**The Bulletin of the International Linear Algebra Society**

# IMAGE

Serving the International Linear Algebra Community

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**Upcoming Conferences, Workshops and Deadlines**



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**Reports on Conferences and Awards and Other News**



**Articles and Reviews**



**The IMAGE Problem Corner is not included in this issue, due to technical difficulties.**

# *UPCOMING CONFERENCES, WORKSHOPS, DEADLINES*

## Preliminary Announcement 15th ILAS Conference, Cancun, Mexico, June 16-20, 2008

The next conference of the International Linear Algebra Society will be held in Cancun, Mexico, June 16-20, 2008. Additional information is available at the website http://star.izt.uam.mx/ILAS08.

Colleagues who are interested in organizing a mini-symposium should contact Luis Verde-Star, at verde@star.izt.uam.mx. A proposal for a mini-symposium must include names and e-mail addresses of the organizers, name of the mini-symposium, brief description of the themes, names and e-mail addresses of at least eight confirmed participants, and the estimated total number of participants.

The Organizing Committee is Rafael Bru, Luz Maria de Alba, Daniel Hershkowitz, Andre Klein, Beatrice Meini, Dale Olesky, Vadim Olshevsky, Jeff Stuart, Daniel Szyld, Luis Verde-Star. Send any questions to Luis Verde-Star, at verde@star.izt.uam.mx.

For information about past ILAS conferences see the ILAS Information Center home-page http://www.ilasic.math.uregina.ca/iic/

We look forward to meeting you in Cancun!
The Organizing Committee

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## IMA Program for Graduate Students on Linear Algebra and Applications Iowa State University, June 29-July 26, 2008

The Institute for Mathematics and Its Applications (IMA) will sponsor a Participating Institution Summer Program for Graduate Students on June 29-July 26, 2008, at Iowa State University. The topic will be Linear Algebra and Applications. The organizers are Leslie Hogben, Wolfgang Kliemann, and Y. T. Poon.

Morning lectures will introduce current research problems and background for those. Students will work in groups in the afternoons. The lecturers will be Bryan Shader on linear algebra and applications to combinatorics; David Watkins on numerical linear algebra, emphasizing eigenvalue calculations; Chi-Kwong Li on matrix inequalities in science and engineering; and Fritz Colonius on applications of linear algebra to dynamical systems.

IMA will pay all expenses for two students from each Participating Institution. The organizers are applying to NSF for supplemental funding to support students from other US universities. Students at institutions outside the US who can obtain funding from their government or university are also invited to apply (the cost is expected to be less than US$1000 + travel per person). Interested faculty are welcome to apply, but will have to supply their own funding.

If you have a student or are a student who may be interested, please email Leslie Hogben now, at LHogben@iastate.edu. This will help determine interest and will ensure that you receive future emailings about the program.

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## Workshop on Operator Theory & Applications College of William and Mary, Williamsburg VA July 22-26, 2008

This will be a comprehensive, inclusive conference covering all aspects of theoretical and applied operator theory. A tentative list of plenary speakers is: J. Agler, A. Boettcher, P. Deift, I. Gohberg, B. Jacob, M. A. Kaashoek, P. Lancaster, B. McCluer, S. A. McCullough, N. Nikolskii, G. Popescu, S. Richter, H. Schneider, and V. Vinnikov.

For details, visit http://www.math.wm.edu/~vladi/IWOTA/IOWTA2008.htm. Organizers: J.A. Ball, V. Bolotnikov, J.W. Helton, L. Rodman, and I.M. Spitkovsky.

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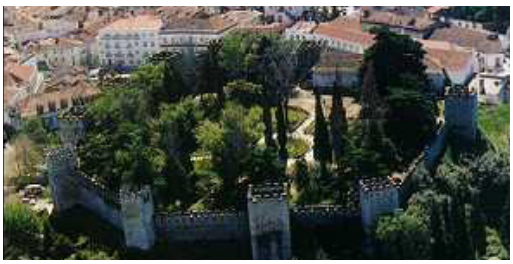
## The 17th International Workshop on Matrices and Statistics Tomar, Portugal, July 23-26, 2008

IWMS08 will be held in Tomar, Portugal to celebrate Professor Theodore Wilbur Anderson's 90th birthday. For more information, contact Professor Francisco Carvalho, fpcarvalho@ipt.pt, Phone: +351 249 328 100, Fax: +351 249 328 186.



**Tomar Castle**

## Call for Nominations
## 2008 Hans Schneider Prize in Linear Algebra
## Deadline December 1, 2007

The 2008 Hans Schneider Prize in Linear Algebra will be awarded at the 15th ILAS Conference in Cancun, Mexico, June 16-20, 2008. Nominations of distinguished individuals judged worthy of consideration for the Prize are now being invited from members of ILAS and the linear algebra community in general. Nominations are open until December 1, 2007 and should be sent, preferably by email, to Richard Brualdi, Chair of the Prize Committee.

The previous recipients of this Prize are:

1993 - Miroslav Fiedler, Shmuel Friedland, Israel Gohberg
1996 - Mike Boyle, David Handelman, Robert C. Thompson
1999 - Ludwig Elsner
2002 - Tsuyoshi Ando, Peter Lancaster
2005 - Richard A. Brualdi, Richard Varga

The Nomination Committee for the 2008 Hans Schneider Prize is: Ravi Bapat, Richard Brualdi (Chair), Danny Hershkowitz (ILAS President - Ex-officio), Leslie Hogben, Hans Schneider, and Paul Van Dooren.

In nominating an individual, the nominator should include:

(1) a brief biographical sketch

(2) a statement explaining why the nominee is considered worthy of the prize, including references to publications or other contributions of the nominee which are considered most significant in making this assessment.

The committee may ask the nominator to supply additional information. For detailed guidelines, see http://www.math.technion.ac.il/iic/ILASPRIZE.html.

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## Special Issue of LAA for
## 14th ILAS Conference, Shanghai, July 2007
## Deadline November 1, 2007

There will be a special issue of LAA devoted to selected papers presented at the conference. See guidelines at http://www.math.wisc.edu/~hans/speciss.html. Submit papers by November 1, 2007 to one of the editors for this issue:

Ilse Ipsen, ipsen@math.ncsu.edu
Julio Moro, jmoro@math.uc3m.es
Peter Semrl, Peter.Semrl@fmf.uni-lj.si
Jiayu Shao, jyshao@sh163.net
Pei Yuan Wu, pywu@math.nctu.edu.tw

## Special Volume of Numerical Linear Algebra in Signals, Systems and Control for IIT Conference, Kharagpur, January 2007
## Deadline October 31, 2007

The Organizing Committee of the conference Numerical Linear Algebra in Signals, Systems and Control held in Kharagpur, India, in January 2007, is pleased to announce that Springer-Verlag will publish a special volume associated with the conference, in the series Lecture Notes in Electrical Engineering. The volume will be dedicated to Professor Biswa Nath Datta, who was honored at an IEEE Banquet ceremony at NLASSC for his extensive interdisciplinary contributions blending linear and numerical linear algebra with control and systems theory.

A core of the volume will be based on the papers of invited speakers and participants of NLASSC as well as on several invited papers written by well-known experts. However, the volume is open to submissions of contributed original research papers by authors who did not participate in NLASSC'07 if the papers are relevant to the scope of the NLASSC area, and survey articles if they contain a state-of-the-art review of important directions of contemporary research in these areas. All papers will be refereed. Deadline: October 31, 2007. Due to space limitations, the Editors recommend that papers be no longer than 25 journal pages. Longer papers can be considered but authors should be aware that such papers are harder to referee and therefore take more time to review.

