send nominations to the AMS Secretary, Carla Savage, Box 8206, Computer Science Department, North Carolina State University, Raleigh, NC 27695-8206. Those nominations will be forwarded by the secretary to the prize selection committee.

Deadline for nominations is March 31, 2014.



AMS

AMERICAN MATHEMATICAL SOCIETY

www.ams.org

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/>.

March 2014

* 1-2 **The Kent State Informal Analysis Seminar, featuring Svetlana Jitomirskaya (UC Irvine) and Nets Katz (Caltech)**, Kent State University, Kent, Ohio.

Description: The seminar follows the format of having two plenary speakers, each of whom deliver a four-hour lecture series designed to be accessible to graduate students. At this meeting, the lecture series will be given by Svetlana Jitomirskaya (UC Irvine), and Nets Katz (Caltech). The conference is supported by the NSF. Funding is available to cover the local expenses, and possibly travel expenses, of a limited number of participants. Graduate students, postdoctoral researchers, and members of underrepresented groups are particularly encouraged to apply for support.

Information: <http://www.math.kent.edu/informal>.

* 2-12 **XIV Winter Diffiety school. Polish edition**, Zakopane, Poland.

Description: Diffiety formalizes the concept of the solution space of a given system of (non-linear) PDEs — much like an algebraic variety does with respect to solutions of a given system of algebraic equations. The aim of this School is to introduce undergraduate and Ph.D. students in Mathematics and Physics (as well as post-doctoral researchers) into this recently emerged area of Mathematics and Theoretical Physics. Please note that this year the School will consist of two parts. First part will be held in Saint Petersburg (Russia) hosted by Lyceum 239. Approximate dates are February 1-6, 2014. The program is mostly targeted at persons new to Diffiety. Besides that there will be separate lectures for veterans. Second part will be held from March 2-12, 2014 in Poland.

Scientific Director: Professor A. M. Vinogradov.

Information: Visit <http://diffiety.org/xiv-winter-diffiety-school/>.

3-7 **AIM Workshop: Postcritically finite maps in complex and arithmetic dynamics**, American Institute of Mathematics, Palo Alto, California. (Sept. 2013, p. 1108)

* 3-7 **Forty-Fifth Southeastern International Conference on combinatorics, Graph Theory and Computing**, Florida Atlantic University, Boca Raton, Florida.

Description: Celebrating its 45th year, the Conference brings together mathematicians and others interested in combinatorics, graph theory and computing, and their interactions. The Conference lectures and contributed papers, as well as the opportunities for informal conversations, have proved to be of great interest to participants.

Lecturers: The 45th Conference will feature distinguished invited plenary lecturers: Noga Alon, Tel-Aviv; Maria Chudnovsky, Columbia; Charles Colbourn, ASU; Fan Chung Graham, UCSD; Ronald Lewis Graham, UCSD; Gary Mullen, Penn State; Scott Vanstone, Waterloo. There will be contributed papers, as well as invited special sessions of papers on: William T. Tutte, the man and some of his contributions (organized by Ronald Mullen); Structured Families of Graphs: mathematical and algorithmic aspects (Martin Charles Golumbic); Finite Fields (Gary Mullen).

Information: <http://math.fau.edu/cgctc/cgctc45/>.

4-7 **11th German Probability and Statistics Days 2014 - Ulmer Stochastik-Tage**, University Ulm, Ulm, Germany. (Sept. 2013, p. 1108)

5-7 **International Workshop on Discrete Structures (IWODS)**, Centre for Advanced Mathematics and Physics, National University of Sciences and Technology, H-12 Islamabad, Pakistan. (Oct. 2013, p. 1202)

8-9 **Ohio River Analysis Meeting 4**, University of Kentucky, Lexington, Kentucky 40506-0027

10-26 **School and Workshop on Classification and Regression Trees**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (May 2013, p. 655)

10-June 13 **Algebraic Techniques for Combinatorial and Computational Geometry**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Oct. 2013, p. 1202)

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/>.

- 11–14 **Algebraic Techniques for Combinatorial and Computational Geometry: Tutorials**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California.
- 12–14 **IAENG International Conference on Operations Research 2014**, Hong Kong, China. (Oct. 2013, p. 1202)
- 12–21 **School “Around Vortices: from Continuum to Quantum Mechanics”**, IMPA, Rio de Janeiro, Brazil.
- 13–15 **48th Annual Spring Topology and Dynamical Systems Conference**, University of Richmond, Richmond, Virginia.
- 13–15 **International Workshop “Advances in Nonlinear Analysis”**, Department of Mathematics, University of Pittsburgh, Pittsburgh, Pennsylvania.
- 14–28 **Representation Theory and Geometry of Reductive Groups**, Kloster Heiligkreuztal, a Monastery in Germany, Altheim, Germany. (Nov. 2013, p. 1397)
- 15–September 15 **Thematic Semester on Moduli Spaces in Rennes - Nantes - Angers - Brest in Spring/Summer 2014**, Universities of Rennes-Nantes-Brest-Angers and Ecole Normale Supérieure of Rennes, Rennes, Brittany, France.
- 17–21 **ICERM Workshop: Stochastic Graph Models**, ICERM, Providence, Rhode Island. (Sept. 2013, p. 1108)
- 20–22 **CONIAPS XVI (16th International Conference of International Academy of Physical Sciences)**, PDPM Indian Institute of Information Technology, Design & Manufacturing, Jabalpur, India.
- * 21–23 **Positive Characteristic Algebraic Geometry Workshop**, University of Illinois at Chicago (UIC), Chicago, Illinois.
Description: This workshop, aimed at graduate students and young postdocs, will expose participants to the use of Frobenius in the study of local singularities and global higher dimensional geometry in positive characteristic. We hope to incorporate a mix of introductory talks and problem sessions in groups, and will focus on presenting a number of open questions with sufficient background to be worked on both during and after the workshop.
Funding: The funding for this workshop comes from a National Science Foundation Research Training Grant (DMS 1246844). Limited funding for travel and lodging is available, to apply, simply indicate that funding is needed when submitting the registration form on this website.
Deadline: For consideration for funding is February 1, 2014. Women and minorities and members of underrepresented groups are especially encouraged to apply.
Information: <http://homepages.math.uic.edu/~kftucker/PosCharAGWorkshop/home.html>.
- 21–23 **Sectional Meeting**, University of Tennessee, Knoxville, Knoxville, Tennessee. (Sept. 2013, p. 1108)
- 24–25 **2nd Annual International Conference on Architecture and Civil Engineering (ACE 2014)**, Hotel Fort Canning, 11 Canning Walk, Singapore, Singapore 17881.
- * 24–25 **Bijjective and Algebraic Combinatorics: In honor of Bruce Sagan’s 60th birthday**, University of Florida, Gainesville, Florida.
Description: This will be a two-day conference scheduled to coincide with Bruce Sagan’s 60th birthday. There will be invited and contributed talks.
Information: <http://sites.google.com/site/saganfest2014/>.
- 24–28 **Combinatorial Geometry Problems at the Algebraic Interface**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Oct. 2013, p. 1202)
- 24–29 **Fractal Geometry and Stochastics V**, Hotel Am Burgholz, Tabarz (Thuringian Forest), Germany.
- 24–April 17 **Mathematical, Statistical and Computational Aspects of the New Science of Metagenomics**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Mar. 2013, p. 363)
- 28–30 **38th Annual SIAM Southeastern Atlantic Section (SEAS) Conference**, Florida Institute of Technology, Melbourne, Florida. (Nov. 2013, p. 1397)
- 29–30 **Sectional Meeting**, University of Maryland, Baltimore County, Baltimore, Maryland. (Sept. 2013, p. 1108)
- 31–April 3 **SIAM Conference on Uncertainty Quantification (UQ14)**, Hyatt Regency Savannah, Savannah, Georgia. (Dec. 2012, p. 1597)
- April 2014**
- 1–5 **Ischia Group Theory 2014**, Grand Hotel delle Terme Re Ferdinando, Ischia, Naples, Italy.
- 3–4 **13th New Mexico Analysis Seminar**, University of New Mexico, Albuquerque, New Mexico. (Nov. 2013, p. 1398)
- 4 **An Afternoon in Honor to Cora Sadosky**, University of New Mexico, Albuquerque, New Mexico. (Nov. 2013, p. 1398)
- 5 **2nd Annual Midwest Women in Mathematics Symposium**, University of Notre Dame, Notre Dame, Indiana.
- * 5–6 **Graduate Student Topology and Geometry Conference**, University of Texas at Austin, Austin, Texas.
Description: The 12th annual Graduate Student Topology and Geometry Conference is intended to expose graduate students to exciting research in geometry and topology, to provide an opportunity for graduate students to give talks on their research, and to bring graduate students together to meet each other and to talk to expert faculty members in these fields. Most of the talks at this conference are given by the graduate student participants, and are complemented by longer talks by distinguished plenary speakers and young faculty.
Information: <http://ma.utexas.edu/conferences/gstgc14/>.
- 5–6 **Sectional Meeting**, University of New Mexico, Albuquerque, New Mexico. (Sept. 2013, p. 1108)
- 7–11 **AIM Workshop: The many facets of the Maslov index**, American Institute of Mathematics, Palo Alto, California. (Sept. 2013, p. 1109)
- 7–11 **ICERM Workshop: Electrical Flows, Graph Laplacians, and Algorithms: Spectral Graph Theory and Beyond**, ICERM, Providence, Rhode Island. (Sept. 2013, p. 1109)
- 7–11 **Reimagining the Foundations of Algebraic Topology**, Mathematical Sciences Research Institute, Berkeley, California. (May 2013, p. 719)
- 7–11 **Tools from Algebraic Geometry**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Oct. 2013, p. 1202)
- 10–17 **Finsler geometry and applications to hyperbolic geometry and Teichmüller spaces**, Galatasaray University, Istanbul, Turkey.
- 11–13 **29th Geometry Festival**, Stony Brook University, Stony Brook, New York.
- 11–13 **Underrepresented Students in Topology and Algebra Research Symposium (USTARS)**, UC Berkeley, Berkeley, California.
- 11–13 **Sectional Meeting**, Texas Tech University, Lubbock, Texas. (Sept. 2013, p. 1109)
- * 12–15 **Applications of Automorphic Forms in Number Theory and Combinatorics**, Louisiana State University, Baton Rouge, Louisiana.
Description: This conference, which will focus on applications of automorphic forms to number theory and combinatorics, will be held in honor of the lifelong work of Wen-Ching Winnie Li, on the occasion

of her birthday. Distinguished speakers include Abel prize winners Jean-Pierre Serre and John Tate. From the synergy of a gathering of researchers with related interests but complimentary knowledge and skills, we expect advances in research programs for the participants, dissemination of important current work by experts to a broad audience, and professional development for junior researchers and graduate students.

Information: <http://www.math.lsu.edu/nt2014/>.

15–16 **3rd International Conference on E-Education & Learning Technologies (ICEELT 2014)**, Bangkok, Thailand.

15–16 **3rd International Conference on Information Integration and Computing Applications (ICIICA 2014)**, Bangkok, Thailand.

21–25 **Combinatorial representation theory**, Centre de recherches mathématiques, Université de Montréal, Pavillon André-Aisenstadt, Montréal (Québec), Canada.

22–May 16 **Advanced Monte Carlo Methods for Complex Inference Problems**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Mar. 2013, p. 364)

23–25 **International Arab Conference on Mathematics and Computations**, Zarqa University, Zarqa, Jordan.

25–27 **The Riviere-Fabes Symposium on Analysis and PDE**, University of Minnesota, Minneapolis, Minnesota.

28–May 2 **AIM Workshop: Exact crossing numbers**, American Institute of Mathematics, Palo Alto, California. (Oct. 2013, p. 1202)

* 28–29 **4th Annual International Conference on Operations Research and Statistics (ORS 2014)**, Phuket, Thailand.

Description: The goal of the Annual International Conference on Operations Research and Statistics is to provide a platform and opportunity for academics, researchers and professionals, and industry experts to share their knowledge.

Information: <http://www.orstat.org/>.

29–30 **2nd International Conference on Information, Communication and Computer Networks (ICICCN 2014)**, Kuala Lumpur, Malaysia.

29–30 **4th International Conference on E-Learning and Knowledge Management Technologies (ICEKMT 2014)**, Kuala Lumpur, Malaysia.

May 2014

1–30 **Self-normalized Asymptotic Theory in Probability, Statistics and Econometrics**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Nov. 2013, p. 1398)

2–4 **14th Chico Topology Conference**, California State University, Chico, Chico, California.

5–9 **AIM Workshop: Projective modules and A1-homotopy theory**, American Institute of Mathematics, Palo Alto, California. (Nov. 2013, p. 1398)

5–9 **Eigenvectors in Graph Theory and Related Problems in Numerical Linear Algebra**, Brown University, Providence, Rhode Island.

5–9 **The Kakeya problem, Restriction problem, and Sum-product Theory**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Oct. 2013, p. 1203)

8–12 **Hall and Cluster Algebras**, Centre de recherches mathématiques, Université de Montréal, Pavillon André-Aisenstadt, Montréal (Québec), Canada.

9–17 **Master-class: Around Thurston-Grothendieck-Teichmüller Theories**, University of Strasbourg, Strasbourg, France.

12–14 **SIAM Conference on Imaging Science (IS14)**, Hong Kong Baptist University, Hong Kong, China. (Aug. 2012, p. 1021)

12–16 **28th Automorphic Forms Workshop**, Moab, Utah. (Oct. 2013, p. 1203)

12–16 **ICERM Topical Workshop: Robust Discretization and Fast Solvers for Computable Multi-Physics Models**, ICERM, Providence, Rhode Island. (Sept. 2013, p. 1109)

12–16 **Model Theory in Geometry and Arithmetic**, Mathematical Sciences Research Institute, Berkeley, California. (June/July 2012, p. 870)

19 **Bers 100 celebration**, City University of New York, Graduate Center New York, New York. (Nov. 2013, p. 1398)

19–22 **SIAM Conference on Optimization (OP14)**, Town and Country Resort & Convention Center, San Diego, California. (Oct. 2013, p. 1203)

19–23 **Finding Algebraic Structures in Extremal Combinatorial Configurations**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Oct. 2013, p. 1203)

19–23 **Lie Theory and Mathematical Physics**, Centre de recherches mathématiques, Université de Montréal, Pavillon André-Aisenstadt, Montréal (Québec), Canada.

19–23 **Polynomials over Finite Fields: Functional and Algebraic Properties**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain.

19–23 **Representations of reductive groups: A conference dedicated to David Vogan on his 60th birthday**, MIT, Cambridge, Massachusetts. (Sept. 2013, p. 1109)

20–22 **Sixth Iberoamerican congress on geometry**, City University of New York, Graduate Center New York, New York. (Nov. 2013, p. 1398)

20–23 **XXI International Seminar NONLINEAR PHENOMENA IN COMPLEX SYSTEMS (Chaos, Fractals, Phase Transitions, Self-organization)**, Joint Institute for Power and Nuclear Research: “Sosny”, Minsk, Belarus, Russia.

20–24 **7th Conference on Function Spaces**, Southern Illinois University, Edwardsville, Illinois.

21–24 **Progress on Difference Equations**, Izmir University of Economics, Department of Mathematics, Izmir, Turkey.

22–25 **13th Serbian Mathematical Congress**, Vrnjacka Banja, Serbia. (Oct. 2013, p. 1203)

23–25 **Non-Associative & Non-Commutative Algebra and Operator Theory. Dakar’s Workshop in Honor of Professor Amin Kaidi**, University Cheikh Anta Diop, Dakar, Senegal.

23–June 1 **GEAR Junior Retreat**, University of Michigan, Ann Arbor, Michigan.

25–28 **XVIII Geometrical Seminar**, Vrnjačka Banja, Serbia. (Oct. 2013, p. 1203)

26–29 **VI Workshop on Dynamical Systems: On the occasion of Marco Antonio Teixeira’s 70th birthday (MAT70)**, Campinas, SP, Brazil. (Sept. 2013, p. 1109)

26–30 **Constructive Functions 2014**, Vanderbilt University, Nashville, Tennessee. (May 2013, p. 655)

26–June 20 **Teichmüller theory and surfaces in 3-manifolds (Intensive Research Period)**, Centro di Ricerca Matematica “Ennio De Giorgi”, Piazza dei Cavalieri 7, 56100 Pisa, Italy.

* 27–30 **International Conference and Workshop on Mathematical Analysis 2014**, University Putra Malaysia, Serdang, Selangor, Malaysia.

