

UNDED

AMERICAN MATHEMATICAL SOCIETY

# Editors ULARIS.

Articles

Susan Friedlander Chief Editor

Book Reviews

Peter Kuchment

VOLUME 50 NUMBER 3

**JULY 2013** 

Available electronically at www.ams.org/bull/

#### Bulletin (New Series) of the American Mathematical Society

The *Bulletin* publishes expository articles on contemporary mathematical research written in a way that gives insight to mathematicians who may not be experts in the particular topic. The *Bulletin* publishes, by invitation only, reviews of selected books in mathematics and short articles in the "Mathematical Perspectives" section.

Submission information. See Information for Authors at the end of this issue.

**Publisher Item Identifier.** The Publisher Item Identifier (PII) appears at the top of the first page of each article published in this journal. This alphanumeric string of characters uniquely identifies each article and can be used for future cataloging, searching, and electronic retrieval.

**Postings to the AMS website.** Articles are posted to the AMS website individually after proof is returned from authors and before appearing in an issue.

Subscription information. Bulletin (New Series) of the American Mathematical Society is published quarterly. It is available electronically from www.ams.org/journals/. For paper delivery, subscription prices for Volume 50 (2013) are US\$513 list, US\$410.40 institutional member, US\$307.80 individual member, US\$461.70 corporate member. The subscription price for members is included in the annual dues. Subscription renewals are subject to late fees. See www.ams.org/journal-faq for more journal subscription information. If ordering the paper version, add US\$5 for delivery within the United States; US\$8 for delivery outside the United States.

Back number information. For back issues see www.ams.org/bookstore/.

Subscriptions and orders should be addressed to the American Mathematical Society, P.O. Box 845904, Boston, MA 02284-5904 USA. *All orders must be accompanied by payment.* Other correspondence should be addressed to the American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA.

**Copying and reprinting.** Material in this journal may be reproduced by any means for educational and scientific purposes without fee or permission with the exception of reproduction by services that collect fees for delivery of documents and provided that the customary acknowledgment of the source is given. This consent does not extend to other kinds of copying for general distribution, for advertising or promotional purposes, or for resale. Requests for permission for commercial use of material should be addressed to the Acquisitions Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA. Requests can also be made by email to reprint-permission@ams.org.

Excluded from these provisions is material in articles for which the author holds copyright. In such cases, requests for permission to use or reprint should be addressed directly to the author(s). (Copyright ownership is indicated in the notice in the lower right-hand corner of the first page of each article.)

This journal is indexed in *Mathematical Reviews*, *Science Citation Index*<sup>®</sup>,

10 9 8 7 6 5 4 3 2 1 18 17 16 15 14 13

Bulletin (New Series) of the American Mathematical Society (ISSN 0273-0979 (print); ISSN 1088-9485 (online)) is published quarterly by the American Mathematical Society at 201 Charles Street, Providence, RI 02904-2294 USA. Periodicals postage is paid at Providence, Rhode Island, and additional mailing offices. POSTMASTER: Send address changes to Bulletin (New Series) of the American Mathematical Society, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA.

<sup>© 2013</sup> American Mathematical Society. All rights reserved.

Science Citation Index<sup>TM</sup>-Expanded, ISI Alerting Services<sup>SM</sup>, CompuMath

Citation  $Index^{\textcircled{B}}$ , and  $Current Contents^{\textcircled{B}}/Physical$ , Chemical &

Earth Sciences. This journal is archived in *Portico* and in *CLOCKSS*. Printed in the United States of America.

Printed in the United States of America.

 $<sup>\</sup>otimes$  The paper used in this journal is acid-free and falls within the guidelines established to ensure permanence and durability.

# BULLETIN OF THE AMERICAN MATHEMATICAL SOCIETY CONTENTS

Vol. 50, No. 3

July 2013

# ARTICLES

| Manfred Denker, Tercentennial anniversary of Bernoulli's law of large |     |
|---|-----|
| numbers   | 373 |
| Robert L. Devaney, Singular perturbations of complex polynomials      | 391 |
| Daniel S. Freed and Michael J. Hopkins, Chern–Weil forms and abstract |     |
| homotopy theory   | 431 |

## MATHEMATICAL PERSPECTIVES

| Edward C. Waymire, About the cover: Ars Conjectandi and Jacques |     |
|---|-----|
| Bernoulli   | 469 |
| Selected Mathematical Reviews                                   | 473 |