Prospective authors are invited to submit their contributions via email directly to one of the following Editors:

Shankar Bhattacharyya, bhatt@ece.tamu.edu, Texas A&M University
Raymond Chan, rchan@math.cuhk.edu.hk, Chinese University of Hong Kong
Paul Van Dooren, vdooren@csam.ucl.ac.be, Editor-in-Chief, Universite Catholique de Louvain
Vadim Olshevsky, olshevsky@math.uconn.edu), University of Connecticut
Aurobinda Routray, aroutray@ee.iitkgp.ernet.in, IIT Kharagpur

Important details on electronic submissions can be found at http://www.nlassc.org
or at its mirror site http://www.math.uconn.edu/~olshevsky/NLASSCproceedings.

The full announcement can be found at http://www.nlassc.org or http://www.math.uconn.edu/~olshevsky/NLASSCproceedings.

# *ILAS BUSINESS*

## ILAS 2006 - 2007 Treasurer's Report
**March 1, 2006 through February 28, 2007**

| | | | |
|---|---|---|---|
| **Net Account Balances on February 28, 2006** | | | |
| Vanguard (ST Fed. Bond Fund 3787.048 Shares) | | | |
| (10.60% Each: General Fund, Conference Fund and ILAS/LAA Fund, | | | |
| 17.40% Taussky Todd Fund, 7.95% Uhlig Fund, 42.85% Schneider Fund) | | | |
| | | $38,703.63 | |
| Checking account | | $43,551.83 | |
| Pending checks | | $ 1,910.00 | |
| Pending VISA/Mastercard/AMEX | | $ 1,020.00 | |
| Outstanding checks payable | | ($ 750.00) | **$84,435.46** |
| General Fund | | $33,431.88 | |
| Conference Fund | | $10,734.81 | |
| ILAS/LAA Fund | | $ 7,971.26 | |
| Olga Taussky Todd/John Todd Fund | | $ 9,640.19 | |
| Frank Uhlig Education Fund | | $ 3,988.45 | |
| Hans Schneider Prize Fund | | $18,668.87 | **$84,435.46** |
| **Income:** | | | |
| Dues | 4220.00 | | |
| Corporate Dues | 800.00 | | |
| General Fund | 5219.95 | | |
| Conference Fund | 219.97 | | |
| LAA Fund | 2219.97 | | |
| Taussky-Todd Fund | 371.07 | | |
| Uhlig Education Fund | 164.97 | | |
| Schneider Prize Fund | 2019.16 | | |
| Errors, Currency Exchange | 50.62 | 15,285.71 | |
| **Expenses:** | | | |
| Speakers (3) | 1565.00 | | |
| ILAS Conference Support | 4000.00 | | |
| LAA Speaker | 1000.00 | | |
| HS Prize Speaker | 1000.00 | | |
| Credit Card and Bank Fees | 256.93 | | |
| License Fees | 61.25 | | |
| Labor - Mailing & Conference | 295.00 | | |
| Postage | 62.71 | | |
| Supplies and Copying | 51.97 | $8,292.86 | |
| **Net Account Balances on February 28, 2007** | | | |
| Vanguard (ST Fed. Bond Fund 3,947.603 Shares) | | | |
| (10.60% Each: General Fund, Conference Fund and ILAS/LAA Fund, | | | |
| 17.40% Taussky Todd Fund, 7.95% Uhlig Fund, 42.85% Schneider Fund) | | | |
| | | $40,778.74 | |
| Checking account | | $50,679.57 | |
| Outstanding checks payable | | ($ 30.00) | **$91,428.31** |
| General Fund | | $37,481.44 | |
| Conference Fund | | $10,954.78 | |
| ILAS/LAA Fund | | $ 9,191.23 | |
| Olga Taussky Todd/John Todd Fund | | $10,011.26 | |
| Frank Uhlig Education Fund | | $ 4,153.52 | |
| Hans Schneider Prize Fund | | $19,636.08 | **$91,428.31** |

Jeffrey L. Stuart, Secretary-Treasurer jeffrey.stuart@plu.edu
PLU Math Department, Tacoma, WA 98447 USA

## ILAS Election Results

By Daniel Hershkowitz, ILAS President

The results for the 2007 ILAS elections are: Chi-Kwong Li was elected to a three year term as ILAS Vice-President, starting March 1, 2007, and Steve Kirkland and Bryan Shader were elected to three year terms as members of the ILAS Board, starting March 1, 2007. On behalf of all ILAS members, thanks to the Nomination Committee members (Volker Mehrmann, Chair, Luz De Alba, Tom Laffey, Peter Semrl and Paul van Dooren), for their efforts on behalf of ILAS, and to all the candidates for their willingness to serve. Thanks also to Christian Mehl, Volker Mehrmann, Reinhard Nabben and Elena Virnik for counting the ballots.

## ILAS Information Center

The electronic ILAS INFORMATION CENTER (IIC) provides current information on international conferences in linear algebra, other linear algebra activities, linear algebra journals, and ILAS-NET notices. Organizations and individuals are invited to contribute. Contact Shaun Fallat (sfallat@math.uregina.ca), IIC manager, for information on how to use IIC. The primary website is http://www.ilasic.math.uregina.ca/iic/index1.html and mirror sites are

## New Deadlines and Call for Submissions for Fall 2007 IMAGE

IMAGE editors welcome information on linear algebra and related topics, including:

- Reports and announcements of workshops and conferences
- Feature articles on emerging applications and topics
- Historical essays
- Book reviews and announcements of new books
- Letters to the editor
- New problems and solutions to old problems

For the Fall 2007 issue, send Problems and Solutions to Hans Joachim Werner by September 1, 2007 (hjw.de@uni-bonn.de). Send everything else to Jane Day by October 1, 2007 (day@math.sjsu.edu).

## All Back Issues of IMAGE Now Online

Searchable online files of all issues of IMAGE, from its first issue in 1988 to the present, are now available on its website, http://www.math.technion.ac.il/iic/IMAGE/.

Our thanks to Roger Horn, George Styan and Jim Weaver for locating and scanning these files, and to Shaun Fallat for posting them.

# *OBITUARY*

## In Memoriam: Morris Newman, 1924-2007

By Charles R. Johnson, The College of William and Mary

We were saddened to hear of the death of Morris Newman on January 4, 2007. He was a wonderful person and one of the strongest mathematicians to work on matrix theory in recent times. Morris worked in both number theory and matrix theory. His book *Integer Matrices* is a frequently referenced classic, and he is known for pioneering work on algorithms for integer and rational matrix calculations. He received a gold medal from the U.S. Commerce Department in 1966 for this work. He published about 100 papers, which included innovative contributions to many topics in matrix theory, such as copositive matrices, van der Waerden's conjecture and determinantal inequalities.