Description: The main goal of this conference is to bring together experts and young talented scientists from all over the world to discuss the modern and recent aspects of mathematical analysis. It is also

to ensure exchange of ideas in various applications of Mathematics in Engineering, Physics, Economics, Biology, etc. The invited talks and the presented papers will be published after peer reviewing by the Institute for Mathematical Research (INSPEM) of Universiti Putra Malaysia. This conference will encourage international collaboration and interactive activities on the modern problems of mathematical analysis. It also provides an opportunity for young researchers to learn the current state of the researchers in the related fields. We welcome researchers from both theoretical and applied mathematics to attend this conference and to use this excellent possibility to exchange ideas with the leading scientists.

Information: <http://einspem.upm.edu.my/icwoma2014>.

27-30 **International Conference on Nonlinear Differential and Difference Equations: Recent Developments and Applications**, Side, Antalya, Turkey. (Nov. 2013, p. 1398)

28-30 **IWCIA 2014 - 16th International Workshop on Combinatorial Image Analysis**, Brno University of Technology, Technická 2, Brno, Czech Republic. (Sept. 2013, p. 1110)

28-30 **Recent Trends in Nonlinear Partial Differential Equations and Applications**, University of Trieste, Trieste, Italy.

29-31 **Computational Management Science 2014 - CMS 2014**, Faculty of Sciences, University of Lisbon, Lisbon, Portugal.

June 2014

2-5 **WSCG 2014 - 22nd International Conference on Computer Graphics, Visualization and Computer Vision 2014**, Primavera Hotel and Congress Centrum, Plzen (close to Prague), Czech Republic.

* 2-6 **AIM Workshop: Descriptive inner model theory**, American Institute of Mathematics, Palo Alto, California.

Description: This workshop, sponsored by AIM and the NSF, will be devoted to inner model theory and descriptive set theory.

Information: <http://aimath.org/workshops/upcoming/innermodel/>.

2-6 **Computational Nonlinear Algebra**, Institute for Computational and Experimental Research in Mathematics, (ICERM), Brown University, Providence, Rhode Island. (Nov. 2013, p. 1398)

2-6 **Conference on Ulam's type stability**, Rytro, Poland.

2-6 **Discrete Groups and Geometric Structures, with Applications V**, KU Leuven, Arenberg Castle, Heverlee (nearby Leuven), Belgium.

2-6 **Hamiltonian Systems and Celestial Mechanics (HAMSYS 2014)**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain.

* 2-21 **Joint ICTP - TWAS School on Coherent State Transforms, Time-Frequency and Time-Scale Analysis, Applications**, The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy.

Description: The topics of this school are coherent states, wavelets and their applications (signal/image processing via Gabor and wavelet analysis, inverse problems, approximation theory), plus necessary concepts of functional analysis and group theory. Coherent states and wavelets are two topics that have undergone a tremendous development in the last years, it is an extremely active domain. They have applications in a huge number of domains of physics, mathematics and engineering. This school, that will present many of the topflight experts in the field, will enable young scientists to catch on that fascinating topic and obtain a knowledge suitable for performing top level research. We plan to go from the basic aspects to up-to-date developments and also to cover some of the most exciting applications, such as inverse problems, analysis of geophysical, astronomical or biological (genome) signals.

Information: <http://agenda.ictp.it/smr.php?2585>.

3-6 **Moduli - Operads - Dynamics II**, Tallinn University of Technology, Tallinn, Estonia. (Oct. 2013, p. 1203)

* 4-14 **School in Dynamical Systems and Ergodic Theory**, Cheikh Anta Diop University, Dakar, Senegal and African Institute for Mathematical Sciences, Mbour, Senegal.

Description: The fields of Dynamical Systems and Ergodic Theory constitute very active areas of research with connections to many other areas of mathematics, such as topology, differential geometry, control theory, functional analysis and probability theory. They also have strong connections to several areas of mathematical physics and other disciplines such as biology and engineering. This school will be an introduction to some current topics in the modern theory of Dynamical Systems and Ergodic Theory, and is aimed primarily at students at the Master's level. Specific background in Dynamics or Ergodic Theory is preferred but not required, whereas a very strong general mathematical background and maturity is essential. The places at the school are very limited and the selection will be competitive.

Information: <http://agenda.ictp.it/smr.php?2622>.

5-7 **Number Theory at Illinois: A Conference in Honor of the Batemans**, University of Illinois, Urbana, Illinois.

* 7-10 **7th Chaotic Modeling and Simulation International Conference (CHAOS2014)**, Lisbon, Portugal.

Description: The forthcoming International Conference (CHAOS2014) on Chaotic Modeling, Simulation and Applications will take place in VIP Executive Zuriq Hotel, Lisbon, Portugal.

Topics: The general topics and the special sessions proposed for the conference include but are not limited to: Chaos and nonlinear dynamics, stochastic chaos, chemical chaos, data analysis and chaos, hydrodynamics, turbulence and plasmas, optics and chaos, chaotic oscillations and circuits, chaos in climate dynamics, geophysical flows, biology and chaos, neurophysiology and chaos, hamiltonian systems, chaos in astronomy and astrophysics, chaos and solitons, micro- and nano- electro-mechanical systems, neural networks and chaos, ecology and economy.

Information: For more information and Abstract/Paper submission and Special Session Proposals please visit the conference website at: <http://www.cmsim.org> or send email to the Conference Secretariat at: secretariat@cmsim.org.

9-13 **AIM Workshop: The Cauchy-Riemann equations in several variables**, American Institute of Mathematics, Palo Alto, California. (Sept. 2013, p. 1110)

9-13 **Categorification and Geometric Representation Theory**, Centre de recherches mathématiques, Université de Montréal, Pavillon André-Aisenstadt, Montréal (Québec), Canada.

9-13 **String Math 2014**, University of Alberta, Edmonton, Alberta, Canada. (Sept. 2013, p. 1110)

9-13 **Tenth edition of the Advanced Course in Operator Theory and Complex Analysis**, Sevilla, Spain. (Sept. 2013, p. 1110)

9-14 **Representations, Dynamics, Combinatorics: In the Limit and Beyond. A conference in honor of Anatoly Vershik's 80th birthday**, Saint-Petersburg, Russia.

9-15 **School on Nonlinear Analysis, Function Spaces and Applications 10**, Trest, Czech Republic.

9-July 4 **Interactions between Dynamics of Group Actions and Number Theory**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Sept. 2013, p. 1110)

10-13 **Geometry of Banach Spaces - A conference in honor of Stanimir Troyanski**, Albacete, Spain. (Nov. 2013, p. 1398)

12-14 **Riemann, topology and physics**, Institut de Recherche Mathématique Avancée, University of Strasbourg, Strasbourg, France. (Oct. 2013, p. 1203)

- * 14–15 **Matm2014–Methodological Aspects of Teaching Mathematics**, Faculty of Education in Jagodina, University of Kragujevac, Serbia.
Aim: The general aim of the Conference is to contribute to the development, promotion and improvement of teaching mathematics in primary school, as well as to the development of teacher competencies necessary for modern primary education.
Suggested Thematic Areas: New developments, trends and researches in mathematics education; Multidisciplinary approach in methodology and teaching mathematics; Information technologies in teaching and learning mathematics; History of mathematics and mathematics education; Pedagogical and psychological aspects of teaching mathematics.
Forms: Details and application form can be downloaded at <http://matm2014.blogspot.com/>.
Language: Official languages of the Conference are Serbian and English.
Deadlines: Application deadline is March 15th, 2014. Full papers deadline is September 15th, 2014.
Information: <http://matm2014.blogspot.com/>.
- 15–20 **4th European Seminar on Computing (ESCO 2014)**, Pilsen, Czech Republic. (Nov. 2013, p. 1398)
- 16–19 **8th Annual International Conference on Mathematics & Computer Science**, Athens, Greece. (Oct. 2013, p. 1204)
- 16–20 **Conference on stochastic processes and high dimensional probability distributions**, Euler International Mathematical Institute of the Russian Academy of Sciences, Saint Petersburg, Russia.
- * 16–20 **Strathmore University International School on Spatial Modelling (ISSM-2014)**, Strathmore University, Nairobi, Kenya.
Description: CARMS will be holding a series of international schools on statistical modelling (ISSM). Each such school will deal with a contemporary theme. ISSM-2014 is the first in this series and is a 5-day school on spatial modelling motivated by and grounded in contemporary problems in biology and environmental sciences. The course targets the following categories of participants: Ph.D. students, recent Ph.D. graduates, practitioners who need to apply the statistical methods in their practice.
Information: <http://www.strathmore.edu/carms>.
- * 16–27 **Fifth International Conference and School Geometry, Dynamics, Integrable Systems–GDIS 2014: Bicentennial of The Great Poncelet Theorem and Billiard Dynamics**, The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy.
Description: The main aim of the school is to introduce young participants into these exciting topics and prepare them for the week-long conference to follow the school. The first week of the activity is devoted to a school that will give an overview of recent developments and interrelations between geometry and dynamical systems, with a special focus on mathematical billiards and integrable systems. The school will provide a background in algebraic geometry, theory of measured foliations and flat surfaces, the discrete integrable systems, 2-2 correspondences, the QRT maps, and the mechanical background of the billiard systems. The second week will be an international conference, where leading experts will report on the newest developments in the field of integrable dynamical systems and their geometry. The event will mark the bicentennial of the great Poncelet theorem.
Information: <http://agenda.ictp.it/smr.php?2586>.
- 16–27 **Summer Graduate School: Dispersive Partial Differential Equations**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2013, p. 1399)
- 17–20 **First International Congress on Actuarial Science and Quantitative Finance**, Universidad Nacional de Colombia, Bogota, Colombia.
- * 18–20 **XIV Encuentro de Algebra Computacional y Aplicaciones EACA 2014**, Barcelona, Spain.
Description: The “Encuentros de Álgebra Computacional y Aplicaciones, EACA” (Meetings on Computer Algebra and Applications) are organized by the Spanish Red Temática de Cálculo Simbólico, Álgebra Computacional y Aplicaciones to provide a meeting frame for researchers in the fields of Computer Algebra and Symbolic Computation, and for those who use these techniques in their research. We emphasize and specially favor the participation of young researchers.
Topics: Effective methods in algebra, analysis, geometry and topology algorithmic complexity scientific computation by means of symbolic-numerical methods symbolic-numeric software development analysis, specification, design and implementation of symbolic computation systems applications to science and technology.
Information: <http://www.ub.edu/eaca2014/>.
- 18–27 **Summer school on the Gan-Gross-Prasad conjectures**, Institut de Mathématiques de Jussieu - Paris, Rive Gauche 4, place Jussieu, Paris, France.
- 21–August 3 **MSRI-UP 2014: Arithmetic Aspects of Elementary Functions**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2013, p. 1399)
- 22–29 **The 52nd International Symposium on Functional Equations**, Innsbruck, Austria.
- 23–25 **17th Conference on Integer Programming and Combinatorial Optimization (IPCO 2014)**, University of Bonn, Bonn, Germany. (Sept. 2013, p. 1110)
- 23–27 **Boltzmann, Vlasov and related equations: Last results and open problems**, University of Cartagena, Cartagena, Colombia. (Nov. 2013, p. 1399)
- 23–27 **Microlocal analysis and applications**, Université de Nice Sophia Antipolis, Nice, France.
- 23–27 **What Next? The mathematical legacy of Bill Thurston**, Cornell University, Ithaca, New York. (Sept. 2013, p. 1110)
- 23–28 **6th International Conference on Advanced Computational Methods in Engineering**, NH Gent Belfort, Gent, Belgium. (Sept. 2013, p. 1110)
- 24–27 **Mathematics Meets Physics**, University of Helsinki, Finland.
- 26–July 1 **Sixth International Conference for Promoting the Application of Mathematics in Technical and Natural Sciences (AMITaNS’14)**, Black-Sea resort, Albena, Bulgaria.
- 29–July 3 **26th International Conference on Formal Power Series and Algebraic Combinatorics (FPSAC)**, DePaul University, Chicago, Illinois. (Sept. 2013, p. 1110)
- 30–July 3 **8th Annual International Conference on Statistics**, The Mathematics & Statistics Research Unit (ATINER), Athens Institute for Education and Research, Athens, Greece.
- 30–July 5 **25th International Conference in Operator Theory**, West University of Timisoara, Timisoara, Romania.
- * 30–July 6 **16th Baikal International Triannual School-Seminar “Methods of Optimization and Their Applications”**, Baikov Ostrog, Olkhon island, Lake Baikal, Russia.
Description: The conference is organized by the Institute of Energy Systems, Russian Academy of Sciences (<http://www.sei.irk.ru>) jointly with Irkutsk State University (<http://www.isu.ru>). The conference is a forum of researchers working on all areas of optimization from the linear programming to the optimal control and applications, incl. inverse problems, machine learning. The program will be also interesting for practitioners who want to increase the efficiency of their business with applications of optimization models.

The organizers are looking forward to see you in Baikal region with its beautiful nature and with admirable lake and mounting views.

Location: Baikalov Ostrog hotel located on the Olkhon island, Lake Baikal, Eastern Siberia.

Information: <http://sei.irk.ru/conferences/mopt2014/en/index.html>.

* 30–July 25 **Clay Mathematics Institute Summer School 2014 Periods and Motives: Feynman amplitudes in the 21st century**, ICMAT, Instituto de Ciencias matemáticas, Madrid, Spain.

Description: This summer school will consist of three weeks of lecture courses supplemented by exercise and problem sessions. The aim of these courses is to provide a pedagogical introduction to the field as well as introducing advanced tools and techniques necessary to play an active role in current research. The courses of the fourth week of this school aim at a higher level. In five mini-courses experts will present topics of great future promise as well as outline some open problems under current investigation.

Information: <http://www.icmat.es/summerschool2014/>.

July 2014

* 1–6 **Random Matrix Theory: Foundations and Applications**, Jagiellonian University, Krakw, Poland.

Description: The conference is a continuation of the “Cracow Matrix sequel”: 2005 - Applications of Random Matrices to Economy and other Complex Systems 2007 - Random Matrix Theory: From fundamental Physics to Applications 2010 - Random Matrices, Statistical Physics and Information Theory. Traditionally, the aim of the conference is to get together mathematicians, physicists, statisticians and other practitioners of random matrix theory, in order to promote recent results and to establish interdisciplinary links for applications. **Early list of Invited Speakers:** Gernot Akemann, Jinho Baik, Jean-Paul Blaizot, Arup Bose, Yang Chen, Merouane Debbah, Thomas Guhr, Eugene Kanzieper, Satya Majumdar, Jamal Najim*, Alexandru Nica, Raj Rao Nadakuditi*, Gregory Schehr, Alexander Soshnikov, Roland Speicher, Jac Verbaarschot*, Pierpaolo Vivo, Jiun-Chau Wang, Konstantin Zarembo, Jean-Bernard Zuber* (* to be confirmed).

Information: <http://th-www.if.uj.edu.pl/~matrix2014/index.html>.

2–4 **The 2014 International Conference of Applied and Engineering Mathematics**, Imperial College London, London, United Kingdom.

3–7 **2014 International Conference on Topology and its Applications**, University of Patras and Technological Educational Institute of Western Greece, Nafpaktos, Greece.

7–10 **International Conference “Mathematics Days in Sofia”**, Institute of Mathematics and Informatics, Bulgarian Academy of Sciences, Sofia, Bulgaria.

7–11 **10th AIMS Conference on Dynamical Systems, Differential Equations and Applications**, Universidad Autónoma de Madrid, Madrid, Spain. (Sept. 2013, p. 1111)

* 7–11 **2nd Barcelona Summer School on Stochastic Analysis**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain.

Description: Two courses will be delivered on Lévy processes and stochastic partial differential equations. Lectures will be delivered from Monday to Friday in two-hour sessions in the morning. Monday, Tuesday, and Thursday afternoon will be devoted to contributed talks and poster sessions.

Information: <http://www.crm.cat/2014/ACStochastic-Analysis>.

7–11 **Conferences on Intelligent Computer Mathematics, CICM 2014**, University of Coimbra, Coimbra, Portugal.

7–18 **Summer Graduate School: Stochastic Partial Differential Equations**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2013, p. 1399)

7–August 29 **The Geometry, Topology and Physics of Moduli Spaces of Higgs Bundles**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Nov. 2013, p. 1399)

8–11 **2014 World Conference on Natural Resource Modeling**, Vilnius University, Vilnius, Lithuania.

9–11 **10th International Workshop on Automated Deduction in Geometry, ADG 2014**, University of Coimbra, Coimbra, Portugal.

9–12 **Applications of Computer Algebra, ACA 2014**, Fordham University, New York, New York.

13–15 **8th International Conference on Modelling in Industrial Maintenance and Reliability (MIMAR)**, St. Catherine’s, Oxford, United Kingdom. (Oct. 2013, p. 1204)

14–18 **AIM Workshop: Mori program for Brauer log pairs in dimension three**, American Institute of Mathematics, Palo Alto, California. (Sept. 2013, p. 1111)

14–18 **The 30th International Colloquium on Group Theoretical Methods in Physics**, Ghent University, Ghent, Belgium. (Sept. 2013, p. 1111)

14–August 8 **Theory of Water Waves**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Sept. 2013, p. 1111)

20–25 **Sixteenth International Conference on Fibonacci Numbers and Their Applications**, Rochester Institute of Technology, Rochester, New York. (Oct. 2013, p. 1204)

21–24 **Mixed Integer Programming (MIP) workshop 2014**, The Ohio State University, Columbus, Ohio.

