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Issue Number 57, pp. 1–32, Fall 2016

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About *IMAGE* 2

Feature Interview

“Students at all levels have something to offer”
 An Interview with Charles R. Johnson, by Carlos M. da Fonseca 3

Linear Algebra Education

Linear Algebra Education Notes from David Strong 4

Article

A note in memory of Bob Thompson: 20 years later, by Wasin So 6

Book Reviews

Matrix Functions and Matrix Equations, by Zhaojun Bai, Weiguo Gao, and Yangfenf Su,
 Reviewed by Chun-Hua Guo 8
Numerical Linear Algebra and Its Applications (Second Edition), by Xiao-Qing Jin, Yi-Min Wei, and Zhi Zhao,
 Reviewed by Fuzhen Zhang 9
Linear Algebra and Matrices: Topics for a Second Course, by Helene Shapiro,
 Reviewed by Rajesh Pereira 9

Send News for *IMAGE* Issue 58 10

Obituary Notices

Obituary Notice: T.W. Anderson 12
 Obituary Notice: T.S. Michael 12

Journal Announcement

LAMA Special Issue in Honor of Marvin Marcus 12

Upcoming Conferences and Workshops

Matrix Equations and Tensor Techniques Workshop, Italy, February 13–14, 2017 13
 The 8th Linear Algebra Workshop (LAW’17), Slovenia, June 12–16, 2017 13
 The 6th International Conference on Matrix Analysis and Applications (ICMAA 2017), Vietnam, June 15–18, 2017 .. 13
 The Householder Symposium XX on Numerical Linear Algebra, USA, June 18–23, 2017 13
 Preservers Everywhere, Hungary, June 19–23, 2017 14
 The Second Malta Conference in Graph Theory and Combinatorics (2MCGTC 2017), Malta, June 26–30, 2017 14
 Rocky Mountain–Great Plains Graduate Research Workshop in Combinatorics 2017 (GRWC 2017), USA, July
 9–22, 2017 15
 ILAS 2017: Connections, USA, July 24–28, 2017 15
 Preconditioning 2017 - International Conference on Preconditioning Techniques for Scientific and Industrial
 Applications, Canada, July 31–August 2, 2017 16
 Matrix Analysis and its Applications — A Special Session for PRIMA 2017, Mexico, August 14–18, 2017 16

Contents continued on page 2.

MAT-TRIAD'2017 - International Conference on Matrix Analysis and its Applications, Poland, September 25–29, 2017	17
--	----

Conference Reports

2016 Western Canada Linear Algebra Meeting (WCLAM), Canada, May 14–15, 2016	17
The 25 th International Workshop on Matrices and Statistics (IWMS-2016), Portugal, June 6–9, 2016	18
The 2016 International Workshop on Matrix Inequalities and Matrix Equations, China, June 8–10, 2016	20
Southeast Asian Mathematical Society (SEAMS) School Diliman on Topics in Matrix Analysis and Applications, Philippines, June 27 – July 7, 2016	20
The 2016 Workshop on Numerical Ranges and Numerical Radii, Taiwan, June 28–30, 2016	21
2016 Workshop on Matrices and Operators, Korea, July 3–6, 2016	22
The 20 th ILAS Conference, Belgium, July 11–15, 2016	23

ILAS News

ILAS Member Honored by AMS	25
2017 ILAS Taussky-Todd Lecturer	25
ILAS and IWOTA introduce the Israel Gohberg Lecture	25
ILAS Elections: Nominations	25
ILAS Elections and Membership	25

Announcement

2020 Householder Symposium	26
----------------------------------	----

Book Announcement

Infinite Matrices and Their Recent Applications, by Shivakumar, Zhang and Sivakumar	26
---	----

IMAGE Problem Corner: Old Problems with Solutions

Problem 56-1: Minimizing Problem	29
Problem 56-3: On Areas of Some Related Triangles	29
Problem 56-4: A Determinant Inequality	30

IMAGE Problem Corner: New Problems

Problem 57-1: Perfect Condition Number	32
Problem 57-2: A Matrix Proof of an Exercise in Calculus	32
Problem 57-3: A PSD Matrix Decomposition	32
Problem 57-4: Factors of a Determinantal Polynomial	32
Problem 57-5: Eisenstein Circulant Matrices	32
Problem 57-6: A Commuting Matrix Problem	32

About *IMAGE*

ISSN 1553-8991. Produced by the International Linear Algebra Society (ILAS). Two issues are published each year, on June 1 and December 1. The editors reserve the right to select and edit material submitted. All issues may be viewed at <http://www.ilasic.org/IMAGE>. *IMAGE* is typeset using L^AT_EX. Photographs for this issue were obtained from websites referenced in articles, university department websites, as noted in the articles, or from reporters directly, unless indicated otherwise here: ILAS 2016 photos [p. 24] taken by Rob Stevens. Note: due to file size restrictions, photographs are not reproduced in their original quality.