Morris was born in Brooklyn in 1924 of Russian immigrant parents. He received his Bachelor's degree in mathematics from NYU, his Master's from Columbia and his Ph.D. from the University of Pennsylvania, specializing in number theory under Hans Rademacher. He worked as a mathematician for the U.S. National Bureau of Standards until 1977. During this period the Bureau was a major center for theoretical and computational mathematics, especially topics involving matrices. He served for a time as head of the NBS Mathematics Group, and hosted many NRC-NAS postdocs, including Steve Pierce, Russell Merris and myself. In 1977, Morris moved to UC Santa Barbara, joining a matrix theory group including Marvin Marcus, Bob Thompson, Ky Fan and Eugene Johnsen. Morris had several students at UCSB and was also a major influence on Bob Thompson in his movement toward the use of integer methods on matrix invariant problems (perhaps the work for which Bob is best known).

There was an 80th birthday meeting for Morris at UCSB in 2004, which I happily attended. I was pleased also to have a lengthy chat with Morris and his wife Aileen in October 2006. He is survived by Aileen, his son Carl, his daughter Sally and her two children.

# REPORTS ON CONFERENCES, AWARDS, AND OTHER NEWS

## International Workshop on Numerical Linear Algebra in Signals, Systems, and Control

This workshop was held on January 9-11, 2007 at the Indian Institute of Technology, Kharagpur (IIT-KGP), sponsored by the IEEE Kharagpur Section, Department of Electrical Engineering of IIT-KGP, and the Systems Society of India – IIT Kharagpur Chapter. The convenor was Professor Aurobinda Routray of IIT Electrical Engineering Department. The conference blended linear and numerical linear algebra with control and systems theory and signal processing.

About one hundred mathematicians, computational scientists, and engineers from several countries, including Australia, Belgium, Brazil, Germany, Hong Kong, India, Sri Lanka, USA, and Venezuela, participated.

This was the first interdisciplinary conference of this type held in India, though a few have been held in the USA, including an AMS conference on "Linear Algebra and its Role in Systems Theory" and four SIAM conferences on "Linear Algebra in Signals, Systems, and Control."

The highlights of the workshop were the Keynote Address on "History of Numerical Linear Algebra" by Gene H. Golub of Stanford University, and an IEEE Banquet ceremony to honor Biswa Datta of Northern Illinois University. Professor Golub set the tone of the conference as he described the development of numerical linear algebra through the ages and its influence on solving scientific and engineering problems.

There was a series of other invited talks by Venkataramanan Balakrishnan (USA), Rajendra Bhatia (India), Shankar Bhattacharyya (USA), Amit Bhaya (Brazil), Raymond Chan (Hong Kong), Biswa Datta (USA), Kanti Datta (India), Karabi Datta (USA), Sian Deng (USA), Sylvan Elhay (Australia),Volker Mehrmann (Germany), Vadim Olshevsky (USA), Mohamed Rahaman (USA), Marcos Raydan (Venezuela), S. C. Dutta Roy (India), Vadim Soklov (USA), Paul Van Dooren (Belgium), and Song Wang (Australia).

These speakers discussed a wide variety of topics, ranging from inverse eigenvalue problems, control of descriptor systems, vibration control, large-scale control systems, model reduction, model updating, optimal control, PID controller and lattice design, control perspectives of numerical algorithms, optimization methods for graph similarity, semidefinite programming, fast algorithms for structured systems and image processing, to theoretical perturbation bounds and nonsingularity of matrix equations.

There was also a panel discussion on "Teaching and Research Directions of Numerical Linear Algebra in Science and Engineering" with Gene Golub, Biswa Datta, Volker Mehrmann, Paul Van Dooren, and Raymond Chan as panelists, and S. K. Das as moderator.

The proceedings of the conference will be dedicated to Professor Biswa Datta, in recognition of his extensive interdisciplinary contributions to the topics of this conference.

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## Biswa Datta Honored at IIT Workshop

On January 10, 2007, Biswa Datta, Distinguished Research Professor at Northern Illinois University, an IEEE Fellow and an IEEE Distinguished Lecturer, was honored for his "Outstanding Contributions to Numerical Linear Algebra related to Control". The ceremony was held at the Banquet of the International Workshop on Numerical Linear Algebra in Signal, Systems, and Control at the Indian Institute of Technology, Kharagpur, India.

The Presider was Professor Kishore, President of IEEE Kharagpur Chapter. The Banquet speaker was Professor Rajendra Bhatia, an eminent mathematician from the Indian Statistical Institute. The other speakers were Professors Gene H. Golub of Stanford University, Paul Van Dooren of Universite Catholique de Louvain, Volker Mehrmann of Technische Universität Berlin, and V. K. Mohan of the Indian Institute of Technology, Kharagpur.

Professor Kishore gave a brief account of Datta's biography and his principal achievements, honors and distinctions. Professor Bhatia noted the versatility of his research expertise and contributions, ranging from theoretical linear algebra to practical control and vibration engineering, as evidenced by his more than one hundred interdisciplinary research papers, two popular interdisciplinary books, *Numerical Linear Algebra and Applications*, and *Numerical Methods for Linear Control System*, and three software packages and toolboxes, MATCOM, MATCONTROL, and *Advanced Numerical Methods*. Special mention was made of his outstanding contributions on stability, D-stability, matrix equations, pole placement, observer design, and vibration control.

Professor Golub remarked on Datta's ability to bring diverse groups of researchers together, and also had kind words for his wife, Karabi Datta, and her contribution to his academic career. Professor Van Dooren spoke about his leadership activities, especially related to several successful interdisciplinary conferences, some of which he referred to as simply "Datta Conferences." Professor Mehrmann talked about his ability to communicate with and motivate young researchers about emerging topics of research, and how Datta and his work have influenced numerous researchers, including himself. Professor Mohan discussed his activities and contributions to the scientific and industrial developments in India as a non-resident Indian scientist.

At the conclusion of the ceremony, Professor Datta was awarded a Plaque of Honor and a flower bouquet by Professor Kishore. In his acceptance remarks, Datta mentioned that he was proud of his mathematical heritage in India, a country that has made fundamental contributions to the development of mathematics and science and that this honor given by a premier institute of India, his native country, was very special to him. Datta, his wife Karabi, and Professor Golub were interviewed by an Indian Television Channel on this occasion. Reports on the conference and ceremony were published in several Indian news media.

## Michael Neumann Honored

by Danny Hershkowitz, The Technion, ILAS President

On behalf of ILAS I am happy to congratulate Professor Michael Neumann for being named Distinguished Professor by the Board of Trustees of the University of Connecticut, in February 2007. This is the University's highest academic honor, and faculty chosen for this title have achieved exceptional distinction in scholarship, teaching, and service.

Quoting the official announcement: "Neumann, who received the Provost's Research Excellence Award for 2004-2005, is an internationally recognized scholar in theoretical and applied linear algebra and matrix analysis. He has been at the University since 1985, and has been a key supporter of the development of the Q Center, which helps students learn math, and of collaborative efforts between the Department of Mathematics and the Neag School of Education in teaching and in research in mathematics education. His research has been supported by the National Science Foundation and the U.S. Air Force, as well as the National Security Agency."

In addition Miki has given valuable service to ILAS in various operations, so by all means this honor has been bestowed on a very well deserving person.

**T. Y. Tam**

## Robert C. Thompson Matrix Meeting 2007

RCT07 was held at Auburn University, March 24, 2007, hosted by Tin Yau Tam. Wasin So and Jane Day were co-organizers. The other attendees were Aji Affane, Marina Arav, Joerg Feldvoss, Peter Gibson, Frank Hall, Hongyu He, Shuangchi He, Randall R. Holmes, Huajun Huang, Enoch Lee, Chi-Kwong Li, Zhongshan Li, Peter M. Nylen, Tom Pate, Fangyang Shen, Helena Smigoc, Ronald L. Smith, Ilya Spitkovsky, Raymond Sze, Necibe Tuncer, Yi Wang, Jim Weaver, Wen Yan, Fuzhen Zhang, Minxian Zhu.