21–25 **Geometric and Asymptotic Group Theory with Applications (GAGTA)**, The University of Newcastle, Australia.

21–25 **Mathematics and Engineering in Marine and Earth Problems**, University of Aveiro, Portugal.

21–25 **Perspectives of Modern Complex Analysis**, Banach Conference Center, Bedlewo, Poland.

21–August 15 **Quantum Control Engineering: Mathematical Principles and Applications**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom. (Sept. 2013, p. 1111)

* 22–25 **Workshop on Infinite Dimensional Analysis Buenos Aires 2014**, Buenos Aires, Argentina.

Description: The meeting will take place in Buenos Aires from the 22nd to the 25th of July 2014 as a joint venture of the Universidad de Buenos Aires, Universidad Di Tella and Universidad de San Andrés. The conference will focus on infinite dimensional holomorphy, Banach space geometry, tensor products of Banach spaces, nonlinear analysis, differentiability, polynomials and multilinear mappings in Banach spaces, hypercyclicity and related topics.

Information: Please contact widaba14@gmail.com.

23–25 **International Symposium on Symbolic and Algebraic Computation (ISSAC 2014)**, Kobe University, Japan.

* 28–August 1 **99 years of General Relativity: ESI-EMS-IAMP Summer School on Mathematical Relativity**, Erwin Schrödinger Institute, Vienna, Austria.

Description: Mathematical General Relativity is a timely topic, with outstanding recent progress in the field by many authors, with growing interest both in the physics and mathematical community. The aim of the school is to provide an introduction to the topics which are currently being studied. The target audience is graduate students and postdocs, both physicists and mathematicians, interested in mathematical general relativity.

Lectures: “Introduction to differential geometry” by Robert Beig (Vienna), two hours; “Introduction to general relativity” by Helmut Friedrich (AEI Golm), three hours; “Lorentzian causality” by Gregory Galloway (Miami), five hours; “Constraint equations” by Justin Corvino (Lafayette), five hours; “The Evolution problem in general relativity” by Hans Ringstroem (KTH Stockholm), five hours; “Wave equations on black hole space-times” by Gustav Holzegel (Imperial, London), five hours; “The galactic center” by Andreas Eckart (Köln), two hours.

Information: <http://homepage.univie.ac.at/piotr.chrusciel/SummerSchool2014>.

28–August 8 **Summer Graduate School: Geometry and Analysis**, Mathematical Sciences Research Institute, Berkeley, California. (Nov. 2013, p. 1399)

August 2014

3–9 **XIX EBT - 19th Brazilian Topology Meeting**, State University of São Paulo (UNESP), São José do Rio Preto, Brazil.

4–9 **10th International Conference on Clifford Algebras and their Applications in Mathematical Physics (ICCA10)**, University of Tartu, Tartu, Estonia. (Sept. 2013, p. 1111)

* 7–10 **International Workshop on Applied Topology**, Chonbuk National University, Jeonju city, South Korea.

Description: As we know, during August 13–21, 2014, the International Congress of Mathematicians (ICM) will be held in Seoul, Korea (<http://www.icm2014.org>). Before ICM 2014, International workshop on Applied Topology will be held at Chonbuk National University (for brevity, CBNU) with the following topics: Set theoretic topology; asymmetric topology; Scott topology (lattice based topology); Lawson topology; digital topology; locally finite topology; applied fuzzy set and fuzzy topology; applied algebraic topology; combinatorial geometry supports: The organizing committee will partially support the fee of accommodation (guest house of CBNU, three nights during the period) up to twenty contributed speakers from abroad with the policy FCFS, banquet ticket, lunch of all contributed speakers.

Deadline for abstracts: May 1, 2014. (Please send abstracts via sehan@jbnu.ac.kr).

Information: <http://en.jbnu.ac.kr/main/main.php>.

11–14 **SIAM Conference on Nonlinear Waves and Coherent Structures (NW14)**, Churchill College, University of Cambridge, Cambridge, United Kingdom. (Sept. 2013, p. 1111)

11–15 **AIM Workshop: Neglected infectious diseases**, American Institute of Mathematics, Palo Alto, California. (Oct. 2013, p. 1204)

11–December 12 **New geometric methods in number theory and automorphic forms**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2013, p. 1111)

11–December 19 **Understanding Microbial Communities; Function, Structure and Dynamics**, Isaac Newton Institute, Cambridge, United Kingdom. (Oct. 2013, p. 1204)

14–15 **Connections for Women: New Geometric Methods in Number Theory and Automorphic Forms**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2013, p. 1111)

17–22 **Recent Developments in Adaptive Methods for PDEs, Collaborative Workshop and Short Course**, Memorial University of Newfoundland, St. John’s, Newfoundland, Canada.

18–December 19 **Geometric Representation Theory**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2013, p. 1111)

* 18–December 19 **Systemic Risk: Mathematical Modelling and Interdisciplinary Approaches**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.

Description: The purpose of this programme is to gather an international panel of mathematical scientists, economists, regulators,

risk professionals, and scientists from related disciplines to discuss theoretical and operational approaches for modelling, measuring and controlling systemic risk in the financial system, with the aim of fostering interdisciplinary exchanges and transfers on this important topic as well as providing a platform for exchange between scientists and regulators. The semester will focus on theoretical developments in understanding the mechanisms underlying systemic risk and financial instability, metrics for identifying sources of systemic risk, as well as the data requirements and statistical tools for monitoring these sources in practice. Several workshops will take place during the programme. For full details please see <http://www.newton.ac.uk/events.html>.

Information: <http://www.newton.ac.uk/programmes/SYR/>.

22–29 **Seventh International Conference on Differential and Functional Differential Equations**, Peoples’ Friendship University of Russia, Moscow, Russia.

* 25–28 **3rd International Eurasian Conference on Mathematical Sciences and Applications**, The Vienna University of Technology, Vienna, Austria.

Description: The main aim of this conference is to contribute to the development of mathematical sciences and applications and to bring together the members of the mathematics community, interdisciplinary researchers, educators, mathematicians, statisticians and engineers from all over the world. The conference will present new results and future challenges in series of invited and short talks and poster presentations. The organizing committee invites you to submit an abstract and participants to this conference.

Information: <http://www.iecmsa.org>.

25–29 **First Brazilian Workshop in Geometry of Banach Spaces BWB 2014**, Maresias Beach Hotel, Maresias (Sao Sebastiao), Brazil.

25–29 **Integrability and Cluster Algebras: Geometry and Combinatorics**, Brown University (ICERM), Providence, Rhode Island.

September 2014

1–December 19 **Trimester program on Non-commutative Geometry and its Applications**, Hausdorff Research Institute for Mathematics, Bonn, Germany. (Nov. 2013, p. 1399)

* 2–5 **Black-Box Global Optimization: Fast Algorithms and Engineering Applications (part of the CST2014 Conference)**, Hotel Royal Continental, Naples, Italy.

Description: The aim of this session is to create a multidisciplinary discussion platform focused on new theoretical, computational and applied results in solving black-box multiextremal optimization problems. In these problems, frequently encountered in engineering design, the objective function and constraints (if any) are multidimensional functions with unknown analytical representations often evaluated by performing computationally expensive simulations. Researchers from both theoretical and applied sciences are welcome to present their recent developments concerning this important class of optimization problems. To encourage young researchers to attend these conferences a 1000 Euro Young (35 years or younger) Researcher Best Paper Prize will be awarded to the best paper presented at the conferences.

Deadlines: Submission of one-page abstracts: December 5, 2013. Notification of acceptance: December 20, 2013. Payment of the regular registration fee: April 15, 2014

Information: <http://www.civil-comp.com/conf/cstect2014/cst2014-s23.htm>.

2–5 **Introductory Workshop: Geometric Representation Theory**, Mathematical Sciences Research Institute, Berkeley, California. (Sept. 2013, p. 1112)

2–5 **NUMAN2014 Recent Approaches to Numerical Analysis: Theory, Methods and Applications**, Chania, Crete, Greece.

2–7 **12th AHA Conference-Algebraic Hyperstructures and its Applications**, Democritus University of Thrace, School of Engineering, Department of Production and Management Engineering 67100, Xanthi, Greece International Algebraic Hyperstructures Association (IAHA). (Oct. 2013, p. 1204)

* 3–5 **International Workshop on Operator Theory 2014 (IWOP2014)**, Queen’s University Belfast, Belfast, Northern Ireland.

Description: This meeting intends to bring together mathematicians working in the areas of Operator Theory on Banach and on Hilbert space. The program will consist of six one-hour plenary lectures by the main speakers and contributed talks by the participants.

Information: <http://iwop2014.martinmathieu.net/>.

* 5–6 **Symposium on Trustworthy Global Computing**, Rome, Italy.

Call for Papers: <http://www.cs.le.ac.uk/events/tgc2014/>. (co-located with Concur 2014). The Symposium on Trustworthy Global Computing is an international annual venue dedicated to secure and reliable computation in the so-called global computers, i.e., those computational abstractions emerging in large-scale infrastructures such as service-oriented architectures, autonomic systems, and cloud computing.

Highlights: Parallel submission to CONCUR 2014 allowed (see submission instructions below).

Keynote speakers: Véronique Cortier (CNRS, France) and Catuscia Palamidessi (INRIA Saclay and LIX, France).

Deadline for abstract submission: May 2, 2014. The TGC series focuses on providing frameworks, tools, algorithms, and protocols for rigorously designing, verifying, and implementing open-ended, large-scaled applications. The related models of

Information: <http://www.cs.le.ac.uk/events/tgc2014/>.

8–December 12 **Mathematics of Turbulence**, Institute for Pure and Applied Mathematics (IPAM), UCLA, Los Angeles, California. (Oct. 2013, p. 1204)

18–20 **Riemann, Einstein and geometry**, Institut de Recherche Mathématique Avancée, University of Strasbourg, France. (Oct. 2013, p. 1204)

20–21 **Sectional Meeting**, University of Wisconsin-Eau Claire, Eau Claire, Wisconsin. (Sept. 2013, p. 1112)

21–26 **12th International Conference of The Mathematics Education into the 21st Century Project: The Future of Mathematics Education in a Connected World**, Hunguest Hotel Sun Resort, Herceg Novi, Montenegro.

* 23–25 **3rd International Conference on Mathematical Applications in Engineering 2014**, Kuala Lumpur, Malaysia.

Description: We are pleased to invite you and all your colleagues to participate in our great event, the 3rd International Conference on Mathematical Applications in Engineering 2014 (ICMAE.14).

Main objective: Of organizing this conference is to provide an international technical forum for engineers, academicians, scientists and researchers to present results of ongoing research in the field of Mathematical Applications in Engineering. The primary focus of the conference is to create an effective medium for institutions and industries to share ideas, innovations and problem solving techniques. For your information the past two conferences (ICMAE 2010, ICMAE2012) were sponsored by many good scientific journals and selected papers were published in those journals, which we are planning to do this time as well.

Information: <http://www.iiium.edu.my/icmae/14/>.

29–October 3 **International Conference on Numerical and Mathematical Modeling of Flow and Transport in Porous Media**, Centre for Advanced Academic Studies (CAAS), 20000 Dubrovnik, Croatia.

October 2014

5–11 **International Conference on Algebraic Methods in Dynamical Systems (Conference in honour of the 60th birthday of Juan J. Morales-Ruiz)**, Universidad del Norte, Barranquilla, Colombia.

18–19 **Sectional Meeting**, Dalhousie University, Halifax, Canada. (Sept. 2013, p. 1112)

* 20–24 **Autumn school on nonlinear geometry of Banach spaces and applications**, Métabief, France.

Description: In the framework of the special trimester “Geometric and non-commutative methods in functional analysis” at Université Franche-Comté (Besançon, France) we organize this “Autumn school on nonlinear geometry of Banach spaces and applications” in the nearby village of Métabief in the Jura mountains. The school will propose 5 short courses delivered by mathematicians working in this domain. We hope to bring together researchers and students with common interest in the field. There will be many opportunities for informal discussions.

Information: <http://trimestres-lmb.univ-fcomte.fr/fa>.

22–24 **28th Midwest Conference on Combinatorics and Combinatorial Computing**, University of Nevada, Las Vegas (UNLV), Las Vegas, Nevada.

23–26 **Ahlfors-Bers Colloquium VI**, Yale University, New Haven, Connecticut. (Oct. 2013, p. 1204)

25–26 **Sectional Meeting**, San Francisco State University, San Francisco, California. (Sept. 2013, p. 1112)

* 27–31 **Conference on Geometric Functional Analysis and its Applications**, Université de Franche-Comté, Besançon, France.

Description: To bring together researchers and students with common interest in this field. The conference will propose many plenary lectures and the participants will have the opportunity to deliver a short talk.

Information: <http://trimestres-lmb.univ-fcomte.fr/fa>.

November 2014

* 5–8 **Fifth Ya.B. Lopatinskii International Conference of Young Scientists on Differential Equations and Its Applications**, Donetsk National University, Donetsk, Ukraine.

Description: This is bringing together young and some venerable researchers in above areas in order to get acquainted, to communicate and to understand what directions are actual and perspective. The word “young” in the title means a general direction of the conference but doesn’t mean any age limitations for participants.

Main topics: General theory of boundary-value problems for partial differential equations (PDE), investigation of boundary-value problems for special classes of PDE, nonlinear boundary-value problems, operator methods in the theory of PDE, mathematical physics, ordinary differential equations and dynamical systems, applications of PDE.

Information: <http://math.donnu.edu.ua/en-us/science/conferences/ICL2014>.

8–9 **Sectional Meeting**, University of North Carolina, Greensboro, North Carolina. (Sept. 2013, p. 1112)

11–January 25 **Inverse Moment Problems: The Crossroads of Analysis, Algebra, Discrete Geometry and Combinatorics**, Institute for Mathematical Sciences, National University of Singapore, Singapore. (Sept. 2013, p. 1112)

* 26–30 **The 19th Asian Technology Conference in Mathematics (ATCM 2014)**, State University of Yogyakarta, Yogyakarta, Indonesia.

Description: The ATCM 2014 is an international conference to be held in Mumbai, India, that will continue addressing technology-based issues in all Mathematical Sciences. Thanks to advanced technological tools such as computer algebra systems (CAS), interactive and dynamic geometry, and hand-held devices, the effectiveness

of our teaching and learning, and the horizon of our research in mathematics and its applications continue to grow rapidly. The aim of this conference is to provide a forum for educators, researchers, teachers and experts in exchanging information regarding enhancing technology to enrich mathematics learning, teaching and research at all levels. English is the official language of the conference. ATCM averagely attracts 300 participants representing over 30 countries around the world. Be sure to submit your abstracts or full papers in time.

Information: <http://atcm.mathandtech.org>.

* 27-29 **Annual meeting of the French research network (GdR) in Noncommutative Geometry**, Besancon, France.

Description: This 3-day workshop is an annual meeting of the French Non-commutative Geometry network, with international participation. The topics include also quantum groups, geometric group theory, operator algebras, operator spaces. The workshop is a part of a trimester in Functional Analysis of the University of Franche-Comte (Besann). The trimester includes also other events, in particular a School on Operator Spaces, Non-commutative Probability and Quantum Groups (December 1-12, Metabief, close to Besann) and a conference on Operator spaces and Quantum Probability (December 15-19, Besann).

Information: <http://trimestres-lmb.univ-fcomte.fr/Noncommutative-Geometry-meeting.html>.

December 2014

* 1-5 **38th Australasian Conference on Combinatorial Mathematics and Combinatorial Computing (ACCMCC)**, Victoria University of Wellington, Wellington, New Zealand.

Description: Contributed talks will be sought from all areas of discrete and combinatorial mathematics and related areas of computer science.

Invited speakers: Mike Atkinson (University of Otago); Simeon Ball (Universitat Politècnica de Catalunya); Alice Devillers (University of Western Australia); Jaroslav Nesetril (Charles University); Sergey Norin (McGill University); James Oxley (Louisiana State University); Andrew Thomason (University of Cambridge); Mark Wilson (University of Auckland); Stefan van Zwam (Princeton University).

Queries: Should be sent to the head of the organising committee, Dillon Mayhew (dillon.mayhew@msor.vuw.ac.nz).

Information: <http://msor.victoria.ac.nz/Events/38ACCMCC>.

1-12 **Winter School on Operator Spaces, Non-commutative Probability and Quantum Groups**, Métabief, France.

6-31 **The Info-Metrics Annual Prize in Memory of Halbert L. White Jr.**, Washington, DC.