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For more information about ILAS, its journals, conferences, and how to join, visit <http://www.ilasic.org>.

FEATURE INTERVIEW

“Students at all levels have something to offer”

Charles R. Johnson Interviewed by Carlos M. da Fonseca¹

C.F. - How did you get interested in mathematics and linear algebra in particular?

C.J. - I always liked mathematics and was good at it. As an undergraduate at Northwestern, I took optimization and econometrics, and duly noted that positive definite matrices played a key role in each, in a manner similar to positive numbers in the scalar case. I was intrigued. In my last year, the *American Mathematical Monthly* offered a prize contest to write an article on “Positive Definite Matrices” so I entered and submitted a piece de-emphasizing symmetry/Hermicity in the definition. I was curious how different things would be. My article was chosen and soon published.² It is item #1 on my publication list, has often been referenced, and has been used pedagogically. It turned out that the judge of the contest was Olga Taussky-Todd, who later became my thesis advisor at Caltech.



C.R. Johnson

C.F. - What is the most important moment in your career? Let us say, “the turning point.”

C.J. - I don’t know of any “turning” points. I was always happy to receive job offers at key moments that allowed me to pursue my interests. I am also very happy about the many collaborators I have met (perhaps 200), including students, who very much helped me to resolve more questions than I otherwise could have.

C.F. - Who was the person most influential in your career?

C.J. - Again there are many, and it is hard to single out a few. Olga was, of course, important. There is an article about her influence in the *Notices*.³ It was nice to meet Roger Horn, by chance, and find that he shared my interest in the need for the *Matrix Analysis* books (leading seller at CUP and referenced about 28,000 times).⁴

C.F. - What was the influence of your Ph.D. supervisor in your career?

C.J. - Let me add that one of Olga’s (small) enduring influences was forcing me to write “ n -by- n ”, with which I now agree, as I share her disdain for gratuitous and unnecessary informality in writing. There are many good Olga stories that I think that I can tell now that she is long gone. She was always very helpful in a kind and motherly way (she had no children besides her students). Feeling somehow that I should be nervous, she and Jack told me that they would take me to the beach the day before my Ph.D. qualifying exam. Perhaps this was a signal that, despite the fact that some people failed, I need not study any more. It went well, and I will leave the story there, though there was some interesting “aftermath.” One of the last conversations I had with Olga (fortunately not the last) was when I called her to tell her of the birth of my second child Emily. Long silence, followed by a crisp and demanding “How do you spell that?” Only then did I recall with horror her long-standing antipathy with another (and one of the very few) female matrix theorists of the time, Emilie Haynsworth. Not having anticipated this in our naming process, fortunately I could reply “with a ‘y’”!

C.F. - Which paper or result of yours do you like most?

C.J. - Again, this is like asking “which of your children do you like the best?” I like all 450 or so, and looked at together they tell quite a story. I never cease to be amazed at what you can accomplish if you are steady and keep doing

¹Department of Mathematics, Kuwait University, Kuwait. carlos@sci.kuniv.edu.kw

²C.R. Johnson, “Positive definite matrices.” *The American Mathematical Monthly* 77.3 (1970) 259–264.

³E.H. Luchins and M.A. McLoughlin. “In Memoriam: Olga Taussky-Todd.” *Notices of the American Mathematical Society* 43.8 (1996) 838–847.

⁴R.A. Horn and C.R. Johnson. *Matrix Analysis*. Cambridge University Press, 1985 (2nd ed. 2012), and R.A. Horn and C.R. Johnson. *Topics in Matrix Analysis*. Cambridge University Press, 1991.

a little at a time over a long period. Of course, I have fond feelings for many papers/results: the characterization of positive definite completability in terms of chordal graphs; resolution of the permanent-on-top conjecture for M -matrices; accurate computation of the field of values; characterization of all determinantal inequalities for M -matrices; and for totally positive matrices; the combinatorial characterization of maximum multiplicity among Hermitian matrices whose graph is a tree in terms of the path cover number; the recent generalization of multiplicity results for Hermitian matrices to geometric multiplicity in general matrices for a given graph, etc.