This informal one day meeting has been held annually since Steve Pierce and Bob Thompson began to host it at UC Santa Barbara and San Diego State University in the mid 1980's. Its purpose has always been to encourage the interaction and collaboration of researchers on matrices, including applications, computation and theory. It was long called the Southern California Matrix Meeting, but the attendees in 2004 voted to rename it to honor Bob Thompson, deceased in 1995. The program and abstracts for RCT07 as well as a list of the previous meetings can be found at http://www.auburn.edu/~tamtiny/rct2007.html.

**Participants, Robert C. Thompson Meeting 2007**

## MAT-TRIAD 2007 – Three Days Full of Matrices

Report by Katarzyna Filipiak

The second conference in the series, MAT-TRIAD 2007 – three days full of matrices -- was held at the Mathematical Research and Conference Center of the Institute of Mathematics of the Polish Academy of Sciences in Będlewo, Poland, on March 22-24. The conference was organized and supported by the Stefan Banach International Mathematical Center, the Faculty of Mathematics and Computer Science and the Faculty of Geography and Geology of the Adam Mickiewicz University, the Department of Mathematical and Statistical Methods of the Agricultural University of Poznań, and the Polish Mathematical Society. It was sponsored by GlaxoSmithKline Pharmaceuticals.

The International Scientific Committee comprised Ljiljana Cvetković (University of Novi Sad, Serbia), Heike Faßbender (Technical University Braunschweig, Germany), Simo Puntanen (University of Tampere, Finland) and Tomasz Szulc (Adam Mickiewicz University, Poznań, Poland; chair). The Local Organizing Committee was chaired by Augustyn Markiewicz, and included Katarzyna Filipiak, Jan Hauke, Jan Wachowiak and Waldemar Wolyński.

The purpose of this conference was to bring together researchers sharing an interest in a variety of aspects of matrix analysis and its applications and offer them the opportunity to discuss current developments in these subjects. There were 64 participants from 12 different countries. Twelve invited talks were presented by Rafael Bru, Ludwig Elsner, Daniel A. Griffith, Charles R. Johnson, Thomas Klein, João T. Mexia, Juan M. Peña, Friedrich Pukelsheim, Sigfried Rump, George P.H. Styan, Götz Trenkler and Roman Zmyślony. Moreover, 32 contributed talks and 4 posters were presented. The talks were mainly devoted to matrix analysis, methods of linear algebra, algorithms of numerical linear algebra, matrix games as well as solutions to problems of mathematical statistics with the use of matrix algebra. The talks were extensively discussed in a friendly and stimulating atmosphere.

The International Scientific Committee selected the best talks presented by Ph.D. students and young scientists in the areas of application of the methods of matrix algebra with a special emphasis on statistics. The winners were: 1st prize – Vladimir Kostić (Serbia), 2nd prize – Miguel Fonseca (Portugal), 3rd prize – Dorota Kubalińska (Germany), and 4th prize – Iwona Wróbel (Poland).

During the conference there was a special session, Statistics and Linear Algebra in Practice, devoted to applications of statistics in pharmacy and medicine. This session, chaired by Daniel A. Griffith, showed current statistical problems in practice.

The birthdays of George P.H. Styan and Erkki P. Liski, two of the leading figures in statistics, were celebrated at the conference.

MAT-TRIAD 2007 Conference Photo.

The attendees at MAT-TRIAD 2007 shared the common opinion that the conference was extremely fruitful and well organized. They proposed to organize the next meeting in the MAT-TRIAD series in 2009.

The list of participants of MAT-TRIAD 2007, abstracts of talks and posters, and the photo-gallery can be found at http://www.mtriad07.amu.edu.pl.

# *ARTICLES AND REVIEWS*

## IMAGE *Philatelic Corner* reprise: George P. H. Styan & Götz Trenkler

Images of postage stamps issued to honour each of five scientists: (1) Tadeusz BANACHIEWICZ, (2) Charles Lutwidge DODGSON [Lewis Carroll], (3) Sir William Rowan HAMILTON, (4) Gottfried Wilhelm von LEIBNIZ, and (5) Takakazu SEKI Kôwa, have appeared in IMAGE 23 (October 1999), 25 (October 2000, two articles), 28 (April 2002), and 30 (April 2003). These articles in IMAGE have been assembled as a single text-searchable pdf file, with the images of the postage stamps now appearing in color. This pdf file is available together with the online version of this issue of IMAGE.

(1) Tadeusz BANACHIEWICZ (1882–1954), IMAGE 25 (October 2000), p. 24. Article [9] by Grala, Markiewicz & Styan, illustrated with a postage stamp featuring a portrait of Banachiewicz issued by Poland in 1983, *Scott* 2872. We have found no other stamp in honour of Banachiewicz.

Banachiewicz was a Polish astronomer, mathematician and geodesist, who is credited with a formula, first published in 1937 [9], for the inverse of a partitioned matrix using (what are now known as) Schur complements [19, 22].

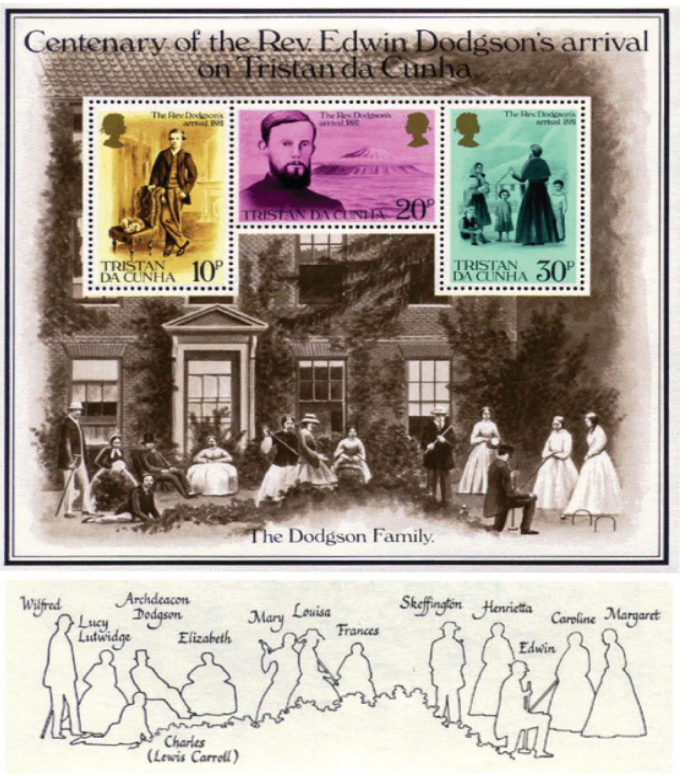


FIG. 1 The Dodgson family: Tristan da Cunha 1981, *Scott* 287a.

(2) Rev. Charles Lutwidge DODGSON [Lewis Carroll] (1832–1898), IMAGE 25 (October 2000), pp. 22–23. Article by Farebrother, Jensen & Styan [6], illustrated with a postage stamp featuring a portrait of Dodgson in celebration of his 150th birthday; the stamp was issued by Mali in 1982, *Scott* C443.