* 9-10 **First call for the training programme “Collaborative Mathematical Research”**, Centre de Recerca Matemàtica, Bellaterra, Barcelona, Spain.

Description: First call for the training programme “Collaborative Mathematical Research”.

Information: <http://www.crm.cat/en/ResearchTraining/CollabMathResearch/Pages/Description.aspx>.

9-19 **Recent Advances in Operator Theory and Operator Algebras-2014**, Bangalore, India.

11-20 **Foundations of Computational Mathematics Conference**, Universidad de la República, Montevideo, Uruguay.

January 2015

4-6 **ACM-SIAM Symposium on Discrete Algorithms (SODA15), being held with Analytic Algorithmics and Combinatorics (ANALCO15) and Algorithm Engineering and Experiments (ALENEX15)**, The Westin Gaslamp Quarter, San Diego, California.

5-June 26 **Periodic and Ergodic Spectral Problems**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.

12-May 22 **Dynamics on Moduli Spaces of Geometric Structures Program**, Mathematical Sciences Research Institute, Berkeley, California.

12-July 3 **Random Geometry**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.

February 2015

* 2-March 8 **ICERM Semester Program: Phase Transitions and Emergent Properties**, Brown University, Providence, Rhode Island.

Description: Emergent phenomena are properties of a system of many components which are only evident or even meaningful for the collection as a whole. A typical example is a system of many molecules, whose bulk properties may change from those of a fluid to those of a solid in response to changes in temperature or pressure. The basic mathematical tool for understanding emergent phenomena is the variational principle, most often employed via entropy maximization. The difficulty of analyzing emergent phenomena, however, makes empirical work essential; computations generate conjectures and their results are often our best judge of the truth. The semester will include three workshops that will concentrate on different aspects of current interest, including unusual settings such as complex networks and quasicrystals, the onset of emergence as small systems grow, and the emergence of structure and shape as limits in probabilistic models.

Information: <http://icerm.brown.edu/sp-s15>.

* 9-13 **Crystals, Quasicrystals and Random Networks**, Brown University, Providence, Rhode Island.

Description: In this workshop we will focus on two significant variants of this classic picture: quasicrystals, and complex networks/random graphs. The analogue of energy minimizing crystals for quasicrystals are aperiodic tilings, such as the kite and dart tilings of Penrose, and for complex networks the analogue of energy minimizing crystals are (multi-partite) extremal graphs, graphs which minimize the number of subgraphs of some type. The workshop will focus on extremal graphs and aperiodic tilings and on the ‘solid’ phases they are believed to yield when random defects are introduced. It is hoped that progress can be made by pooling the expertise of researchers interested in the various aspects of these subjects.

Information: <http://icerm.brown.edu/sp-s15-w1>.

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.

March 2015

* 16-20 **Small Clusters, Polymer Vesicles and Unusual Minima**, Brown University, Providence, Rhode Island.

Description: This workshop will explore emergent phenomena in the context of small clusters, supramolecular self-assembly and the shape of self-assembled structures such as polymer vesicles. The emphasis will be on surprises which arise when common conditions are not satisfied, for instance when the number of components is small, or they are highly non-spherical, or there are several types of components. Interactions vary from hard sphere repulsion to competition between coarse-grained liquid-crystalline ordering competing with shape deformation.

Information: <http://icerm.brown.edu/sp-s15-w2>.

April 2015

* 13-17 **Limit Shapes**, Brown University, Providence, Rhode Island.

Description: Since the days of Boltzmann, it has been well accepted that natural phenomena, when described using tools of statistical

mechanics, are governed by various “laws of large numbers.” For practitioners of the field this usually means that certain empirical means converge to constants when the limit of a large system is taken. However, evidence has been amassed that such laws apply also to geometric features of these systems and, in particular, to many naturally-defined shapes. The last decade has seen a true explosion of “limit-shape” results. New tools of combinatorics, random matrices and representation theory have given us new models for which limit shapes can be determined and further studied. The goal of the workshop is to attempt to confront this “ZOO” of combinatorial examples with older foundational work and develop a better understanding of the general limit shape phenomenon.

Information: <http://icerm.brown.edu/sp-s15-w3>.

July 2015

* 13–December 18 **Coupling Geometric PDEs with Physics for Cell Morphology, Motility and Pattern Formation**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.

Description: The aim of this six-month research programme is to create a unique forum to strengthen and develop research links between state-of-the-art experimental “wet” sciences (biology, medicine, bio-physics) and theoretical “dry” sciences (pure, applied and computational mathematics, theoretical physics, statistics). In this programme we will discuss and present in a hands-on format current experimental methodology for cell motility and pattern formation. We will emphasise interactions between experimentalists and theoreticians, with the dual goals of understanding how current mathematical techniques from physics, differential geometry, mathematical modelling and numerical analysis can help to understand current problems in the areas of cell motility and pattern formation, and what new mathematical techniques may emerge in the process. Several workshops will take place during the programme. For full details please see www.newton.ac.uk/events.html.

Information: <http://www.newton.ac.uk/programmes/CGP/>.

* 20–August 14 **Metric and Analytic Aspects of Moduli Spaces**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.

Description: The term ‘moduli space’ has its origins in the classification of conformal structures on two-dimensional surfaces. Closed surfaces are classified topologically by their genus, but for fixed genus, the set of inequivalent conformal structures is essentially a smooth finite-dimensional manifold, a first example of a moduli space. In more recent times, many other instances of mathematical structures of this type have come to light, above all in gauge theory. They continue to have a major impact in modern geometry, topology and mathematical physics.

Goal: The goal of the programme is to explore moduli spaces from the metric and analytical points of view. We shall survey the current state of the art with a focus on four themes: 4-dimensional hyperkahler manifolds; compactification of moduli spaces; analysis on moduli spaces; new constructions and challenges. There will be a 5-day workshop during the second week of the programme. For full details please see <http://www.newton.ac.uk/events.html>.

Information: <http://www.newton.ac.uk/programmes/MAM/>.

* **Mathematical, Foundational and Computational Aspects of the Higher Infinite**, Isaac Newton Institute for Mathematical Sciences, Cambridge, United Kingdom.

Description: Current set-theoretic research on infinity focuses on the following three broad areas: large Cardinals and inner model theory, descriptive set-theoretic methods and classification problems, and infinite combinatorics. The programme HIF will connect these three main strands of set-theoretic research and other fields of set theory to the wider scope of mathematics, to research in the foundations of mathematics, including some philosophical issues, and to research on computational issues of infinity, e.g., in theoretical computer science and constructive mathematics. Three workshops

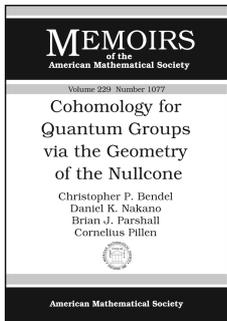
are planned during the programme: The first one (24-28 August 2015) will be the 5th European Set Theory Conference. The second workshop, entitled “New challenges in iterated forcing” will be a Satellite Meeting held at the University of East Anglia in Norwich (November 2–6, 2015). A final workshop will take place on December 14–18, 2015. For full details please see <http://www.newton.ac.uk/events.html>.

Information: <http://www.newton.ac.uk/programmes/HIF/>.

New Publications Offered by the AMS

To subscribe to email notification of new AMS publications, please go to <http://www.ams.org/bookstore-email>.

Algebra and Algebraic Geometry



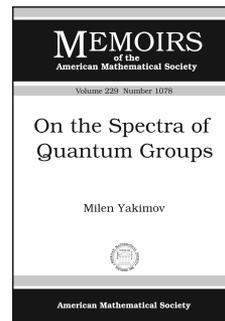
Cohomology for Quantum Groups via the Geometry of the Nullcone

Christopher P. Bendel, *University of Wisconsin-Stout, Menomonie, Wisconsin*, **Daniel K. Nakano**, *University of Georgia, Athens, Georgia*, **Brian J. Parshall**, *University of Virginia, Charlottesville, Virginia*, and **Cornelius Pillen**, *University of South Alabama, Mobile, Alabama*

Contents: Preliminaries and statement of results; Quantum groups, actions, and cohomology; Computation of Φ_0 and $\mathcal{N}(\Phi_0)$; Combinatorics and the Steinberg Module; The cohomology algebra $H^*(u_{\zeta}(\mathfrak{g}), \mathbb{C})$; Finite generation; Comparison with positive characteristic; Support varieties over u_{ζ} for the Modules $\nabla_{\zeta}(\lambda)$ and $\Delta_{\zeta}(\lambda)$; Appendix A; Bibliography.

Memoirs of the American Mathematical Society, Volume 229, Number 1077

May 2014, 93 pages, Softcover, ISBN: 978-0-8218-9175-9, LC 2013051269, 2010 *Mathematics Subject Classification*: 20G42, 20G10; 17B08, **AMS members US\$56.80**, List US\$71, Order code MEMO/229/1077



On the Spectra of Quantum Groups

Milen Yakimov, *Louisiana State University, Baton Rouge, Louisiana*

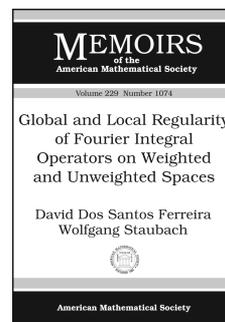
Contents: Introduction; Previous results on spectra of quantum function algebras; A description of the centers of Joseph's localizations; Primitive ideals of $R_q[G]$ and a Dixmier map for $R_q[G]$; Separation of variables for the algebras $S_{\mathfrak{w}}^+$; A

classification of the normal and prime elements of the De Concini-Kac-Procesi algebras; Module structure of $R_{\mathfrak{w}}$ over their subalgebras generated by Joseph's normal elements; A classification of maximal ideals of $R_q[G]$ and a question of Goodearl and Zhang; Chain properties and homological applications; Bibliography.

Memoirs of the American Mathematical Society, Volume 229, Number 1078

May 2014, 91 pages, Softcover, ISBN: 978-0-8218-9174-2, LC 2014000519, 2010 *Mathematics Subject Classification*: 16T20; 20G42, 17B37, 53D17, **AMS members US\$56.80**, List US\$71, Order code MEMO/229/1078

Analysis



Global and Local Regularity of Fourier Integral Operators on Weighted and Unweighted Spaces

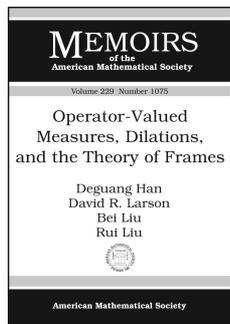
David Dos Santos Ferreira, *Université Paris 13, Villetaneuse, France*, and **Wolfgang Staubach**, *Uppsala University, Sweden*

Contents: Prolegomena; Global boundedness of Fourier integral operators; Global and local weighted L^p boundedness of Fourier

integral operators; Applications in harmonic analysis and partial differential equations; Bibliography.

Memoirs of the American Mathematical Society, Volume 229, Number 1074

May 2014, 65 pages, Softcover, ISBN: 978-0-8218-9119-3, LC 2013051215, 2010 *Mathematics Subject Classification*: 35S30, 42B99, **AMS members US\$50.40**, List US\$63, Order code MEMO/229/1074



Operator-Valued Measures, Dilations, and the Theory of Frames

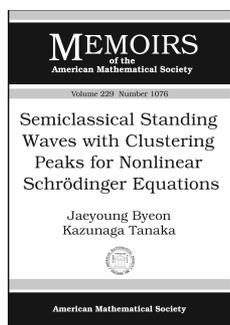
Deguang Han, *University of Central Florida, Orlando, Florida*, **David R. Larson**, *Texas A&M University, College Station, Texas*, **Bei Liu**, *Tianjin University of Technology, China*, and **Rui Liu**, *Nankai University, Tianjuin, China*

Contents: Introduction; Preliminaries; Dilation of operator-valued measures; Framings and dilations; Dilations of maps; Examples; Bibliography.

Memoirs of the American Mathematical Society, Volume 229, Number 1075

May 2014, 84 pages, Softcover, ISBN: 978-0-8218-9172-8, LC 2013051213, 2010 *Mathematics Subject Classification*: 46G10, 46L07, 46L10, 46L51, 47A20; 42C15, 46B15, 46B25, 47B48, **AMS members US\$52**, List US\$65, Order code MEMO/229/1075

Differential Equations



Semiclassical Standing Waves with Clustering Peaks for Nonlinear Schrödinger Equations

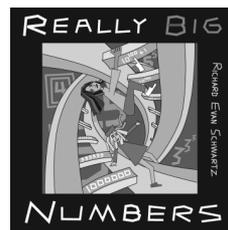
Jaeyoung Byeon, *KAIST, Daejeon, Republic of Korea*, and **Kazunaga Tanaka**, *Waseda University, Tokyo, Japan*

Contents: Introduction and results; Preliminaries; Local centers of mass; Neighborhood $\Omega_\epsilon(\rho, R, \beta)$ and minimization for a tail of u in Ω_ϵ ; A gradient estimate for the energy functional; Translation flow associated to a gradient flow of $V(x)$ on \mathbf{R}^N ; Iteration procedure for the gradient flow and the translation flow; An $(N + 1)\ell_0$ -dimensional initial path and an intersection result; Completion of the proof of Theorem 1.3; Proof of Proposition 8.3; Proof of Lemma 6.1; Generalization to a saddle point setting; Bibliography.

Memoirs of the American Mathematical Society, Volume 229, Number 1076

May 2014, 89 pages, Softcover, ISBN: 978-0-8218-9163-6, LC 2013051230, 2010 *Mathematics Subject Classification*: 35J60; 35B25, **AMS members US\$56.80**, List US\$71, Order code MEMO/229/1076

General Interest



Really Big Numbers

Richard Evan Schwartz, *Brown University, Providence, RI*

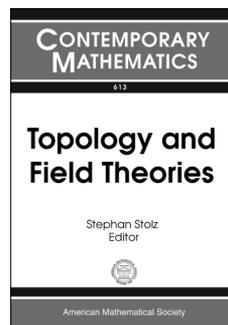
A superb, beautifully illustrated book for kids — and those of us still children at heart — that takes you up (and up, and up, and up, and up, and up, and ...) through the counting numbers, illustrating the power of the different notations mathematicians have invented to talk about VERY BIG NUMBERS. Many of us use words to try to describe the beauty and the power of mathematics. Schwartz does it with captivating, full-color drawings.

— **Keith Devlin**, NPR Math Guy and author of *The Math Instinct* and *The Math Gene*

Open this book and embark on an accelerated tour through the number system, starting with small numbers and building up to really gigantic ones, like a trillion, an octillion, a googol, and even ones too huge for names! Along the way, you'll become familiar with the sizes of big numbers in terms of everyday objects, such as the number of basketballs needed to cover New York City or the number of trampolines needed to cover the earth's surface. Take an unforgettable journey part of the way to infinity!

May 2014, 192 pages, Softcover, ISBN: 978-1-4704-1425-2, 2010 *Mathematics Subject Classification*: 00-XX, **AMS members US\$20**, List US\$25, Order code MBK/84

Mathematical Physics



Topology and Field Theories

Stephan Stolz, *University of Notre Dame, IN*, Editor

This book is a collection of expository articles based on four lecture series presented during the 2012 Notre Dame Summer School in Topology and Field Theories.

The four topics covered in this volume are: Construction of a local conformal field theory associated to a compact Lie group, a level and a Frobenius object in the corresponding fusion category; Field theory interpretation of certain polynomial invariants associated to knots and links; Homotopy theoretic construction of far-reaching generalizations of the topological field theories that Dijkgraaf and Witten associated to finite groups; and a discussion of the action of the orthogonal group $O(n)$ on the full subcategory of an n-category consisting of the fully dualizable objects.

The expository style of the articles enables non-experts to understand the basic ideas of this wide range of important topics.

This item will also be of interest to those working in geometry and topology.

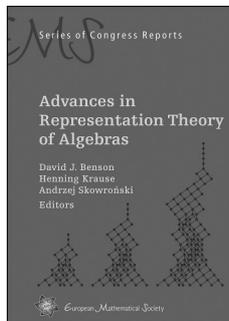
Contents: **A. Henriques**, Three-tier CFTs from Frobenius algebras; **S. Gukov** and **I. Saberi**, Lectures on knot homology and quantum curves; **G. Heuts** and **J. Lurie**, Ambidexterity; **C. J. Schommer-Pries**, Dualizability in low-dimensional higher category theory.