## **BOOK REVIEWS**

| J. Maurice Rojas (Reviewer), Inevitable randomness in discrete           |     |
|--|-----|
| mathematics, by József Beck  | 481 |
| Yuri Kifer (Reviewer), Random perturbations of dynamical systems, by     |     |
| Mark I. Freidlin and Alexander D. Wentzell                               | 489 |
| V. Nekrashevych (Reviewer), How groups grow, by Avinoam Mann             | 495 |
| Rodrigo A. Pérez (Reviewer), Early days in complex dynamics: a history   |     |
| of complex dynamics in one variable during 1906–1942, by Daniel S.       |     |
| Alexander, Felice Iavernaro, and Alessandro Rosa                         | 503 |
| David E. Rowe (Reviewer), Plato's ghost: the modernist transformation of |     |
| mathematics, by Jeremy Gray  | 513 |
| Markus Linckelmann (Reviewer), Fusion systems in algebra and topology,   |     |
| by M. Aschbacher, R. Kessar, and B. Oliver; The theory of fusion         |     |
| systems: an algebraic approach, by David A. Craven                       | 523 |
|  |     |

### Editorial Board for Articles

David J. Benson Daniel S. Freed Edward Frenkel Susan Friedlander, Chair Mark Goresky Andrew J. Granville Bryna R. Kra Gregory F. Lawler Barry Mazur Paul H. Rabinowitz Andrew A. Ranicki Christoph M. Thiele Yuri Tschinkel Michael Wolf

#### Editorial Board for Book Reviews

Jonathan L. Alperin David Cox Evans M. Harrell Lisa Jeffrey Steven G. Krantz Peter Kuchment, Chair Ken Ono Philip E. Protter

### Consultants to the Editors

Gerald L. Alexanderson Jane Kister

Chief Editor: Susan Friedlander

#### **Editorial Information**

Information on the backlog for this journal can be found on the AMS website starting from http://www.ams.org/bull.

In an effort to make articles available as quickly as possible, articles are posted to the AMS website individually after proof is returned from authors and before appearing in an issue.

A Consent to Publish is required before we can begin processing your paper. After a paper is accepted for publication, the Providence office will send a Consent to Publish form to all authors of the paper. By submitting a paper to this journal, authors certify that the results have not been submitted to nor are they under consideration for publication by another journal, conference proceedings, or similar publication.

#### Information for Authors

The *Bulletin* publishes expository articles on contemporary mathematical research written in a way that gives insight to mathematicians who may not be experts in the particular topic. The first page must consist of a short *descriptive title*, followed by an *abstract* that summarizes the article in language suitable for mathematicians in the general area. The *descriptive title* should be short but informative; useless or vague phrases such as "some remarks about" or "concerning" should be avoided. The *abstract* should be a brief technical description of the new material.

A well-written expository article will include motivating problems and examples, some indication of the historical development of the subject, and of course the results and open problems that make it an interesting and exciting area of mathematics. In most cases proofs should be at most briefly sketched, and there should be a good bibliography whose main aim is to help those wishing to pursue the subject further. Articles reporting on recent mathematical research should include an introductory section addressed to nonexperts describing the motivation, background, and significance of the results announced. Following the statement of results, there should be a sketch of proofs that may be addressed to experts, including elements of the proof which are novel. References should be given so that an interested reader can find the details.

Each paper should include a footnote with the 2010 *Mathematics Subject Classification* representing the primary and secondary subjects of the article. The classifications are accessible from www.ams.org/msc/. The Mathematics Subject Classification footnote may be followed by a list of *key words and phrases* describing the subject matter of the article

and taken from it. Journal abbreviations used in bibliographies are listed in the latest *Mathematical Reviews* annual index. The series abbreviations are also accessible from www.ams.org/msnhtml/serials.pdf. To help in preparing and verifying references, the AMS offers MR Lookup, a Reference Tool for Linking, at www.ams.org/mrlookup/. When the manuscript is submitted, authors should supply the Editor with electronic addresses if available.

Mathematicians giving AMS lectures (Gibbs Lectures, Colloquium Lectures, and Progress in Mathematics Lectures) or invited hour addresses at meetings of the Society are encouraged to write up their lectures using the guidelines for expository articles described above. Submissions will be reviewed by the Editorial Board for Articles, and authors will be notified of its decision.