In 1866 and 1867, Dodgson wrote two of the first books [3, 4] ever published on determinants [7]. Under the pseudonym Lewis Carroll, he wrote the well-known *Alice's Adventures in Wonderland* (1865) and its sequel *Through the Looking-Glass, and What Alice Found There* (1871), together recently reissued (with a new introduction by Martin Gardner) as a single paperback [1].

Charles Dodgson is shown on a souvenir sheet from Tristan da Cunha issued in 1981 as noted (but not depicted) in the article [6]. In the photograph (on the souvenir sheet, Fig. 1) of the Dodgson Family outside the Croft Rectory (near Darlington, Yorkshire), c. 1860, Charles is shown seated on the ground at the left in the group but is not depicted on any of the stamps.

Three stamps (10p, 20p and 30p) and a souvenir sheet (*Scott* 287a) were issued in celebration of the centenary of the arrival of the Rev. Edwin Heron Dodgson (1846–1918) on Tristan da Cunha. Charles, his youngest brother Edwin, and eleven other members of the Dodgson family are shown and identified on the verso of the souvenir sheet (Fig. 1). Edwin Dodgson apparently saved the population of Tristan da Cunha from starvation and his portrait is depicted on the 20p stamp arriving at Tristan as resident missionary on 25 February 1881 [20].

We have found no other stamp or souvenir sheet depicting Charles Dodgson, but there are many stamps that show characters from *Alice's Adventures in Wonderland*.

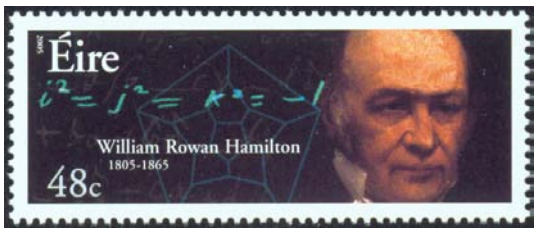


FIG. 2 A quaternion formula and Sir William Rowan Hamilton: Ireland 2005, *Scott* 1599.

(3) Sir William Rowan HAMILTON (1805–1865), IMAGE 28 (April 2002), p. 17. Two articles [5, 17] illustrated with three postage stamps issued by Ireland. Two stamps were issued in 1943: *Scott* 126 & 127, in celebration of the centenary of the discovery of quaternions by Hamilton and each featuring a portrait of him. In 1843, Hamilton invented quaternions, a four-dimensional non-commutative generalization of complex numbers. A third stamp issued in 1983, *Scott* 562, features (only) the quaternion formulas

$$i^2 = j^2 = k^2 = -1,$$

$$ij = k,\ jk = i,\ ki = j,\ ji = -k,\ kj = -i,\ ik = -j.$$

Ireland issued a fourth stamp in honour of Hamilton in 2005, *Scott* 1599, featuring his portrait and the quaternion formula $i^2 = j^2 = k^2 = -1$, see Fig. 2.

The Cayley–Hamilton theorem, named after Hamilton and Sir Arthur Cayley (1821–1895) states that every square matrix over the real or complex field, satisfies its own characteristic equation.

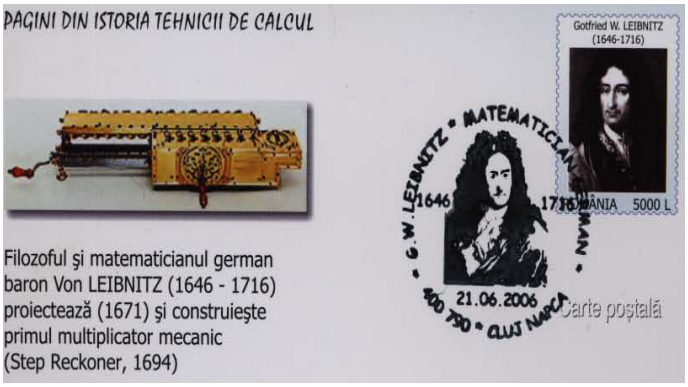


FIG. 3 Postcard for Gottfried W. von Leibniz: Romania 2006.

(4) Gottfried Wilhelm von LEIBNIZ (1646–1716), IMAGE 30 (April 2003), pp. 13–16. Article by Farebrother, Styan & Tee [8], illustrated with eight postage stamps: Albania 1996, *Scott* 2515; Germany (Deutsches Reich) 1926, *Scott* 360; German Democratic Republic 1950, *Scott* 66; Federal Republic of Germany (a) 1966, *Scott* 962, (b) 1980, *Scott* 1329, (c) 1996, *Scott* 1933; German Democratic Republic 1950, *Scott* 66; Romania 1966, *Scott* 3387; and St. Vincent 1991, *Scott* 1557.

Leibniz was a philosopher, physicist, and mathematician who developed calculus independently of Sir Isaac Newton (1643–1727). Leibniz solved a system of simultaneous linear equations in 1693 and then discovered determinants, independently of Seki [8, 16].

A postcard was issued by Romania in 2006, featuring an image of a stamp with a portrait of Leibniz (spelled Leibnitz in the caption), see Fig. 3. Romania had issued a stamp earlier in honour of Leibniz in 1966, *Scott* 3387. The postcard also shows the "Step Reckoner", a machine capable of addition, subtraction, multiplication, division, and finding square roots, which Leibniz introduced in 1671. See also [8].

(5) Takakazu SEKI Kôwa (1642–1708), IMAGE 23 (October 1999), p. 8. This IMAGE *Philatelic Corner* article [16] was illustrated with a postage stamp featuring a portrait of Seki and issued by Japan in 1992, *Scott* 2147[1]. We have found no other stamp in honour of Seki.

"Seki was a Japanese mathematician who created a new mathematical notation system and used it to discover many of the theorems and theories that were being, or were shortly to be, discovered in the West, including recreating some results in calculus. It is said he discovered Bernoulli numbers before Jacob[2] Bernoulli I (1654–1705)" [20].

In 1683 Seki discovered determinants. He treated only $2 \times 2$ and $3 \times 3$ matrices, and failed to obtain a general formula. Yet his result was more general than the one obtained by Leibniz ten years later. [8, 16, 20].

We now identify five other scholars who have contributed to linear algebra and who have been honored with a postage stamp. We continue the numbering from above: (6) Carl Friedrich GAUSS, (7) Loo-Keng HUA, (8) Gustav Robert KIRCHHOFF, (9) Aleksei Nikolaevich KRYLOV, (10) Pierre-Simon, Marquis de LAPLACE.


FIG. 4 Carl Friedrich Gauss:
(upper left) German Democratic Republic 1977, *Scott* 1811;
(upper right) Federal Republic of Germany 1954, *Scott* 724;
(lower left) Federal Republic of Germany 1977, *Scott* 1246;
(lower right) Nicaragua 1994, *Scott* 1984i.

(6) Carl Friedrich GAUSS[3] (1777–1855) "is considered by many to have been the greatest mathematician who has ever lived, and his astounding career requires several volumes to document. He was referred to by his peers as the 'prince of mathematicians'. Upon Gauss's death one of his peers wrote that 'His mind penetrated into the deepest secrets of numbers, space, and nature; he measured the course of the stars, the form and forces of the Earth; he carried within himself the evolution of mathematical sciences of a coming century.' History has proven this remark to be true" [11, p. 2].

Gaussian elimination is an algorithm in linear algebra for determining the solutions of a system of linear equations, for determining the rank of a matrix, and for calculating the inverse of an invertible square matrix, see, e.g., [11, §1.2].