Contemporary Mathematics, Volume 613

April 2014, approximately 183 pages, Softcover, ISBN: 978-1-4704-1015-5, LC 2013037475, 2010 *Mathematics Subject Classification*: 57R56, 81T40, 18G99, 55N99, **AMS members US\$62.40**, List US\$78, Order code CONM/613

New AMS-Distributed Publications

Algebra and Algebraic Geometry



Advances in Representation Theory of Algebras

David J. Benson, *University of Aberdeen, United Kingdom*, **Henning Krause**, *University of Bielefeld, Germany*, and **Andrzej Skowroński**, *Nicolaus Copernicus University, Toruń, Poland*, Editors

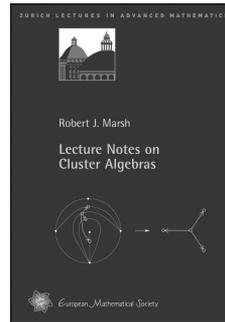
This volume presents a collection of articles devoted to representations of algebras and related topics. Distinguished experts in this field presented their work at the International Conference on Representations of Algebras, which took place in Bielefeld in 2012. Many of the expository surveys are included here. Researchers of representation theory will find in this volume interesting and stimulating contributions to the development of the subject.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: **L. A. Hügel**, Infinite dimensional tilting theory; **D. J. Benson**, A survey of modules of constant Jordan type and vector bundles on projective space; **K. Bongartz**, On representation-finite algebras and beyond; **J. Brundan**, Quiver Hecke algebras and categorification; **T. Brüstle** and **D. Yang**, Ordered exchange graphs; **S. Mozgovoy**, Introduction to Donaldson–Thomas invariants; **H. Nakajima**, Cluster algebras and singular supports of perverse sheaves; **J. Pevtsova**, Representations and cohomology of finite group schemes; **M. Prest**, Superdecomposable pure-injective modules; **J. Šťovíček**, Exact model categories, approximation theory, and cohomology of quasi-coherent sheaves; List of Contributors.

EMS Series of Congress Reports, Volume 9

December 2013, 378 pages, Hardcover, ISBN: 978-3-03719-125-5, 2010 *Mathematics Subject Classification*: 16Gxx, 13Dxx, 18Exx, 20Cxx, **All Individuals US\$78.40**, List US\$98, Institutional member US\$78.40, Order code EMSSCR/9



Lecture Notes on Cluster Algebras

Robert J. Marsh, *University of Leeds, United Kingdom*

Cluster algebras are combinatorially defined commutative algebras which were introduced by S. Fomin and A. Zelevinsky as a tool for studying the dual canonical basis of a quantized enveloping algebra and totally positive matrices. The aim of these

notes is to give an introduction to cluster algebras which is accessible to graduate students or researchers interested in learning more about the field while giving a taste of the wide connections between cluster algebras and other areas of mathematics.

The approach taken emphasizes combinatorial and geometric aspects of cluster algebras. Cluster algebras of finite type are classified by the Dynkin diagrams, so a short introduction to reflection groups is given in order to describe this and the corresponding generalized associahedra. A discussion of cluster algebra periodicity, which has a close relationship with discrete integrable systems, is included.

This book ends with a description of the cluster algebras of finite mutation type and the cluster structure of the homogeneous coordinate ring of the Grassmannian, both of which have a beautiful description in terms of combinatorial geometry.

This item will also be of interest to those working in discrete mathematics and combinatorics.

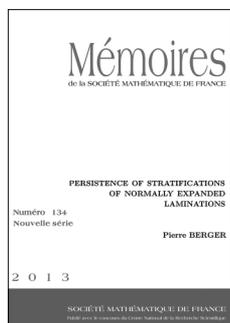
A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: Introduction; Cluster algebras; Exchange pattern cluster algebras; Reflection groups; Cluster algebras of finite type; Generalized associahedra; Periodicity; Quivers of finite mutation type; Grassmannians; Bibliography; Nomenclature; Index.

Zurich Lectures in Advanced Mathematics, Volume 19

January 2014, 122 pages, Softcover, ISBN: 978-3-03719-130-9, 2010 *Mathematics Subject Classification*: 13F60, 05E40, 14M15, 17B22, 17B63, 18E30, 20F55, 51F15, 52B05, 52B11, 57Q15, **AMS members US\$28.80**, List US\$36, Order code EMSZLEC/19

Analysis



Persistence of Stratifications of Normally Expanded Laminations

Pierre Berger, *Université Paris 13, Villetaneuse, France*

This manuscript complements the Hirsch-Pugh-Shub (HPS) theory on persistence of normally hyperbolic

laminations and implies several structural stability theorems.

The author generalizes the concept of lamination by defining a new object: the stratification of laminations. It is a stratification whose strata are laminations. The main theorem implies the persistence of some stratifications whose strata are normally expanded. The dynamics is a C^r -endomorphism of a manifold (which is possibly not invertible and with critical points). The persistence means that any C^r -perturbation of the dynamics preserves a C^r -close stratification.

If the stratification consists of a single stratum, the main theorem implies the persistence of normally expanded laminations by endomorphisms, and hence implies the HPS theorem. Another application of this theorem is the persistence, as stratifications, of submanifolds with boundary or corners normally expanded. Several examples are also given in product dynamics.

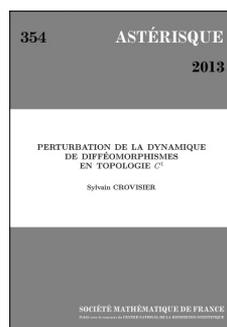
As diffeomorphisms that satisfy axiom A and the strong transversality condition (AS) defines canonically two stratifications of laminations: the stratification whose strata are the (un)stable sets of basic pieces of the spectral decomposition. The main theorem implies the persistence of some "normally AS" laminations which are not normally hyperbolic and other structural stability theorems.

A publication of the Société Mathématique de France, Marseille (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Geometry of stratification of laminations; Persistence of stratifications of laminations; Proof of the persistence of stratifications; A. Analysis on laminations and on trellis; B. Adapted metric; C. Plaque-expansiveness; D. Preservation of leaves and of laminations; Bibliography.

Mémoires de la Société Mathématique de France, Number 134

October 2013, 113 pages, Softcover, ISBN: 978-2-85629-767-4, 2010 *Mathematics Subject Classification:* 37D10, 37F15, 34D30, 37D20, 57N80, **AMS members US\$36**, List US\$45, Order code SMFMEM/134



Perturbation de la Dynamique de Difféomorphismes en Topologie C^1

Sylvain Crovisier, *University of Paris-Sud, Orsay, France*

This memoir deals with the dynamics of diffeomorphisms of compact manifolds.

For the study of generic properties or for the construction of examples, it is often useful to be able to perturb a system. This generally leads to delicate problems: a local modification of the dynamics may cause a radical change in the behavior of the orbits. For the C^1 topology, the author proposes various techniques which allow perturbation while controlling the dynamic: putting in transversal position, connection of orbits, perturbation of the tangent dynamics,... The author derives various applications to the description of C^1 -generic diffeomorphisms.

A publication of the Société Mathématique de France, Marseille (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Décomposition de la dynamique; Techniques de perturbation, généricité; Connexions de pseudo-orbites; Connexions globales; Hyperbolicité non uniforme; Réduction de la dimension ambiante; Bifurcations de points périodiques; Points périodiques homocliniquement liés; Dynamique loin des tangentes homoclines : modèles centraux; Hyperbolicités topologique et uniforme; A. Centralisateurs de difféomorphismes; Bibliographie; Index.

Astérisque, Number 354

October 2013, 164 pages, Softcover, ISBN: 978-2-85629-764-3, 2010 *Mathematics Subject Classification:* 37C05, 37C20, 37C25, 37C29, 37C50, 37C70, 37C75, 37D05, 37D10, 37D15, 37D20, 37D25, 37D30, **AMS members US\$53.60**, List US\$67, Order code AST/354



Microlocalization of Subanalytic Sheaves

Luca Prelli, *Università degli Studi di Padova, Italy*

The author defines the specialization and microlocalization functors for subanalytic sheaves. Applying these tools to the sheaves of tempered and Whitney holomorphic functions, he generalizes some classical constructions. He also proves that the microlocalizations of tempered and Whitney holomorphic functions have a natural structure of module over the ring of microdifferential operators and are locally invariant under contact transformations.

This item will also be of interest to those working in differential equations.

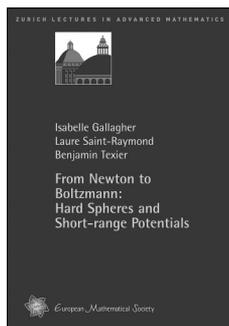
A publication of the Société Mathématique de France, Marseille (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Review on sheaves on subanalytic sites; Conic sheaves on subanalytic sites; Fourier-Sato transform for subanalytic sheaves; Specialization of subanalytic sheaves; Microlocalization of subanalytic sheaves; Holomorphic functions with growth conditions; Integral transforms; A. Review on subanalytic sets; Bibliography.

Mémoires de la Société Mathématique de France, Number 135

November 2013, 101 pages, Softcover, ISBN: 978-2-85629-768-1, 2010 *Mathematics Subject Classification*: 32C38, 35A27, 18F20, 32B20, **AMS members US\$36**, List US\$45, Order code SMFMEM/135

Differential Equations



From Newton to Boltzmann

Hard Spheres and Short-Range Potentials

Isabelle Gallagher, *Université Paris Diderot, France*, **Laure Saint-Raymond**, *Ecole Normale Supérieure, Paris, France*, and **Benjamin Texier**, *Université Paris Diderot, France*

The question addressed in this monograph is the relationship between the time-reversible Newton dynamics for a system of particles interacting via elastic collisions and the irreversible Boltzmann dynamics which gives a statistical description of the collision mechanism. Two types of elastic collisions are considered: hard spheres and compactly supported potentials.

Following the steps suggested by Lanford in 1974, the authors describe the transition from Newton to Boltzmann by proving a rigorous convergence result in short time, as the number of particles tends to infinity and their size simultaneously goes to zero, in the Boltzmann-Grad scaling.

Boltzmann's kinetic theory rests on the assumption that particle independence is propagated by the dynamics. This assumption is central to the issue of appearance of irreversibility. For finite numbers of particles, correlations are generated by collisions. The convergence proof establishes that for initially independent configurations, independence is statistically recovered in the limit.

This book is intended for mathematicians working in the fields of partial differential equations and mathematical physics and is accessible to graduate students with a background in analysis.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

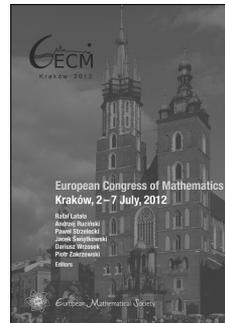
Contents: *I. Introduction:* The low density limit; The Boltzmann equation; Main results; *II. The case of hard spheres:* Microscopic dynamics and BBGKY hierarchy; Uniform a priori estimates for the BBGKY and Boltzmann hierarchies; Statement of the convergence result; Strategy of the proof of convergence; *III. The case of short-range potentials:* Two-particle interactions; Truncated marginals and the BBGKY hierarchy; Cluster estimates and uniform a priori estimates; Convergence result and strategy of proof; *IV. Termwise convergence:* Elimination of recollisions; Truncated

collision integrals; Proof of convergence; Concluding remarks; Bibliography; Index.

Zurich Lectures in Advanced Mathematics, Volume 18

January 2014, 150 pages, Softcover, ISBN: 978-3-03719-129-3, 2010 *Mathematics Subject Classification*: 35Q20, 35Q70, **AMS members US\$30.40**, List US\$38, Order code EMSZLEC/18

General Interest



European Congress of Mathematics

Kraków, July 2-7, 2012

Rafał Łatała, *University of Warsaw, Poland*, **Andrzej Ruciński**, *Adam Mickiewicz University, Poznań, Poland*, **Paweł Strzelecki**, *University of Warsaw, Poland*, **Jacek Świątkowski**, *University of Wrocław, Poland*, and **Dariusz Wrzosek** and **Piotr Zakrzewski**, *University of Warsaw, Poland*, Editors

The European Congress of Mathematics, held every four years, has become a well-established major international mathematical event. Following those in Paris (1992), Budapest (1996), Barcelona (2000), Stockholm (2004), and Amsterdam (2008), the Sixth European Congress of Mathematics (6ECM) took place in Kraków, Poland, July 2-7, 2012, with about 1000 participants from all over the world.

Ten plenary, thirty-three invited lectures, and three special lectures formed the core of the program. As at all the previous EMS congresses, ten outstanding young mathematicians received the EMS prizes in recognition of their research achievements. In addition, two more prizes were awarded: the Felix Klein Prize for a remarkable solution of an industrial problem, and—for the first time—the Otto Neugebauer Prize for a highly original and influential piece of work in the history of mathematics. The program was complemented by twenty-four minisymposia with nearly 100 talks that covered all areas of mathematics. Six panel discussions were organized, covering a variety of issues ranging from the financing of mathematical research to gender imbalance in mathematics.

These proceedings, which present extended versions of most of the invited talks delivered during the congress, provide a permanent record of the best of what mathematics offers today.

Contents: *Plenary Lectures:* **A. Constantin**, Some mathematical aspects of water waves; **C. De Lellis** and **L. Székelyhidi**, Continuous dissipative Euler flows and a conjecture of Onsager; **H. Edelsbrunner** and **D. Morozov**, Persistent homology: theory and practice; **M. Gromov**, In a search for a structure, Part 1: On entropy; **C. Hacon**, Classification of algebraic varieties; **A. Braverman** and **D. Kazhdan**, Representations of affine Kac-Moody groups over local and global fields: A survey of some recent results; **S. Serfaty**, Emergence of the Abrikosov lattice in several models with two dimensional Coulomb interaction; **S. Shelah**, Dependent classes, E72; **M. Talagrand**, Chaining and the geometry of stochastic processes; *Invited Lectures:* **A. Alekseev**, Duflo isomorphism, the

Kashiwara–Vergne conjecture and Drinfeld associators; **J. Bertoin**, Coagulation with limited aggregations; **S. Cantat**, The Cremona group in two variables; **V. Caselles**, Variational models for image inpainting; **A. Celletti**, KAM theory and its applications: From conservative to dissipative systems; **P. Colmez**, Le programme de Langlands p -adique; **T. Coates**, **A. Corti**, **S. Galkin**, **V. Golyshev**, and **A. Kasprzyk**, Mirror symmetry and Fano manifolds; **H. Esnault**, On flat bundles in characteristic 0 and $p > 0$; **A. A. Gaifullin**, Combinatorial realisation of cycles and small covers; **I. Gallagher**, Remarks on the global regularity for solutions to the incompressible Navier–Stokes equations; **O. Häggström**, Why the empirical sciences need statistics so desperately; **A. Iserles**, Computing the Schrödinger equation with no fear of commutators; **A. S. Kechris**, Dynamics of non-archimedean Polish groups; **B. Keller**, Cluster algebras and cluster monomials; **S. Kołodziej**, Weak solutions to the complex Monge–Ampère equation; **G. Kozma**, Reinforced random walk; **F. Merle**, On blow-up curves for semilinear wave equations; **A. E. Mironov**, Commuting higher rank ordinary differential operators; **D. Nualart**, Stochastic calculus with respect to the fractional Brownian motion; **A. Olevskii**, Sampling, interpolation, translates; **L. Parnowski**, Multidimensional periodic and almost-periodic spectral problems; **B. Schlein**, Effective equations for quantum dynamics; **P. Śniady**, Combinatorics of asymptotic representation theory; **H. Jia** and **V. Sverák**, On scale-invariant solutions of the Navier–Stokes equations; **S. Todorčević**, Ramsey-theoretic analysis of the conditional structure of weakly-null sequences; *Prize Winners’ Lectures*: **S. Brendle**, Uniqueness results for minimal surfaces and constant mean curvature surfaces in Riemannian manifolds; **A. Figalli**, Stability in geometric and functional inequalities; **A. Ioana**, Classification and rigidity for von Neumann algebras; **M. Lewin**, A nonlinear variational problem in relativistic quantum mechanics; **C. Manolescu**, Grid diagrams in Heegaard Floer theory; **G. Miermont**, Random maps and continuum random 2-dimensional geometries; **T. Sanders**, Approximate (Abelian) groups; **C. Ulcigrai**, Shearing and mixing in parabolic flows; **E. Trelat**, Optimal control theory and some applications to aerospace problems; **J. P. Hogendijk**, Mathematics and geometric ornamentation in the medieval Islamic world; *Special Lectures*: **J. F. Rodrigues**, Some mathematical aspects of the Planet Earth; **P. Welch**, Turing’s mathematical work; **A. Siemaszko** and **M. P. Wojtkowski**, Counting Berg partitions via Sturmian words and substitution tilings.

December 2013, 824 pages, Hardcover, ISBN: 978-3-03719-120-0, 2010 *Mathematics Subject Classification*: 00Bxx, **AMS members US\$102.40**, List US\$128, Order code EMSEMC/2012

Geometry and Topology



Problème de Plateau, Équations Fuchsiennes et Problème de Riemann-Hilbert

Laura Desideri, *Université de Lille 1, Villeneuve d’Ascq, France*

A note to readers: This book is in French.