Book Reviews are by invitation only. The first page must include the title of the book being reviewed; the name(s) of the author(s); publisher; city of publication; year of publication; number of pages, including front matter; price if known; and ISBN. There should also be a footnote with the 2010 *Mathematics Subject Classification* representing the primary and secondary subjects of the book under review. The classifications are accessible from www.ams.org/msc/. To help in preparing and verifying references, the AMS offers MR Lookup, a Reference Tool for Linking, at www.ams.org/mrlookup/.

Initial submission. Authors of articles may submit manuscripts for consideration as PDF files at http://www.ams.org/peer-review/submission.pl. Manuscripts must be a single file with images embedded. Authors will have a chance to view the manuscript and data entered before releasing the manuscript into the system. Two-digit 2010 *Mathematics Subject Classification* numbers are included in a pull-down menu; classifications are accessible from http://www.ams.org/msc/. Complete author instructions are available at the site.

Authors who cannot supply a PDF file may submit a paper copy of their manuscript to *Bulletin*/Peer-Review Manuscript Submissions, 201 Charles Street, Providence, RI 02904-2294 USA. These submissions will be scanned into a PDF file and entered by AMS staff into the peer-review system. All the data required in the submission form must be provided to avoid delays in posting the manuscript.

The *Bulletin* Chief Editor will be notified as new submissions arrive. The Editor will collect these submissions and assign them to subject area specialists. Queries concerning the status of submissions could be sent to the Editor at amsb@usc.edu.

Electronically prepared manuscripts. The AMS encourages electronically prepared manuscripts, with a strong preference for  $\mathcal{AMS}$ -ETEX. To this end, the Society has prepared  $\mathcal{AMS}$ -ETEX author packages for each AMS publication. Author packages include instructions for preparing electronic manuscripts, the AMS Author Handbook, samples, and a style file that generates the particular design specifications of that publication series. Articles properly prepared using the  $\mathcal{AMS}$ -ETEX style file and the \label and \ref commands automatically enable extensive intra-document linking to the bibliography and other elements of the article for searching electronically on the Web. Because linking must often be added manually to electronically prepared manuscripts in other forms of TEX, using  $\mathcal{AMS}$ -ETEX also reduces the amount of technical intervention once the files are received by the AMS. This results in fewer errors in processing and saves the author proofreading time.  $\mathcal{AMS}$ -ETEX papers also move more efficiently through the production stream, helping to minimize publishing costs.

 $\mathcal{A}_{\mathcal{M}}S$ -EATEX is the highly preferred format of TEX, but author packages are also available in  $\mathcal{A}_{\mathcal{M}}S$ -TEX. Those authors who make use of these style files from the beginning of the writing process will further reduce their own efforts. Manuscripts prepared electronically in EATEX or plain TEX are normally not acceptable due to the high amount of technical time required to insure that the file will run properly through the AMS in-house production system. EATEX users will find that  $\mathcal{A}_{\mathcal{M}}S$ -EATEX is the same as EATEX with additional commands to simplify the typesetting of mathematics, and users of plain TEX should have the foundation for learning  $\mathcal{A}_{\mathcal{M}}S$ -EATEX. Authors may retrieve an author package for the Bulletin of the AMS from www.ams. org/bull/bullauthorpac.html or via FTP to ftp.ams.org (login as anonymous, enter your complete email address as password, and type cd pub/author-info). The AMS Author Handbook and the Instruction Manual are available in PDF format from the author package link. The author package can also be obtained free of charge by sending email to tech-support@ams.org or from the Publication Division, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA. When requesting an author package, please specify AMS-IATEX or AMS-TEX and the publication in which your paper will appear. Please be sure to include your complete email address.

After acceptance. The source files for the final version of the electronic manuscript should be sent to the Providence office immediately after the paper has been accepted for publication. Authors should indicate if the paper has been prepared using  $\mathcal{AMS}$ -EATEX or  $\mathcal{AMS}$ -TEX. Electronically prepared manuscripts can be submitted via the Web at www.ams.org/submit-book-journal/, sent via email to pub-submit@ams.org, or sent on CD to the Electronic Prepress Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA. When sending a manuscript electronically via email or CD, please be sure to include a message indicating in which publication the paper has been accepted. No corrections will be accepted electronically. Authors must mark changes on their proof copies and return them to the Providence office. Complete instructions on how to send files are included in the author package.

The final file of an accepted article should also be sent by email to both bulletin@math.uic.edu and susan@math.northwestern.edu.