[1] *Scott* numbers refer to the *2007 Standard Postage Stamp Catalogue* [10].

[2] First name also written as Jacques, Jakob or James.

[3] Last name also written as Gauß.

We have found four stamps in honour of Gauss (Fig. 4). Shown on the 1977 stamp from the Federal Republic of Germany, *Scott* 1246 (Fig. 4, lower left), is the Gaussian plane of complex numbers (Gausssche Zahlenebene), and on the stamp from Nicaragua, *Scott* 1984i (Fig. 4, lower right), in addition to a portrait of Gauss (lower right) is a portrait (upper left) of the well-known Polish astronomer Nicolaus Copernicus (1473–1543), who formulated a modern heliocentric theory of the solar system [20]; in addition, in the center of this stamp is shown the Observatory at Göttingen—Gauss lived and worked in Göttingen for over 50 years and worked at the Observatory from its inauguration in 1816 onwards.


FIG. 5 Loo-Keng Hua: China 1988, *Scott* 2148.


FIG. 6 Loo-Keng Hua: Postcard from China 2000.

(7) Loo-Keng HUA[4] (1910–1985) was a great mathematician and a Chinese legendary hero. He had little formal education, but made enormous contributions to number theory, algebra, complex analysis, matrix geometry and applied mathematics" [14]. In particular the inequality

$$\det(I - A^*A) \cdot \det(I - B^*B) \leq |\det(I - A^*B)|^2$$

is known as the "Hua determinantal inequality" [14]. Here the matrices $A$ and $B$ are contractive, i.e., the singular values all lie in the half-open unit interval $[0, 1)$; on the right-hand side, the symbol $|\cdot|$ denotes absolute value.

China issued a stamp in honour of Hua in 1988 (Fig. 5) and a postcard (Fig. 6) in celebration of his 90th birthday in 2000 (Hua died in 1985). The text in the upper right of the postcard says, "To Mr. Hua Luogeng, from Mao Zedong, 18 March 1964. I have received and then read the poem and letter. Your strong will is higher than the clouds. Congratulations." And in the upper left "Work hard without counting the years: self strengthen forever."

[4]The name "Loo-Keng Hua" is also written as "Hua Loo-keng".


FIG. 7 Gustav Robert Kirchhoff:
(left) Germany (Berlin) 1974, *Scott* 9N345;
(right) German Democratic Republic 1974, *Scott* 1541.

(8) Gustav Robert KIRCHHOFF (1824–1887) was a German physicist who contributed to the fundamental understanding of electrical circuits. Kirchhoff's matrix-tree theorem concerns the number of spanning trees in a graph. In electrical engineering, the Kirchhoff matrix, or admittance matrix, is also called a double-centered matrix since all its rows and columns sum to 0, and an equicofactor matrix since all its first cofactors are equal. The common value of these cofactors is called the network determinant and is equal to the number of associated spanning trees [18, 20]. We found only two stamps for Kirchhoff, both issued in 1974 (Fig. 7).


FIG. 8 Aleksei Nikolaevich Krylov:
(left) USSR 1956, *Scott* 1792; (right) USSR 1963, *Scott* 2713.

(9) Aleksei Nikolaevich KRYLOV (1863–1945) was a Russian naval engineer working on the theories of buoyancy, stability, rolling and pitching, vibrations, compass theories, etc.

He was also an applied mathematician and in 1931 showed how to use sequences of the form $\mathcal{K} = \{b, Ab, A^2b, \ldots, A^{k-1}b\}$ to construct the characteristic polynomial of a matrix; the $n \times k$ matrix $K = (b : Ab : A^2b : \cdots : A^{k-1}b)$ is called a Krylov matrix and $\mathcal{K}$ a Krylov sequence, see, e.g., Meyer [11, pp. 646, 649]. Here $A$ is an $n \times n$ complex matrix and $b$ is an $n \times 1$ nonnull complex vector. We found only two stamps depicting Krylov, both issued by the USSR (Fig. 8).

(10) Pierre-Simon, Marquis de LAPLACE (1749–1827) was a French mathematician and astronomer who put the final capstone on mathematical astronomy in his five-volume *Mécanique Céleste* (1799–1825). In linear algebra, the Laplace expansion of the determinant of an $n \times n$ square matrix $A$ expresses the determinant $\det(A)$ as a sum of $n$ determinants of $(n-1)\times(n-1)$ submatrices of $A$. There are $2n$ such expressions, one for each row and column of $A$. In graph theory the Laplacian matrix is a matrix representation of a graph. We have found only two stamps depicting Laplace, one issued by France and the other by Mozambique (Fig. 9).


FIG. 9 Pierre-Simon de Laplace: (left) France 1955, *Scott* B298; (right) Mozambique 2001, *Scott* unlisted?

## Acknowledgements

Most of the images of the stamps in this article are also on the excellent open-access website of Jeff Miller [12]; see also the Reinhardt website [15] and the beautiful book by Robin Wilson [21]. For biographical and related material we visited the open-access websites of MacTutor [13] and *Wikipedia* [20]. Many thanks to Oskar Maria Baksalary, Ka Lok Chu and Evelyn Matheson Styan for their help. This research has been supported in part by the Natural Sciences and Engineering Research Council of Canada.

## References

[1] Lewis Carroll (2000). *Alice's Adventures in Wonderland & Through the Looking-Glass,* featuring the Original Illustrations by John Tenniel, with a New Introduction by Martin Gardner. Reissue edition, Signet Classics.

[2] David Crystal (1994). *The Cambridge Biographical Encyclopedia*. Cambridge University Press.

[3] Charles L. Dodgson (1866). *Condensation of Determinants: Being a New and Brief Method for Computing their Arithmetical Values*. London.

[4] Charles L. Dodgson (1867). *An Elementary Treatise on Determinants, with their Application to Simultaneous Linear Equations and Algebraical Geometry.* Macmillan, London.

[5] R. William Farebrother (2002). A note on Hamilton and quaternions. *Image: The Bulletin of the International Linear Algebra Society*, no. 28 (April 2002), p. 17.

[6] R. William Farebrother, Shane T. Jensen & George P. H. Styan (2000). Charles Lutwidge Dodgson: a biographical and philatelic note. *Image: The Bulletin of the International Linear Algebra Society*, no. 25 (October 2000), pp. 22–23.

[7] R. William Farebrother, Shane T. Jensen & George P. H. Styan (2002). Sir Thomas Muir and nineteenth-century books on determinants. *Image: The Bulletin of the International Linear Algebra Society*, no. 28 (April 2002), pp. 6–15.

[8] R. William Farebrother, George P. H. Styan & Garry J. Tee (2003). Gottfried Wilhelm von Leibniz: 1646–1716. *Image: The Bulletin of the International Linear Algebra Society*, no. 30 (April 2003), pp. 13–16.

[9] Jolanta Grala, Augustyn Markiewicz & George P. H. Styan (2000). Tadeusz Banachiewicz: 1882–1954. *Image: The Bulletin of the International Linear Algebra Society*, no. 25 (October 2000), p. 24.

[10] James E. Kloetzel, ed. (2006). *Scott 2007 Standard Postage Stamp Catalogue*, 163rd edition (on paper in 6 volumes and on 12 CD-ROMs with text-searchable pdf files). Scott Publishing, Sidney, Ohio.