This dissertation is devoted to the resolution of the Plateau problem in the case of a polygonal boundary in the three-dimensional euclidean

space. It relies on a method developed by René Garnier and published in 1928 in a paper which seems today to be totally forgotten. Even if Garnier’s method is more geometrical and constructive than the variational one, it is sometimes really complicated, and even obscure or incomplete. The authors rewrite his proof with a modern formalism, fill some gaps, and propose some alternative easier proofs.

This work mainly relies on a systematic use of Fuchsian systems and on the relation that we establish between the reality of such systems and their monodromy. Garnier’s method is based on the following result: using the spinorial Weierstrass representation for minimal surfaces, the authors can associate to each minimal disk with a polygonal boundary a real Fuchsian second order equation defined on the Riemann sphere. The monodromy of the equation is encoded by the oriented directions of the edges of the boundary.

To solve the Plateau problem, the authors are thus led to solve a Riemann–Hilbert problem. Then, they proceed in two steps: first, by means of isomonodromic deformations, they construct the family of all minimal disks with a polygonal boundary with given oriented directions. Then, by studying the edges’s lengths of these polygonal boundaries, they show that every polygon is the boundary of a minimal disk.

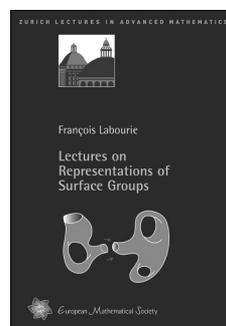
This item will also be of interest to those working in differential equations.

A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Surfaces minimales; Équations fuchsiennes et systèmes fuchsiens; Équation associée à un disque minimal à bord polygonal; Déformations isomonodromiques; Rapports de longueurs des côtés; A. Le système de Garnier; B. Démonstrations de résultats utilisés au chapitre 5; Bibliographie.

Mémoires de la Société Mathématique de France, Number 133

October 2013, 116 pages, Softcover, ISBN: 978-2-85629-766-7, 2010 *Mathematics Subject Classification*: 53A10, 34A30, 34M35, 34M50, 34M55, 32G34, **AMS members US\$38.40**, List US\$48, Order code SMFMEM/133



Lectures on Representations of Surface Groups

François Labourie, *Université Paris Sud, Orsay, France*

The subject of these notes is the character variety of representations of a surface group in a Lie group. The author emphasizes the various points of view (combinatorial, differential, and algebraic) and is interested in the description of its smooth points, symplectic structure, volume and connected components. He also shows how a three manifold bounded by the surface leaves a trace in this character variety.

These notes were originally designed for students with only elementary knowledge of differential geometry and topology. In the first chapters, the author does not focus on the details of the differential geometric constructions and refers to classical textbooks, while in the more advanced chapters proofs occasionally are provided only for special cases where they convey the flavor of the general arguments. These notes might also be used by researchers entering

this fast expanding field as motivation for further studies. The concluding paragraph of every chapter provides suggestions for further research.

A publication of the European Mathematical Society (EMS). Distributed within the Americas by the American Mathematical Society.

Contents: Introduction; Surfaces; Vector bundles and connections; Twisted cohomology; Moduli spaces; Symplectic structure; 3-manifolds and integrality questions; Bibliography; Index.

Zurich Lectures in Advanced Mathematics, Volume 17

December 2013, 146 pages, Softcover, ISBN: 978-3-03719-127-9, 2010 *Mathematics Subject Classification:* 53D30, 53C10, 58D27, 32G15, 58J28, **AMS members US\$30.40**, List US\$38, Order code EMSZLEC/17

Probability and Statistics



One-Dimensional General Forest Fire Processes

Xavier Bressaud, *Université Paul Sabatier, Toulouse, France*, and **Nicolas Fournier**, *Université Paris-Est, Créteil, France*

The authors consider the one-dimensional generalized forest fire process: at each

site of \mathbb{Z} , seeds and matches fall according to i.i.d. stationary renewal processes. When a seed falls on an empty site, a tree grows immediately. When a match falls on an occupied site, a fire starts and destroys immediately the corresponding connected component of occupied sites. Under some quite reasonable assumptions on the renewal processes, we show that when matches become less and less frequent, the process converges, with a correct normalization, to a limit forest fire model.

According to the nature of the renewal processes governing seeds, there are four possible limit forest fire models. The four limit processes can be perfectly simulated. This study generalizes consequently previous results where seeds and matches were assumed to fall according to Poisson processes.

This item will also be of interest to those working in mathematical physics.

A publication of the Société Mathématique de France, Marseilles (SMF), distributed by the AMS in the U.S., Canada, and Mexico. Orders from other countries should be sent to the SMF. Members of the SMF receive a 30% discount from list.

Contents: Introduction; Notation and results; Proofs; Numerical simulations; Appendix; Bibliography.

Mémoires de la Société Mathématique de France, Number 132

October 2013, 138 pages, Softcover, ISBN: 978-2-85629-765-0, 2010 *Mathematics Subject Classification:* 60K35, 82C22, **AMS members US\$38.40**, List US\$48, Order code SMFMEM/132



BASIC ERGODIC THEORY

THIRD EDITION

M. G. Nadkarni, *University of Mumbai, India*

This is an introductory text on ergodic theory. The presentation has a slow pace, and the book can be read by anyone with a background in basic measure theory and metric topology.

The third edition has, among other improvements, a new chapter on additional topics that include Liouville's theorem of classical mechanics, the basics of Shannon Entropy and the Kolmogorov-Sinai theorem, and van der Waerden's theorem on arithmetical progressions.

Hindustan Book Agency; 2013; 196 pages; Hardcover; ISBN: 978-93-80250-43-4; List US\$48; AMS members US\$38.40; Order code HIN/58

PROBABILITY THEORY

A FOUNDATIONAL COURSE

R. P. Pakshirajan, *University of Mysore, India*

This book shares the dictum of J. L. Doob in treating probability theory as a branch of measure theory and establishes this relationship early. Probability measures in product spaces are introduced right at the start as a way of laying the groundwork to later claim the existence of stochastic processes with prescribed finite-dimensional distributions.

Hindustan Book Agency; 2013; 564 pages; Hardcover; ISBN: 978-93-80250-44-1; List US\$68; AMS members US\$54.40; Order code HIN/60

ATIYAH-SINGER INDEX THEOREM

AN INTRODUCTION

Amiya Mukherjee, *Indian Statistical Institute, Calcutta, India*

This monograph is a thorough introduction to the Atiyah-Singer index theorem for elliptic operators on compact manifolds without boundary. The main theme is only the classical index theorem and some of its applications, but not the subsequent developments and simplifications of the theory.

Hindustan Book Agency; 2013; 276 pages; Hardcover; ISBN: 978-93-80250-54-0; List US\$60; AMS members US\$48; Order code HIN/64

SELECTED PAPERS OF V. S.

VARADARAJAN

VOLUMES 2 AND 3

Donald G. Babbitt and **Ramesh Gangolli**, *K. R. Parthasarathy*, *Indian Statistical Institute, New Delhi, India*, **Enrico G. Beltrametti** and **Gianni Cassinelli**, *University of Genova, Italy*, **Rita Fiorese**, *Università di Bologna, Italy*, and **Anatoly N. Kochubei**, *National Academy of Sciences of Ukraine, Kiev, Ukraine*, Editors

The current volumes contain the papers on fundamental questions of individual and families of meromorphic differential equations that are treated by a new group theoretic and functional approach; papers on representation theory of Lie groups; papers on foundations of physics, supersymmetry, and P-adic aspects of quantum physical theories; papers on analysis, especially oscillatory integrals, on semi-simple lie groups, their conjugacy classes, and their flag manifolds; and finally, several review articles, both personal and mathematical, on a number of the above topics.

Hindustan Book Agency; 2013; 1366 pages; Hardcover; ISBN: 978-93-80250-57-1; List US\$165; AMS members US\$132; Order code HIN/65

Publications of Hindustan Book Agency are distributed within the Americas by the American Mathematical Society. Maximum discount of 20% for all commercial channels.



Order Online:
www.ams.org/bookstore

Order by Phone:
(800) 321-4267 (U.S. & Canada),
(401) 455-4000 (Worldwide)

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.

Knoxville, Tennessee

University of Tennessee, Knoxville

March 21–23, 2014

Friday – Sunday

Meeting #1097

Southeastern Section

Associate secretary: Brian D. Boe

Announcement issue of *Notices*: January 2014

Program first available on AMS website: February 6, 2014

Program issue of electronic *Notices*: March 2014

Issue of *Abstracts*: Volume 35, Issue 2

Deadlines

For organizers: Expired

For abstracts: Expired

*The scientific information listed below may be dated.
For the latest information, see www.ams.org/amsmtg/sectional.html.*

Invited Addresses

Maria Chudnovsky, Columbia University, *Coloring graphs with forbidden induced subgraphs* (Erdős Memorial Lecture).

Ilse Ipsen, North Carolina State University, *Introduction to randomized matrix algorithms*.

Daniel Krashen, University of Georgia, *Algebraic structures and the arithmetic of fields*.

Suresh Venapally, Emory University, *Quadratic forms and Galois cohomology*.

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at <http://www.ams.org/cgi-bin/abstracts/abstract.pl>.

Algebraic Methods in Graph Theory and Combinatorics, **Felix Lazebnik**, University of Delaware, **Andrew Woldar**, Villanova University, and **Bangteng Xu**, Eastern Kentucky University.

Arithmetic of Algebraic Curves, **Lubjana Beshaj**, Oakland University, **Caleb Shor**, Western New England University, and **Andreas Malmendier**, Colby College.

Commutative Ring Theory (in honor of the retirement of David E. Dobbs), **David Anderson**, University of Tennessee, Knoxville, and **Jay Shapiro**, George Mason University.

Completely Integrable Systems and Dispersive Nonlinear Equations, **Robert Buckingham**, University of Cincinnati, and **Peter Perry**, University of Kentucky.

Complex Analysis, Probability, and Metric Geometry, **Matthew Badger**, Stony Brook University, **Jim Gill**, St. Louis University, and **Joan Lind**, University of Tennessee, Knoxville.

Discontinuous Galerkin Finite Element Methods for Partial Differential Equations, **Xiaobing Feng** and **Ohannes Karakashian**, University of Tennessee, Knoxville, and **Yulong Xing**, University of Tennessee, Knoxville, and Oak Ridge National Laboratory.

Diversity of Modeling and Optimal Control: A Celebration of Suzanne Lenhart's 60th Birthday, **Wandi Ding**, Middle Tennessee State University, and **Renee Fister**, Murray State University.

Fractal Geometry and Ergodic Theory, **Mrinal Kanti Roychowdhury**, University of Texas Pan American.

Galois Cohomology and the Brauer Group, **Ben Antieau**, University of Washington, **Daniel Krashen**, University of Georgia, and **Suresh Venapally**, Emory University.

Geometric Topology, **Craig Guilbault**, University of Wisconsin-Milwaukee, and **Steve Ferry**, Rutgers University.

Geometric Topology and Number Theory, **Eriko Hiro-naka** and **Kathleen Petersen**, Florida State University.

Geometric and Algebraic Combinatorics, **Benjamin Braun** and **Carl Lee**, University of Kentucky.

Geometric and Combinatorial Methods in Lie Theory, **Amber Russell** and **William Graham**, University of Georgia.

Graph Theory, **Chris Stephens**, **Dong Ye**, and **Xiaoya Zha**, Middle Tennessee State University.

Harmonic Analysis and Nonlinear Partial Differential Equations, **J. Denzler**, **M. Frazier**, **Tuoc Phan**, and **T. Todorova**, University of Tennessee, Knoxville.

Invariant Subspaces of Function Spaces, **Catherine Beneteau**, University of South Florida, **Alberto A. Condori**, Florida Gulf Coast University, **Constanze Liaw**, Baylor University, and **Bill Ross**, University of Richmond.

Mathematical Modeling of the Within- and Between-Host Dynamics of Infectious Diseases, **Megan Powell**, University of St. Francis, and **Judy Day** and **Vitaly Ganusov**, University of Tennessee, Knoxville.

Mathematical Physics and Spectral Theory, **Roger Nichols**, The University of Tennessee at Chattanooga, and **Günter Stolz**, University of Alabama at Birmingham.

Metric Geometry and Topology, **Catherine Searle**, Oregon State University, **Jay Wilkins**, University of Connecticut, and **Conrad Plaut**, University of Tennessee, Knoxville.

Nonlinear Partial Differential Equations in the Applied Sciences, **Lorena Bociu**, North Carolina State University, **Ciprian Gal**, Florida International University, and **Daniel Toundykov**, University of Nebraska-Lincoln.

Randomized Numerical Linear Algebra, **Ilse Ipsen**, North Carolina State University.

Recent Development on Hyperbolic Conservation Laws, **Geng Chen**, **Ronghua Pan**, and **Weizhe Zhang**, Georgia Tech.

Scientific Computing, Numerical Analysis, and Mathematical Modeling, **Vasilios Alexiades**, **Xiaobing Feng**, and **Steven Wise**, University of Tennessee, Knoxville.

Singularities and Physics, **Mboyo Esole**, Harvard University, and **Paolo Aluffi**, Florida State University.

Stochastic Processes and Related Topics, **Jan Rosinski** and **Jie Xiong**, University of Tennessee, Knoxville.

Von Neumann Algebras and Free Probability, **Remus Nicoara**, University of Tennessee, Knoxville, and **Arnaud Brothier**, Vanderbilt University.

Baltimore, Maryland

University of Maryland, Baltimore County

March 29–30, 2014

Saturday – Sunday

Meeting #1098

Eastern Section

Associate secretary: Steven H. Weintraub

Announcement issue of *Notices*: January 2014

Program first available on AMS website: February 26, 2014

Program issue of electronic *Notices*: March 2014

Issue of *Abstracts*: Volume 35, Issue 2

Deadlines

For organizers: 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

Maria Gordina, University of Connecticut, *Stochastic analysis and geometric functional inequalities*.

L. Mahadevan, Harvard University, *Shape: Mathematics, physics, and biology*.

Nimish Shah, Ohio State University, *Dynamics of subgroup actions on homogeneous spaces and its interaction with number theory*.

Dani Wise, McGill University, *Cube complexes*.

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at <http://www.ams.org/cgi-bin/abstracts/abstract.pl>.

Data Assimilation Applied to Controlled Systems, **Damon McDougall**, University of Texas at Austin, and **Richard Moore**, New Jersey Institute of Technology.

Difference Equations and Applications, **Michael Radin**, Rochester Institute of Technology.

Discrete Geometry in Crystallography, **Egon Schulte**, Northeastern University, and **Marjorie Senechal**, Smith College.

Harmonic Analysis and Its Applications, **Susanna Dann**, University of Missouri, **Azita Mayeli**, Queensborough College, City University of New York, and **Gestur Olafsson**, Louisiana State University.

Interaction between Complex and Geometric Analysis, **Peng Wu**, Cornell University, and **Yuan Yuan**, Syracuse University.

Invariants in Low-Dimensional Topology, **Jennifer Hom**, Columbia University, and **Tye Lidman**, University of Texas at Austin.

Knots and Applications, **Louis Kauffman**, University of Illinois at Chicago, **Samuel Lomonaco**, University of

Maryland, Baltimore County, and **Jozef Przytycki**, George Washington University.

Low-dimensional Topology and Group Theory, **David Futer**, Temple University, and **Daniel Wise**, McGill University.

Mathematical Biology, **Jonathan Bell** and **Brad Peercy**, University of Maryland Baltimore County.

Mathematical Finance, **Agostino Capponi**, John Hopkins University.

Mechanics and Control, **Jinglai Shen**, University of Maryland Baltimore County, and **Dmitry Zenkov**, North Carolina State University.

Novel Developments in Tomography and Applications, **Alexander Katevich**, **Alexandru Tamasan**, and **Alexander Tovbis**, University of Central Florida.

Open Problems in Stochastic Analysis and Related Fields, **Masha Gordina**, University of Connecticut, and **Tai Melcher**, University of Virginia.

Optimization and Related Topics, **M. Seetharama Gowda**, **Osman Guler**, **Florian Potra**, and **Jinlai Shen**, University of Maryland at Baltimore County.

Substitution and Tiling Dynamical Systems, **Natalie Priebe Frank**, Vassar College, and **E. Arthur Robinson Jr.**, George Washington University.

Theory and Applications of Differential Equations on Graphs, **Jonathan Bell**, University of Maryland Baltimore County, and **Sergei Avdonin**, University of Alaska Fairbanks.

Undergraduate Research and its Impact on Students and Faculty, **Matthias Gobbert** and **Nagaraj Neerchal**, University of Maryland, Baltimore County, and **Padmanabhan Seshaiyer**, George Mason University.