Electronic graphics. Comprehensive instructions on preparing graphics are available from www.ams.org/authors/journals.html. A few of the major requirements are given here.

Submit files for graphics as EPS (Encapsulated PostScript) files. This includes graphics originated via a graphics application as well as scanned photographs or other computergenerated images. If this is not possible, TIFF files are acceptable as long as they can be opened in Adobe Photoshop or Illustrator.

Authors using graphics packages for the creation of electronic art should avoid the use of any lines thinner than 0.5 points in width. Many graphics packages allow the user to specify a "hairline" for a very thin line. Hairlines often look acceptable when proofed on a typical laser printer. However, when produced on a high-resolution laser imagesetter, hairlines become nearly invisible and will be lost entirely in the final printing process.

Screens should be set to values between 15% and 85%. Screens which fall outside of this range are too light or too dark to print correctly. Variations of screens within a graphic should be no less than 10%.

AMS policy on making changes to articles after posting. Articles are posted to the AMS website individually after proof is returned from authors and before appearing in an issue. To preserve the integrity of electronically published articles, once an article is individually posted to the AMS website but not yet in an issue, changes cannot be made in place in the paper. However, an "Added after posting" section may be added to the paper right before the References when there is a critical error in the content of the paper. The "Added after posting" section gives the author an opportunity to correct this type of critical error before the article is put into an issue for printing and before it is then reposted with the issue. The "Added after posting" section remains a permanent part of the paper. The AMS does not keep author-related information such as affiliation, current address, and email address up to date after a paper is initially posted.

Once the article is assigned to an issue, even if the issue has not yet been posted to the AMS website, corrections may be made to the paper only by submitting a traditional errata to the Editor. The errata will appear in a future print issue and will link back and forth on the Web to the original article online. Secure manuscript tracking on the Web. Authors can track their manuscripts through the AMS journal production process using the personal AMS ID and Article ID printed in the upper right-hand corner of the Consent to Publish form sent to each author who publishes in AMS journals. Access to the tracking system is available from www.ams.org/mstrack/. An explanation of each production step is provided on the Web through links from the manuscript tracking screen. Questions may be sent to bull-query@ams.org.

Inquiries. Any inquiries concerning a paper that has been accepted for publication that cannot be answered via the manuscript tracking system mentioned above should be sent to bull-query@ams.org or directly to the Electronic Prepress Department, American Mathematical Society, 201 Charles Street, Providence, RI 02904-2294 USA.

# BULLETIN OF THE AMERICAN MATHEMATICAL SOCIETY CONTENTS

Vol. 50, No. 3

# July 2013

## ARTICLES

| Manfred Denker, Tercentennial anniversary of Bernoulli's law of large |     |
|---|-----|
| numbers   | 373 |
| Robert L. Devaney, Singular perturbations of complex polynomials      | 391 |
| Daniel S. Freed and Michael J. Hopkins, Chern–Weil forms and abstract |     |
| homotopy theory   | 431 |
|   |     |

# MATHEMATICAL PERSPECTIVES

| Edward C. Waymire, About the cover: Ars Conjectandi and Jacques |     |
|---|-----|
| Bernoulli   | 469 |
| Selected Mathematical Reviews                                   | 473 |

# BOOK REVIEWS

| J. Maurice Rojas (Reviewer), Inevitable randomness in discrete           |     |
|--|-----|
| mathematics, by József Beck  | 481 |
| Yuri Kifer (Reviewer), Random perturbations of dynamical systems, by     |     |
| Mark I. Freidlin and Alexander D. Wentzell                               | 489 |
| V. Nekrashevych (Reviewer), How groups grow, by Avinoam Mann             | 495 |
| Rodrigo A. Pérez (Reviewer), Early days in complex dynamics: a history   |     |
| of complex dynamics in one variable during 1906–1942, by Daniel S.       |     |
| Alexander, Felice Iavernaro, and Alessandro Rosa                         | 503 |
| David E. Rowe (Reviewer), Plato's ghost: the modernist transformation of |     |
| mathematics, by Jeremy Gray  | 513 |
| Markus Linckelmann (Reviewer), Fusion systems in algebra and topology,   |     |
| by M. Aschbacher, R. Kessar, and B. Oliver; The theory of fusion         |     |
| systems: an algebraic approach, by David A. Craven                       | 523 |
|  |     |