[11] Carl D. Meyer (2000). *Matrix Analysis and Applied Linear Algebra* (with CD-ROM with text-searchable pdf files). SIAM, Philadelphia.

[12] Jeff Miller, maintainer. *Images of Mathematicians on Postage Stamps.* Online open-access website: `http://jeff560.tripod.com/` New Port Richey, Florida, updated April 2007.

[13] John J. O'Connor and Edmund F. Robertson, creators. *The MacTutor History of Mathematics Archive:* Online open-access website, School of Mathematics and Statistics, University of St Andrews, St Andrews, Scotland, UK, updated April 2007: `http://www-history.mcs.st-andrews.ac.uk/history/index.html`

[14] Christopher C. Paige, George P. H. Styan, Bo-Ying Wang & Fuzhen Zhang (2007). Hua's matrix inequality and Schur complements. *International Journal of Information and System Sciences*, in press.

[15] Joachim Reinhardt (2007). Physics-related stamps. Online open-access website, Frankfurt-am-Main, Germany: `http://th.physik.uni-frankfurt.de/~jr/physstamps.html`

[16] George P. H. Styan, ed. (1999). IMAGE Philatelic Corner [Takakazu Seki Kôwa]. *Image: The Bulletin of the International Linear Algebra Society*, no. 23 (October 1999), p. 8.

[17] George P. H. Styan (2002). Biographies, portraits and stamps on the Web. *Image: The Bulletin of the International Linear Algebra Society*, no. 28 (April 2002), p. 17.

[18] George P. H. Styan & Gerald E. Subak-Sharpe (1997). Inequalities and equalities associated with the Campbell–Youla generalized inverse of the indefinite admittance matrix of resistive networks. *Linear Algebra and its Applications,* 250, 349–370.

[19] George P. H. Styan & Götz Trenkler (2007). A philatelic excursion with Jeff Hunter in probability and matrix theory. *Journal of Applied Mathematics and Decision Sciences*, invited paper submitted for publication.

[20] *Wikipedia, The Free Encyclopedia:* `http://en.wikipedia.org` Online open-access website: Wikimedia Foundation.

[21] Robin J. Wilson (2001). *Stamping Through Mathematics*. Springer-Verlag New York.

[22] Fuzhen Zhang, ed. (2005). *The Schur Complement and Its Applications*. Springer Science+Business Media.

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## Book Review: *The Unknown Quantity: A Real and Imaginary History of Algebra*

by John Derbyshire, John Henry Press, Washington, DC, 2006, 374 pages.

Reviewed by Jeffrey L. Stuart, Pacific Lutheran University

What's not to be loved about a book that contains the sentence, "We have a glimpse here of a key notion in late 20th-century algebra, the notion of attaching algebraic objects to a manifold." Within the paragraph that contains this sentence, John Derbyshire mentions groups in the context of algebraic topology and modules in the context of algebraic geometry, before finishing by alluding to the French mathematicians Leray, Serre and Grothendieck. Clearly, this book is not targeted at the intellectually curious lay person. To quote the dust jacket, it is "written for those among us who are not encumbered with a fear of formulae." And yet, neither is this book an encyclopedia of algebra, nor even an introductory text. Although sprinkled with formulae, and even with a few explicitly stated theorems, this is not a compendium of the "greatest hits" of algebra. Rather, this book attempts to broadly describe the big ideas, the personalities and the controversies that have shaped the development of algebra and its subfields over the last four thousand years. In a work of finite length, that necessarily requires excluding far more than is included, and applying intense brevity to that which is covered. While one could quibble with the choice of material to exclude, few will question the merits of the topics included. As an example of the brevity of presentations, among the 20th century topics covered, Derbyshire devotes exactly three pages to category theory. He informally describes what categories and functors are, highlights those ideas with a few simple examples, mentions Eilenberg and MacLaine, and finally, samples from both sides of the current debate over whether the use of category theory actually contributes to the development of mathematics.

The exposition is lively and conversational with the key ideas and results supported by simple examples, an occasional equation, and informative diagrams and graphs. When Derbyshire turns his attention from algebra to algebraists, his short biographical sketches attempt to capture who the algebraist was as a person, how he or she fit into contemporary political and mathematical society, and why their mathematics mattered to them and should matter to us. These sketches are animated personal stories rather than dry recitations of results and students. While the overall organization of the book is historical, the individual chapters are organized thematically rather than strictly chronologically, so that the reader has a sense of being carried forward both within fields and more broadly across the whole of algebra.

Within chapters, subsections are numbered so that the reader can easily navigate to cross-references, and there is an extensive index of topics and mathematicians. (Since I am not a historian, I cannot assess whether Derbyshire has his dates and attributions correct, but as a reader, I had a clear sense that he has made an effort to indicate when he is speculating and when he is discussing matters on which mathematical historians are still unsettled.) The book is divided into three parts, and within each part the reader will find one or more mathematical "primers". The first part is preceded by the first primer, which is devoted to numbers and polynomials. In this primer, Derbyshire gives a whirlwind tour of the various number sets: natural numbers, integers, rational numbers, real numbers, and complex numbers, culminating with descriptions of complex multiplication and the complex plane. The primer closes with an explanation of what polynomials are.

The first part covers algebra from the dawn of arithmetic through the solution of the cubic and quartic equations, and on to the development of modern algebraic notation. The second part begins with Newton's work on the decomposition of symmetric polynomials in terms of elementary symmetric polynomials, continues through Abel's work on the unsolvability of the quintic equation and Hamilton's work on quaternions, pauses to discuss vector spaces and matrices, and then concludes with De Morgan's work on the algebra of sets, the algebraic foundations of logic in the work of Boole, and the introduction of abstract groups by Cayley. The third part begins with a primer on field theory to prepare the reader for the work of Galois. From Galois' splitting fields, Derbyshire moves on to the great age of ring theory before turning to algebraic geometry, algebraic topology, universal algebras and all other matters algebraic in the 20th century (all without a single mention of Bourbaki).

So what about *linear* algebra? Derbyshire's primer on vector spaces would be familiar to anyone who has taught a course in elementary linear algebra. He describes vector space properties in the context of $\mathbf{R}^n$ supported by geometric pictures in the plane. He continues with a brief discussion of independence and dimension before presenting sets of polynomials and sets of functions as further examples of vector spaces. After a brief mention of dual spaces, he introduces vector multiplication to conclude with a discussion of algebras. All of this is achieved in eleven pages without a formal definition or an explicit theorem.

Determinants and matrices appear in a chapter aptly named "An Oblong Arrangement of Terms". While adhering to modern notation, Derbyshire briefly discusses how the study of systems of linear equations arose during the Han dynasty in China (first century C.E.). Citing *The Nine Chapters on the Art of Calculation*, he states that the Chinese mathematicians were using what is now called Gaussian elimination to solve a system of three equations in three unknowns. (He does not make it clear whether the

*Nine Chapters* contained a general formulation of Gaussian elimination, or whether it contained applications to larger systems.) Leaving China, the author wanders through Europe and Japan in pursuit of determinants before arriving at matrices. The discussion of matrices is limited to three topics: that the set of n x n matrices form an $n^2$-dimensional algebra, that the complex numbers can be represented as a subalgebra of the $2 \times 2$ real matrices, and that the quaternions can be represented as a subalgebra of the $4 \times 4$ real matrices. There is no mention of eigenvalues, let alone any discussion of the spectral theory of real, symmetric matrices.