C.F. - What is the area in matrix theory you currently find most interesting?

C.J. - I like all parts of matrix analysis and their interaction with the rest of mathematics and have worked on many. I have worked most, of late, on the role of combinatorial ideas in understanding matrix structure. This is incredibly exciting. I have gotten back into the monster nonnegative inverse eigenvalue problem, thanks to colleagues. Might as well go for broke. But there are many good questions to keep me going.

C.F. - The *IMAGE* readers would like to know about your experience at William & Mary.

C.J. - The students are wonderful and I work with several good ones each year. It's a significant part of what makes this worthwhile. When I came, the administration was excellent: forward-looking, interested in excellence in both research and education, and mindful of incentives and the careful use of resources to achieve objectives. This was important in attracting me. After I came, the President (of W & M) would call me up once a month or so to get together to talk about how things were going and what might be needed to improve things further. From a department that had no recognition, in a few years, with the hiring of the likes of Leiba Rodman, Ilya Spitkovsky, Hugo Woerdeman, and Roy Mathias, we were able to build likely one of the strongest departments of mathematics at a small school, and the recognized world-leading group in matrix analysis. It was a case study in what can be accomplished in a short time with modest resources, careful, opportunistic hiring and a commitment to excellence. Unfortunately, with changes in the administration (the President left for AAA to triple his salary) and the onset of a culture of malfeasance administration, meritocracy and excellence died. Now we are left with folks in charge who have no interest in teaching or research. So, another case study in how good things can be destroyed quickly in academia. All of the four mentioned folks are gone now and, with them, a wonderful department.

C.F. - Do you have any advice to young researchers, especially to linear algebraists?

C.J. - Yes: Work hard on challenging problems in which you find intrinsic interest. Work with others at least some of the time and realize that students at all levels can be eager and have something to offer. There are plenty of good questions. And if mathematical research is a job, rather than a pleasure, change professions - but, please, not to administration!

C.F. - Thanks for this interview, Charlie.

LINEAR ALGEBRA EDUCATION

Notes from David Strong, Contributing Editor for Linear Algebra Education

- A short blog written by Drew Armstrong (University of Miami) on why Linear Algebra should be a two-semester sequence can be found at <http://blogs.ams.org/matheducation/2016/09/19/more-linear-algebra-please>.
- At the upcoming Joint Meetings of the AMS and MAA to be held in Atlanta, January 4–7, 2017, two sessions will be devoted to Innovative and Effective Ways to Teach Linear Algebra. These sessions are organized by David Strong, Gil Strang and Megan Wawro, and will be held the Friday and Saturday mornings of the meetings.
- At the upcoming ILAS meeting, to be held in July 2017 at Iowa State University, there will be a session devoted to the teaching and learning of linear algebra organized by Rachel Quinlan (National University of Ireland Galway, Ireland) and Megan Wawro (Virginia Polytechnic Institute and State University).

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ARTICLE

A note in memory of Bob Thompson: 20 years later

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A special session in memory of Bob Thompson, who was a founding editor of *IMAGE* and of *Linear and Multilinear Algebra*, and a founding member of ILAS, was organized during the 5th International Conference on Matrix Analysis and Applications in December 2015 at Nova Southeastern University in Florida, USA. Not only his impact in linear algebra, but also his kindness in life was reflected upon in the talks given in the session. Bob Thompson was a self-proclaimed “average mathematician” [1]. His sudden death in December 1995 saddened the linear algebra community. A number of articles [2, 3, 4, 5] have been written about his mathematics, his service, and his personality.

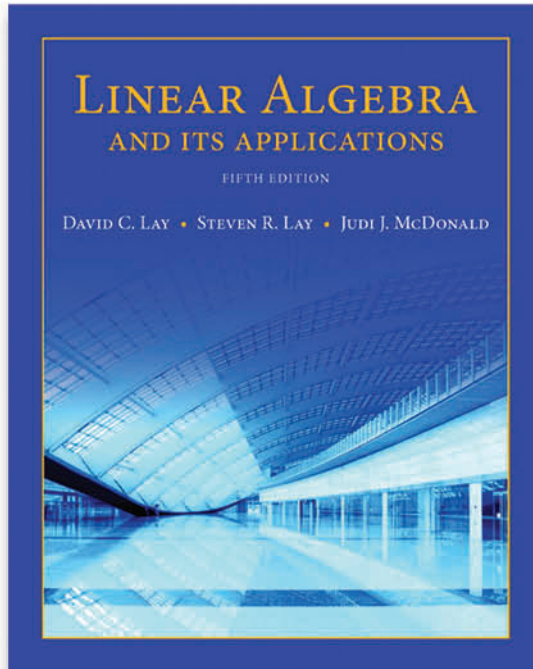
The best way to learn about his kindness was through personal interactions with him, as many speakers of the special session shared. His kindness was also shown through his collaboration with his students. According to the Mathematics Genealogy Project, Bob had ten Ph.D. students. The author of this article is one of them. He coauthored articles with all of his Ph.D. students except one. According to *Mathematical Reviews*, Bob had 120 publications, 22 of which were coauthored with his Ph.D. students.