Albuquerque, New Mexico

University of New Mexico

April 5–6, 2014

Saturday – Sunday

Meeting #1099

Western Section

Associate secretary: Michel L. Lapidus

Announcement issue of *Notices*: January 2014

Program first available on AMS website: To be announced

Program issue of electronic *Notices*: April 2014

Issue of *Abstracts*: Volume 35, Issue 2

Deadlines

For organizers: Expired

For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtg/section1.html.

Invited Addresses

Anton Gorodetski, University of California Irvine, *Hyperbolic dynamics and spectral properties of one-dimensional quasicrystals*.

Fan Chung Graham, University of California, San Diego, *Some problems and results in spectral graph theory*.

Adrian Ioana, University of California, San Diego, *Rigidity for von Neumann algebras and ergodic group actions*.

Karen Smith, University of Michigan, Ann Arbor, *The power of characteristic p* .

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at <http://www.ams.org/cgi-bin/abstracts/abstract.pl>.

Analysis and Topology in Special Geometries, **Charles Boyer**, **Daniele Grandini**, and **Dimitar Vassilev**, University of New Mexico.

Arithmetic and Differential Algebraic Geometry, **Alexandru Buium**, University of New Mexico, **Taylor Dupuy**, University of California, Los Angeles, and **Lance Edward Miller**, University of Arkansas.

Commutative Algebra, **Daniel J. Hernandez**, University of Utah, **Karen E. Smith**, University of Michigan, and **Emily E. Witt**, University of Minnesota.

Descriptive Set Theory and its Applications, **Alexander Kechris**, California Institute of Technology, and **Christian Rosendal**, University of Illinois, Chicago.

Flat Dynamics, **Jayadev Athreya**, University of Illinois, Urbana-Champaign, **Robert Niemeyer**, University of New Mexico, Albuquerque, **Richard E. Schwartz**, Brown University, and **Sergei Tabachnikov**, The Pennsylvania State University.

Harmonic Analysis and Dispersive Equations, **Matthew Blair**, University of New Mexico, and **Jason Metcalfe**, University of North Carolina.

Harmonic Analysis and Its Applications, **Jens Gerlach Christensen**, Colgate University, and **Joseph Lakey** and **Nicholas Michalowski**, New Mexico State University.

Harmonic Analysis and Operator Theory (in memory of Cora Sadosky), **Laura De Carli**, Florida International University, **Alex Stokolos**, Georgia Southern University, and **Wilfredo Urbina**, Roosevelt University.

Hyperbolic Dynamics, Dynamically Defined Fractals, and Applications, **Anton Gorodetski**, University of California Irvine.

Interactions in Commutative Algebra, **Louiza Fouli** and **Bruce Olberding**, New Mexico State University, and **Janet Vassilev**, University of New Mexico.

Mathematical Finance, **Indranil SenGupta**, North Dakota State University.

Modeling Complex Social Processes Within and Across Levels of Analysis, **Simon DeDeo**, Indiana University, and **Richard Niemeyer**, University of Colorado, Denver.

Nonlinear Waves and Singularities in Water Waves, Optics and Plasmas, **Alexander O. Korotkevich** and **Pavel Lushnikov**, University of New Mexico, Albuquerque.

Partial Differential Equations in Materials Science, **Lia Bronsard**, McMaster University, and **Tiziana Giorgi**, New Mexico State University.

Physical Knots, honoring the retirement of Jonathan K. Simon, **Greg Buck**, St. Anselm College, and **Eric Rawdon**, University of St. Thomas.

Progress in Noncommutative Analysis, **Anna Skripka**, University of New Mexico, and **Tao Mei**, Wayne State University.

Spectral Theory, **Milivoje Lukic**, Rice University, and **Maxim Zinchenko**, University of New Mexico.

Stochastic Processes in Noncommutative Probability, **Michael Anshelevich**, Texas A&M University, and **Todd Kemp**, University of California San Diego.

Stochastics and PDEs, **Juraj Földes**, Institute for Mathematics and Its Applications, **Nathan Glatt-Holtz**, Institute for Mathematics and Its Applications and Virginia Tech, and **Geordie Richards**, Institute for Mathematics and Its Applications and University of Rochester.

The Common Core and University Mathematics Instruction, **Justin Boyle**, **Michael Nakamaye**, and **Kristin Umland**, University of New Mexico.

The Inverse Problem and Other Mathematical Methods Applied in Physics and Related Sciences, **Hanna Makaruk**, Los Alamos National Laboratory, and **Robert Owczarek**, University of New Mexico and Enfitek, Inc.

Topics in Spectral Geometry and Global Analysis, **Ivan Avramidi**, New Mexico Institute of Mining and Technology, and **Klaus Kirsten**, Baylor University.

Weighted Norm Inequalities and Related Topics, **Oleksandra Beznosova**, Baylor University, **David Cruz-Uribe**, Trinity College, and **Cristina Pereyra**, University of New Mexico.

Lubbock, Texas

Texas Tech University

April 11–13, 2014

Friday – Sunday

Meeting #1100

Central Section

Associate secretary: Georgia Benkart

Announcement issue of *Notices*: January 2014

Program first available on AMS website: February 27, 2014

Program issue of electronic *Notices*: April 2014

Issue of *Abstracts*: Volume 35, Issue 2

Deadlines

For organizers: Expired

For abstracts: Expired

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtg/sectional.html.

Invited Addresses

Nir Avni, Northwestern University, *To be announced.*

Alessio Figalli, University of Texas, *To be announced.*
Jean-Luc Thiffeault, University of Wisconsin-Madison, *To be announced.*

Rachel Ward, University of Texas at Austin, *To be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at <http://www.ams.org/cgi-bin/abstracts/abstract.pl>.

Algebraic Geometry, **David Weinberg**, Texas Tech University.

Analysis and Applications of Dynamic Equations on Time Scales, **Heidi Berger**, Simpson College, and **Raegan Higgins**, Texas Tech University.

Applications of Special Functions in Combinatorics and Analysis, **Atul Dixit**, Tulane University, and **Timothy Huber**, University of Texas Pan American.

Approximation Theory in Signal Processing, **Rachel Ward**, University of Texas at Austin, and **Rayan Saab**, University of California San Diego.

Complex Function Theory and Special Functions, **Roger W. Barnard** and **Kent Pearce**, Texas Tech University, **Kendall Richards**, Southwestern University, and **Alex Solynin** and **Brock Williams**, Texas Tech University.

Developments from PASI 2012: Commutative Algebra and Interactions with Related Disciplines, **Kenneth Chan**, University of Washington, and **Jack Jeffries**, University of Utah.

Differential Algebra and Galois Theory, **Lourdes Juan** and **Arne Ledet**, Texas Tech University, **Andy R. Magid**, University of Oklahoma, and **Michael F. Singer**, North Carolina State University.

Fractal Geometry and Dynamical Systems, **Mrinal Kanti Roychowdhury**, The University of Texas-Pan American.

Geometry and Geometric Analysis, **Lance Drager** and **Jeffrey M. Lee**, Texas Tech University.

Homological Methods in Algebra, **Lars W. Christensen**, Texas Tech University, **Hamid Rahmati**, Miami University, and **Janet Striuli**, Fairfield University.

Hysteresis and Multi-rate Processes, **Ram Iyer**, Texas Tech University.

Interactions between Commutative Algebra and Algebraic Geometry, **Brian Harbourne** and **Alexandra Seceleanu**, University of Nebraska-Lincoln.

Issues Regarding the Recruitment and Retention of Women and Minorities in Mathematics, **James Valles Jr.**, Prairie View A&M University, and **Doug Scheib**, Saint Mary-of-the-Woods College.

Lie Groups, **Benjamin Harris**, **Hongyu He**, and **Gestur Ólafsson**, Louisiana State University.

Linear Operators in Representation Theory and in Applications, **Markus Schmidmeier**, Florida Atlantic University, and **Gordana Todorov**, Northeastern University.

Mathematical Models of Infectious Diseases in Plants, Animals and Humans, **Linda Allen**, Texas Tech University, and **Vrushal Bokil**, Oregon State University.

Navier-Stokes Equations and Fluid Dynamics, **Radu Dascalu**, Oregon State University, and **Luan Hoang**, Texas Tech University.

Noncommutative Algebra, Deformations, and Hochschild Cohomology, **Anne Shepler**, University of North Texas, and **Sarah Witherspoon**, Texas A&M University.

Numerical Methods for Systems of Partial Differential Equations, **JaEun Ku**, Oklahoma State University, and **Young Ju Lee**, Texas State University.

Optimal Control Problems from Neuron Ensembles, Genomics and Mechanics, **Bijoy K. Ghosh** and **Clyde F. Martin**, Texas Tech University.

Qualitative Theory for Non-linear Parabolic and Elliptic Equations, **Akif Ibragimov**, Texas Tech University, and **Peter Polacik**, University of Minnesota.

Recent Advancements in Differential Geometry and Integrable PDEs, and Their Applications to Cell Biology and Mechanical Systems, **Giorgio Bornia**, **Akif Ibragimov**, and **Magdalena Toda**, Texas Tech University.

Recent Advances in the Applications of Nonstandard Finite Difference Schemes, **Ronald E. Mickens**, Clark Atlanta University, and **Lih-Ing W. Roeger**, Texas Tech University.

Recent Developments in Number Theory, **Dermot McCarthy** and **Chris Monico**, Texas Tech University.

Statistics on Manifolds, **Leif Ellingson**, Texas Tech University.

Topology and Physics, **Razvan Gelca** and **Alastair Hamilton**, Texas Tech University.

Undergraduate Research, **Jerry Dwyer**, **Levi Johnson**, **Jessica Spott**, and **Brock Williams**, Texas Tech University.

Tel Aviv, Israel

Bar-Ilan University, Ramat-Gan and Tel-Aviv University, Ramat-Aviv

June 16–19, 2014

Monday - Thursday

Meeting #1101

The Second Joint International Meeting between the AMS and the Israel Mathematical Union.

Associate secretary: Michel L. Lapidus

Announcement issue of *Notices*: January 2014

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 abstracts: To be announced

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/internmtgs.html.

Invited Addresses

Ian Agol, University of California, Berkeley, *3-manifolds and cube complexes*.

Gil Kalai, Hebrew University, *Influence, thresholds, and noise sensitivity*.

Michael Larsen, Indiana University, *Borel's theorem on word maps and some recent variants*.

Leonid Polterovich, Tel-Aviv University, *Symplectic topology: from dynamics to quantization*.

Tamar Zeigler, Technion, Israel Institute of Technology, *Patterns in primes and dynamics on nilmanifolds*.

Special Sessions

Additive Number Theory, **Melvyn B. Nathanson**, City University of New York, and **Yonutz V. Stanchescu**, Afeka Tel Aviv Academic College of Engineering.

Algebraic Groups, Division Algebras and Galois Cohomology, **Andrei Rapinchuk**, University of Virginia, and **Louis H. Rowen** and **Uzi Vishne**, Bar Ilan University.

Applications of Algebra to Cryptography, **David Garber**, Holon Institute of Technology, and **Delaram Kahrobaei**, City University of New York Graduate Center.

Asymptotic Geometric Analysis, **Shiri Artstein** and **Boaz Klar'tag**, Tel Aviv University, and **Sasha Sodin**, Princeton University.

Combinatorial Games, **Aviezri Fraenkel**, Weizmann University, **Richard Nowakowski**, Dalhousie University, Canada, **Thane Plambeck**, Counterwave Inc., and **Aaron Siegel**, Twitter.

Combinatorics, **Gil Kalai**, Hebrew University of Jerusalem.

Dynamics and Number Theory, **Alex Kontorovich**, Yale University.

Field Arithmetic, **David Harbater**, University of Pennsylvania, and **Moshe Jarden**, Tel Aviv University.

Financial Mathematics, **Jean-Pierre Fouque**, University of California, and **Eli Merzbach** and **Malka Schaps**, Bar Ilan University.

Geometric Group Theory and Low-Dimensional Topology, **Ian Agol**, University of California, Berkeley, and **Zlil Sela**, Hebrew University.

Geometry and Dynamics, **Yaron Ostrover**, Tel Aviv University.

History of Mathematics, **Leo Corry**, Tel Aviv University, **Michael N. Fried**, Ben Gurion University, and **Victor Katz**, University of District of Columbia.

Mirror Symmetry and Representation Theory, **Roman Bezrukavnikov**, Massachusetts Institute of Technology, and **David Kazhdan**, Hebrew University.

Nonlinear Analysis and Optimization, **Boris Mordukhovich**, Wayne State University, and **Simeon Reich** and **Alexander Zaslavski**, Technion Israel Institute of Technology.

PDEs: Modeling Theory and Numerics, **Edriss S. Titi**, University of California Irvine.

Qualitative and Analytic Theory of ODE's, **Andrei Gabri- elov**, Purdue University, and **Yossef Yomdin**, Weizmann Institute of Science.

Quasigroups, Loops and Applications, **Tuval Foguel**, Western Carolina University.

Random Matrix Theory, **Brendan Farrell**, California Institute of Technology, **Mark Rudelson**, University of Michigan, and **Ofer Zeitouni**, Weizmann Institute of Science.

Recent Trends in History and Philosophy of Mathematics, **Misha Katz**, Bar Ilan University, and **David Sherry**, Northern Arizona University.

Teaching with Mathematical Habits in Mind, **Theodore Eisenberg**, Ben Gurion University, **Davida Fishman**, California State University, San Bernardino, and **Jennifer Lewis**, Wayne State University.

The Mathematics of Menahem M. Schiffer, **Peter L. Duren**, University of Michigan, and **Lawrence Zalcman**, Bar Ilan University.

Topological Graph Theory and Map Symmetries, **Jonathan Gross**, Columbia University, and **Toufik Mansour**, University of Haifa.

Eau Claire, Wisconsin

University of Wisconsin-Eau Claire

September 20–21, 2014

Saturday – Sunday

Meeting #1102

Central Section

Associate secretary: Georgia Benkart

Announcement issue of *Notices*: June 2014

Program first available on AMS website: August 7, 2014

Program issue of electronic *Notices*: September 2014

Issue of *Abstracts*: Volume 35, Issue 3

Deadlines

For organizers: March 20, 2014

For abstracts: July 29, 2014

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtg/sectional.html.

Invited Addresses

Matthew Kahle, Ohio State University, *To be announced.*

Markus Keel, University of Minnesota, *To be announced.*

Svitlana Mayboroda, University of Minnesota, *To be announced.*

Dylan Thurston, Indiana University, *To be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at <http://www.ams.org/cgi-bin/abstracts/abstract.pl>.

Algebraic Combinatorics (Code: SS 8A), **Pavlo Pylyavskyy**, **Victor Reiner**, and **Dennis Stanton**, University of Minnesota.

Cohomology and Representation Theory of Groups and Related Structures (Code: SS 6A), **Christopher Bendel**, University of Wisconsin-Stout, and **Christopher Drupieski**, De Paul University.

Commutative Ring Theory (Code: SS 3A), **Michael Axte**, University of St. Thomas, and **Joe Stickles**, Millikin University.

Directions in Commutative Algebra: Past, Present and Future (Code: SS 1A), **Joseph P. Brennan**, University of Central Florida, and **Robert M. Fossum**, University of Illinois at Urbana-Champaign.

Graph and Hypergraph Theory (Code: SS 7A), **Sergei Bezrukov**, University of Wisconsin-Superior, **Dalibor Froncek**, University of Minnesota Duluth, and **Xiaofeng Gu**, **Uwe Leck**, and **Steven Rosenberg**, University of Wisconsin-Superior.

Lie Algebras and Representation Theory (Code: SS 5A), **Michael Lau**, Université Laval, **Ian Musson**, University of Wisconsin, Milwaukee, and **Matthew Ondrus**, Weber State University.

New Trends in Toric Varieties (Code: SS 4A), **Christine Berkesch Zamaere**, University of Minnesota, **Daniel Erman**, University of Wisconsin-Madison, and **Hal Schenck**, University of Illinois Urbana-Champaign.

Von Neumann Algebras and Related Fields (Code: SS 2A), **Stephen Avsec** and **Ken Dykema**, Texas A&M University.

Halifax, Canada

Dalhousie University

October 18–19, 2014

Saturday – Sunday

Meeting #1103

Eastern Section

Associate secretary: Steven H. Weintraub

Announcement issue of *Notices*: August 2014

Program first available on AMS website: September 5, 2014

Program issue of electronic *Notices*: October 2014

Issue of *Abstracts*: Volume 35, Issue 3

Deadlines

For organizers: March 18, 2014

For abstracts: August 19, 2014

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtg/sectional.html.

Invited Addresses

François Bergeron, Université du Québec à Montréal, *Title to be announced.*

Sourav Chatterjee, New York University, *Title to be announced.*

William M. Goldman, University of Maryland, *Title to be announced.*

Sujatha Ramdorai, University of British Columbia, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at <http://www.ams.org/cgi-bin/abstracts/abstract.pl>.