This is a book that I would happily recommend to a graduate student or a colleague who wants to see the big picture of what algebra was, is and is becoming. I certainly learned a lot of history and even a little algebra from the book, and I will use the history to inform my teaching.

---

## Simple Sudoku

Contributed by Richard William Farebrother

In its most general form and for $m = n^2$, a sudoku grid consists of an $m$x$m$ array such that each row, each column and each of the $m$ contiguous $n$x$n$ submatrices contains a complete set of the numerals 1, 2, ..., $m$ in some order.

In a standard sudoku, with $m = 3^2$, we have a 9×9 grid satisfying these conditions. A crude estimate (based on an analysis of the nine contiguous submatrices) suggests that there are rather fewer than $362880 \cdot (86400)^3 \cdot (216)^5$ such arrangements.

In this note we consider the much simpler case of a 4×4 grid: The letters $w$, $x$, $y$, $z$ representing the numerals 1, 2, 3, 4 can be placed in the upper left 2×2 submatrix in $4 \cdot 3 \cdot 2 \cdot 1 = 24$ different ways. Given any one such arrangement, then the second row and the second column can each be completed in two distinct ways. Arbitrarily selecting any one such arrangement, say $\begin{bmatrix} w & x & & \\ y & z & w & x \\ & w & & \\ & y & & \end{bmatrix}$, we find that the missing elements in the first row and the first column of this matrix may be completed in any one of four distinct ways:

$$\begin{bmatrix} w & x & y & z \\ y & z & w & x \\ x & w & & \\ z & y & & \end{bmatrix}, \begin{bmatrix} w & x & y & z \\ y & z & w & x \\ z & w & & \\ x & y & & \end{bmatrix}, \begin{bmatrix} w & x & z & y \\ y & z & w & x \\ x & w & & \\ z & y & & \end{bmatrix}, \begin{bmatrix} w & x & z & y \\ y & z & w & x \\ z & w & & \\ x & y & & \end{bmatrix}.$$

Now, the remaining elements of the first three matrices may be completed uniquely whilst the fourth leads to an internal contradiction as the (3,4) and the (4,3) elements cannot be defined. Thus we have the three arrangements:

$$\begin{bmatrix} w & x & y & z \\ y & z & w & x \\ x & w & z & y \\ z & y & x & w \end{bmatrix}, \begin{bmatrix} w & x & y & z \\ y & z & w & x \\ z & w & x & y \\ x & y & z & w \end{bmatrix}, \begin{bmatrix} w & x & z & y \\ y & z & w & x \\ x & w & y & z \\ z & y & x & w \end{bmatrix},$$

from which we may generate a full set of twelve templates by interchanging their last two rows and/or their last two columns. Each of these twelve templates is associated with 24 possible permutations of the elements in the upper left 2×2 submatrix. There is thus a total of $12 \cdot 24 = 288$ possible solutions to a 4×4 sudoku problem and the relevant solution is easily identified by comparing the available information with each of these twelve templates in turn.

In passing, we note that both the principal diagonals and the central 2×2 submatrix of the template, $\begin{bmatrix} w & x & z & y \\ y & z & w & x \\ x & w & y & z \\ z & y & x & w \end{bmatrix}$, also contain the numerals 1, 2, 3, 4 in some order. I shall leave the corresponding analysis of the traditional 9×9 problem to further research.

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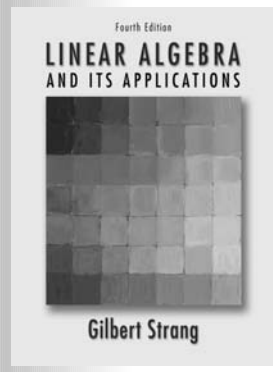


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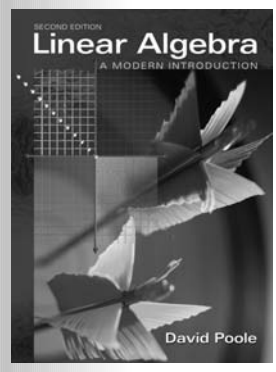


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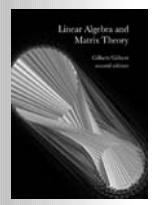


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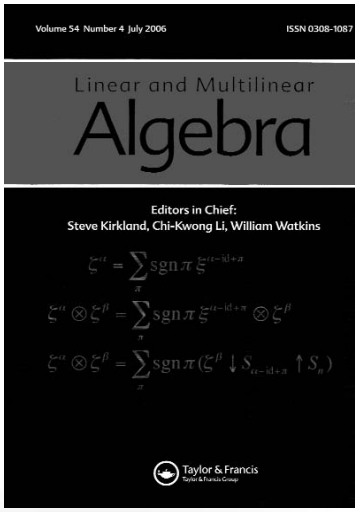


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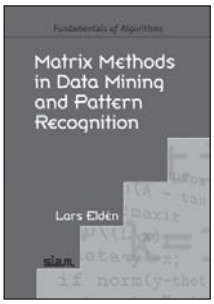


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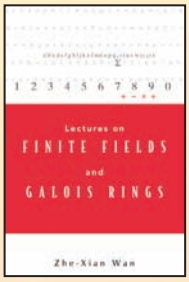


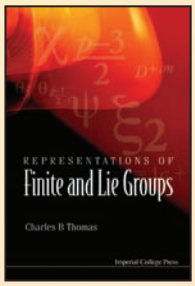


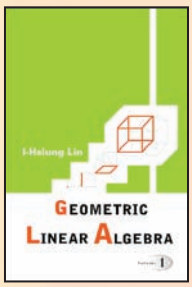


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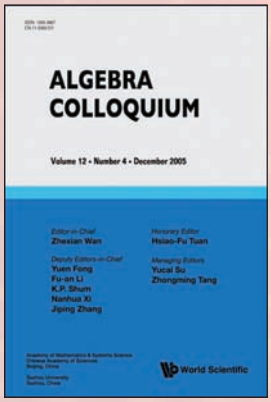


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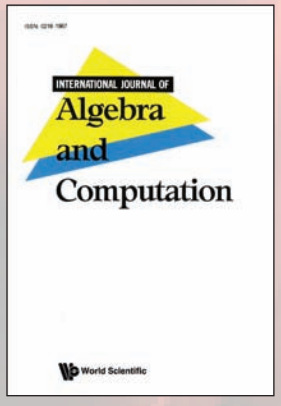


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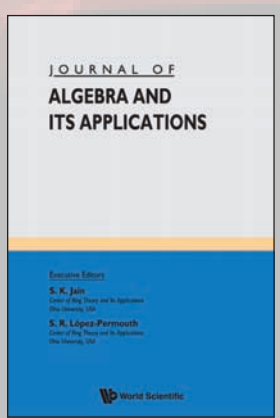


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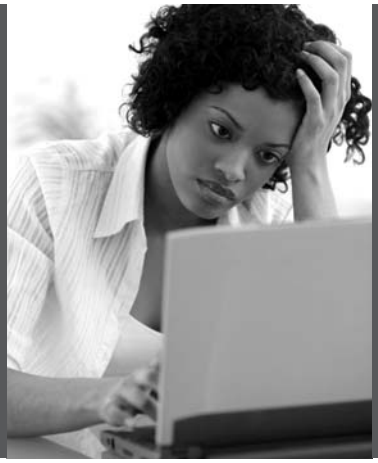

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