Commutative Algebra and Its Interactions with Algebraic Geometry (Code: SS 2A), **Susan Marie Cooper**, Central Michigan University, **Sara Faridi**, Dalhousie University, and **William Traves**, U.S. Naval Academy.

Sampling Theory (Code: SS 4A), **John J. Benedetto**, University of Maryland, **Jean-Pierre Gabardo**, McMaster University, and **Ozgun Yilmaz**, University of British Columbia.

Special Functions and Their Applications (Code: SS 3A), **Mourad E. H. Ismail**, University of Central Florida, and **Nasser Saad**, University of Prince Edward Island.

p-adic Methods in Arithmetic (Code: SS 1A), **Henri Darmon**, McGill University, **Adrian Iovita**, Concordia University, and **Sujatha Ramdorai**, University of British Columbia.

San Francisco, California

San Francisco State University

October 25–26, 2014

Saturday – Sunday

Meeting #1104

Western Section

Associate secretary: Michel L. Lapidus

Announcement issue of *Notices*: August 2014

Program first available on AMS website: September 11, 2014

Program issue of electronic *Notices*: October 2014

Issue of *Abstracts*: Volume 35, Issue 4

Deadlines

For organizers: March 25, 2014

For abstracts: September 3, 2014

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Kai Behrend, University of British Columbia, Vancouver, Canada, *Title to be announced.*

Kiran S. Kedlaya, University of California, San Diego, *Title to be announced.*

Julia Pevtsova, University of Washington, Seattle, *Title to be announced.*

Burt Totaro, University of California, Los Angeles, *Title to be announced.*

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at <http://www.ams.org/cgi-bin/abstracts/abstract.pl>.

Algebraic Geometry (Code: SS 1A), **Renzo Cavalieri**, Colorado State University, **Noah Giansiracusa**, University of California, Berkeley, and **Burt Totaro**, University of California, Los Angeles.

Categorical Methods in Representation Theory (Code: SS 4A), **Eric Friedlander**, University of Southern California, **Srikanth Iyengar**, University of Nebraska, Lincoln, and **Julia Pevtsova**, University of Washington.

Geometry of Submanifolds (Code: SS 3A), **Yun Myung Oh**, Andrews University, **Bogdan D. Suceava**, California State University, Fullerton, and **Mihaela B. Vajiac**, Chapman University.

Polyhedral Number Theory (Code: SS 2A), **Matthias Beck**, San Francisco State University, **Martin Henk**, Universität Magdeburg, and **Joseph Gubeladze**, San Francisco State University.

Recent Progress in Geometric Analysis (Code: SS 5A), **David Bao**, San Francisco State University, and **Ovidiu Munteanu**, University of Connecticut.

Greensboro, North Carolina

University of North Carolina, Greensboro

November 8–9, 2014

Saturday – Sunday

Meeting #1105

Southeastern Section

Associate secretary: Brian D. Boe

Announcement issue of *Notices*: August 2014

Program first available on AMS website: September 25, 2014

Program issue of electronic *Notices*: November 2014

Issue of *Abstracts*: Volume 35, Issue 4

Deadlines

For organizers: April 8, 2014

For abstracts: September 16, 2014

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtgs/sectional.html.

Invited Addresses

Susanne Brenner, Louisiana State University, *Title to be announced.*

Skip Garibaldi, Emory University, *Title to be announced.*

Stavros Garoufaldis, Georgia Institute of Technology, *Title to be announced.*

James Sneyd, University of Auckland, *Title to be announced* (AMS-NZMS Maclaurin Lecture).

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at <http://www.ams.org/cgi-bin/abstracts/abstract.pl>.

Difference Equations and Applications (Code: SS 1A), **Michael A. Radin**, Rochester Institute of Technology, and **Youssef Raffoul**, University of Dayton.

San Antonio, Texas

Henry B. Gonzalez Convention Center and Grand Hyatt San Antonio

January 10–13, 2015

Saturday – Tuesday

Meeting #1106

Joint Mathematics Meetings, including the 121st Annual Meeting of the AMS, 98th Annual Meeting of the Mathematical Association of America (MAA), 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 (ASL), 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: Not applicable

Program issue of electronic *Notices*: January 2015

Issue of *Abstracts*: Volume 36, Issue 1

Deadlines

For organizers: April 1, 2014

For abstracts: To be announced

Washington, District of Columbia

Georgetown University

March 7–8, 2015

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: August 7, 2014

For abstracts: To be announced

East Lansing, Michigan

Michigan State University

March 13–15, 2015

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: To be announced

For abstracts: To be announced

Huntsville, Alabama

University of Alabama in Huntsville

March 27–29, 2015

Friday – Sunday

Southeastern Section

Associate secretary: Brian D. Boe

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 20, 2014

For abstracts: To be announced

Las Vegas, Nevada

University of Nevada, Las Vegas

April 18–19, 2015

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: September 18, 2014

For abstracts: To be announced

Porto, Portugal

University of Porto

June 10–13, 2015

Wednesday – Saturday

First Joint International Meeting involving the American Mathematical Society (AMS), the European Mathematical Society (EMS), and the Sociedade de Portuguesa Matematica (SPM).

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 abstracts: To be announced

Chicago, Illinois

Loyola University Chicago

October 3–4, 2015

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*: October 2015

Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 10, 2015

For abstracts: To be announced

Memphis, Tennessee

University of Memphis

October 17–18, 2015

Saturday – Sunday

Southeastern Section

Associate secretary: Brian D. Boe

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 17, 2015

For abstracts: August 18, 2015

The scientific information listed below may be dated. For the latest information, see www.ams.org/amsmtg/sectional.html.

Special Sessions

If you are volunteering to speak in a Special Session, you should send your abstract as early as possible via the abstract submission form found at <http://www.ams.org/cgi-bin/abstracts/abstract.pl>.

Computational Analysis (Code: SS 1A), George Anastassiou, University of Memphis.

Fullerton, California

California State University, Fullerton

October 24–25, 2015

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*: October 2015

Issue of *Abstracts*: To be announced

Deadlines

For organizers: March 27, 2015

For abstracts: To be announced

New Brunswick, New Jersey

Rutgers University

November 14–15, 2015

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: 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 (MAA), 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 (ASL), 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 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: Brian D. Boe

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 abstracts: To be announced

Charleston, South Carolina

College of Charleston

March 10–12, 2017

Friday – Sunday

Southeastern Section

Associate secretary: Brian D. Boe

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: November 10, 2016

For abstracts: To be announced

Pullman, Washington

Washington State University

April 22–23, 2017

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: 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 (MAA), 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 (ASL), with sessions contributed by the Society for Industrial and Applied Mathematics (SIAM).

Associate secretary: Georgia Benkart

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 abstracts: To be announced

Meetings and Conferences of the AMS

Associate Secretaries of the AMS

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: Brian D. Boe, Department of Mathematics, University of Georgia, 220 D W Brooks Drive, Athens, GA 30602-7403, e-mail: brian@math.uga.edu; telephone: 706-542-2547.

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.

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:

2014

March 21-23	Knoxville, Tennessee	p. 326
March 29-30	Baltimore, Maryland	p. 327
April 5-6	Albuquerque, New Mexico	p. 328
April 11-13	Lubbock, Texas	p. 329
June 16-19	Tel Aviv, Israel	p. 330
September 20-21	Eau Claire, Wisconsin	p. 331
October 18-19	Halifax, Canada	p. 331
October 25-26	San Francisco, California	p. 332
November 8-9	Greensboro, North Carolina	p. 332

2015

January 10-13	San Antonio, Texas Annual Meeting	p. 333
March 7-8	Washington, DC	p. 333
March 13-15	East Lansing, Michigan	p. 333
March 20-22	Huntsville, Alabama	p. 333
April 18-19	Las Vegas, Nevada	p. 333
June 10-13	Porto, Portugal	p. 334
October 3-4	Chicago, Illinois	p. 334
October 17-18	Memphis, Tennessee	p. 334
October 24-25	Fullerton, California	p. 334
November 14-15	New Brunswick, New Jersey	p. 334

2016

January 6-9	Seattle, Washington Annual Meeting	p. 334
-------------	---------------------------------------	--------

2017

January 4-7	Atlanta, Georgia Annual Meeting	p. 335
March 10-12	Charleston, South Carolina	p. 335
April 22-23	Pullman, Washington	p. 335

2018

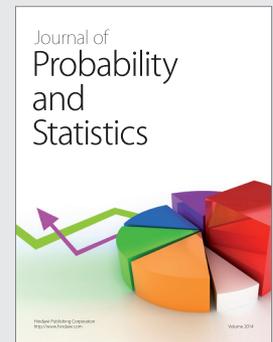
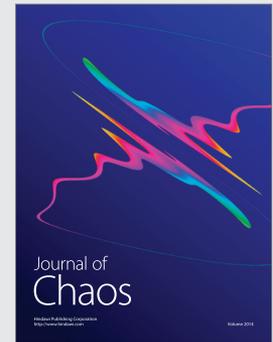
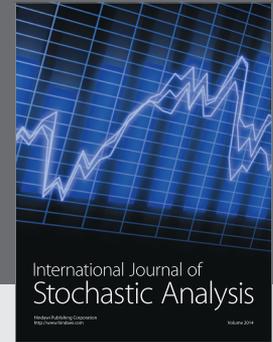
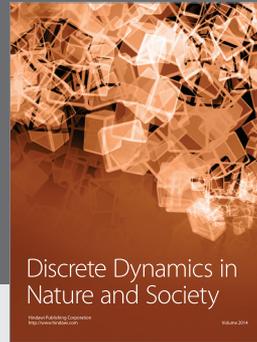
January 10-13	San Diego, California Annual Meeting	p. 335
---------------	---	--------

Important Information Regarding AMS Meetings

Potential organizers, speakers, and hosts should refer to page 99 in the January 2014 issue of the *Notices* for general information regarding participation in AMS meetings and conferences.

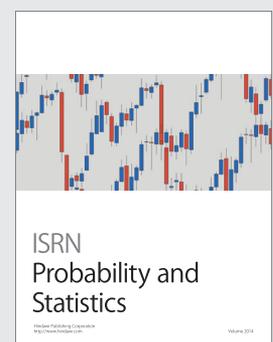
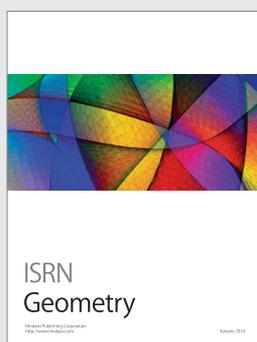
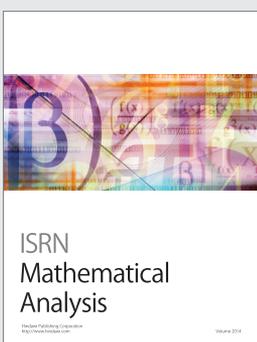
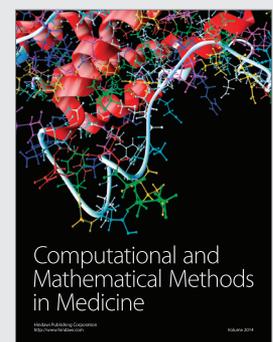
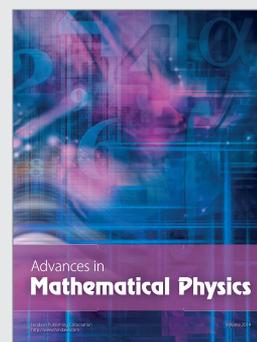
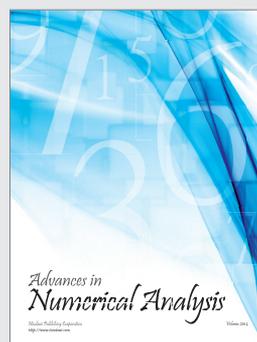
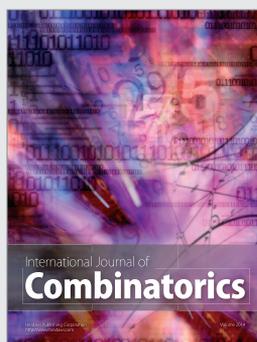
Abstracts

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.



Hindawi

Submit your manuscripts at
<http://www.hindawi.com>



March is Women's History Month: Celebrating Contemporary Works By and About Female Mathematicians

American Mathematical Society Distribution Center
35 Monticello Place, Pawtucket, RI 02861 USA



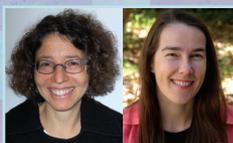
Difference Sets TEXTBOOK

Connecting Algebra, Combinatorics, and Geometry

Emily H. Moore, Grinnell College, IA, and **Harriet S. Pollatsek**, Mount Holyoke College, South Hadley, MA

Difference sets belong both to group theory and to combinatorics, and studying them requires tools from geometry, number theory, and representation theory. This book lays a foundation for these topics, including a primer on representations and characters of finite groups. The goal of the authors was to serve prospective undergraduate researchers of difference sets, as well as to provide a rich text for a senior seminar or capstone course in mathematics with the hope that readers will acquire a solid foundation that will empower them to explore the literature on difference sets independently.

Student Mathematical Library, Volume 67; 2013; 298 pages; Softcover; ISBN: 978-0-8218-9176-6; List US\$49; AMS members US\$39.20; Order code STML/67



Harmonic Analysis Applied Mathematics

From Fourier to Wavelets

María Cristina Pereyra, The University of New Mexico, Albuquerque, NM, and **Lesley A. Ward**, University of South Australia, Mawson Lakes Campus, Adelaide, Australia

This rich and engaging text is an introduction to serious analysis and computational harmonic analysis through the lens of Fourier and wavelet analysis. Through an accessible combination of rigorous proof, inviting motivation, and numerous applications (plus over 300 exercises), the authors convey the remarkable beauty and applicability of the ideas that have grown from Fourier theory. Ideal for an advanced undergraduate and beginning graduate student audience

Student Mathematical Library, Volume 63; 2012; 410 pages; Softcover; ISBN: 978-0-8218-7566-7; List US\$58; AMS members US\$46.40; Order code STML/63

Pioneering Women in American Mathematics The Pre-1940 PhD's

Judy Green, Marymount University, Arlington, VA, and **Jeanne LaDuke**, DePaul University, Chicago, IL

What a service Judy Greene and Jeanne LaDuke have done the mathematics community! Approximately thirty years of research have produced a detailed picture of graduate mathematics for women in the United States before 1940. ... The book is well-organized and well-written, and I recommend it heartily to all.

—*AWM Newsletter*

History of Mathematics, Volume 34; 2009; 345 pages; Hardcover; ISBN: 978-0-8218-4376-5; List US\$81; AMS members US\$64.80; Order code HMATH/34

Change Is Possible Stories of Women and Minorities in Mathematics

Patricia Clark Kenschaft, Montclair State University, Upper Montclair, NJ

Kenschaft reveals the passions that motivated past and present mathematicians and the obstacles they overcame to achieve their dreams. Through research and in-depth personal interviews, she has explored the sensitive issues of racism and sexism, rejoicing in positive changes and alerting us to issues that still need our attention.

—*Claudia Zaslavsky, the author of "Africa Counts" and other books on equality issues in mathematics education*

2005; 212 pages; Softcover; ISBN: 978-0-8218-3748-1; List US\$32; AMS members US\$25.60; Order code CHANGE

Women in Numbers 2 Research Directions in Number Theory

Chantal David, Concordia University, Montreal, Quebec, Canada, **Matilde Lalin**, University of Montreal, Quebec, Canada, and **Michelle Manes**, University of Hawaii, Honolulu, HI, Editors

The articles collected in this volume encompass a wide range of topics in number theory including Galois representations, the Tamagawa number conjecture, arithmetic intersection formulas, Mahler measures, and more.

This book is co-published with the Centre de Recherches Mathématiques.

Contemporary Mathematics, Volume 606; 2013; 206 pages; Softcover; ISBN: 978-1-4704-1022-3; List US\$76; AMS members US\$60.80; Order code CONM/606

Computability Theory

Rebecca Weber, Dartmouth College, Hanover, NH

[An] interesting and very well-written book. ... As a result of good, clear writing, appeal to intuition when appropriate, and careful attention to the needs of a student-reader, Weber's book ... seems to be as accessible to undergraduates as is reasonably possible; anybody contemplating teaching a course in this subject will certainly want to carefully examine it, as will any student in such a course. The book should also prove valuable to people wanting to learn this material by self-study.

—*Mark Hunacek, MAA Reviews*

Student Mathematical Library, Volume 62; 2012; 203 pages; Softcover; ISBN: 978-0-8218-7392-2; List US\$37; AMS members US\$29.60; Order code STML/62



Order Online:
www.ams.org/bookstore

Order by Phone:
(800)321-4267 (U.S. & Canada),
(401)455-4000 (Worldwide)