The best way to learn about his mathematics is through his ten lectures given at Johns Hopkins University in 1988. Fortunately, these lecture notes were preserved and are available in digital form from the website <http://www.math.sjsu.edu/~so/thompson.html>. His impact in linear algebra was also shown through his selection of problems. A problem dear to Bob’s heart is the similarity among the inequalities satisfied by the eigenvalues of the sum of Hermitian matrices, the singular values of the product of complex matrices, and the eigenvalues of the product of unitary matrices. Bob established many such inequalities in several series of papers. After Bob’s death, good progress was made on all three problems, see [6], [7] and [8], respectively. However, the tools used were what Bob would call “high road”, i.e., they come from parts of mathematics that would be unfamiliar to a linear algebraist [9]. And it would be nice to find a “low road” proof for these problems, i.e., using mathematics that is familiar to a linear algebraist [9]. Another problem dear to Bob’s heart is the convexity of the intersection of the numerical range of a quaternionic matrix with the upper half complex plane. He found a “low road” proof of this result [10], and he asked whether a “high road” proof exists. This is a challenge to the linear algebra community, especially the new generation!

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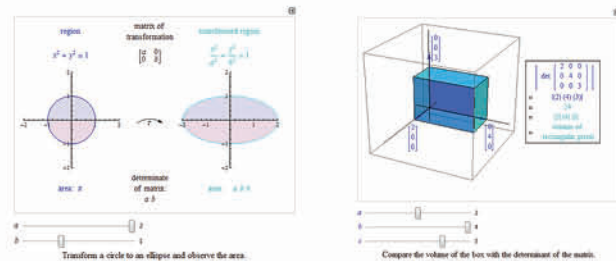
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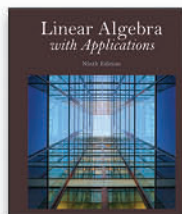


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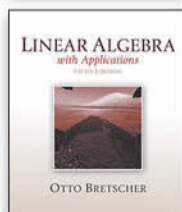
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BOOK REVIEWS

Matrix Functions and Matrix Equations, by Zhaojun Bai, Weiguo Gao, and Yangfenf Su

World Scientific, Singapore, 2015, ISBN 978-981-4675-76-5 (hardcover);
978-981-4675-78-9 (e-book), vii+148 pages.

Reviewed by Chun-Hua Guo, University of Regina, chun-hua.guo@regina.ca

This book is a collection of summaries of the lectures from the 4th Gene Golub SIAM Summer School, on “Matrix Functions and Matrix Equations.” The lectures were delivered by five prominent researchers, some with teaching assistants: *Matrix functions: a short course*, by Nicholas Higham and Lijing Lin; *A short course on exponential integrators*, by Marlis Hochbruck; *Matrix equations and model reduction*, by Peter Benner, Tobias Breiten, and Lihong Feng; *Rayleigh quotient based optimization methods for eigenvalue problems*, by Ren-Cang Li; and *Factorization-based sparse solvers and preconditioners*, by Xiaoye Li.

The summary by Higham and Lin touches on many aspects of matrix functions. It starts with some historical notes. Then three equivalent definitions of a matrix function are given and some basic properties of matrix functions are presented. The condition number of a matrix function is then defined and an explicit expression is given using the Fréchet derivative of the matrix function. Quite a few interesting applications are then described. Various numerical methods are presented for computing $f(A)$ for small/medium size A . A few numerical procedures for computing $f(A)b$, the action of $f(A)$ on a vector b , are also described for large sparse A . While the summary covers some essential features of matrix functions, one would still need to read Higham’s book on matrix functions to get a better understanding of the subject.

The presentation of Hochbruck is much more focused and more detailed. It is on the construction, analysis, and implementation of exponential integrators for time dependent partial differential equations. Specifically, the equations under consideration are autonomous evolution equations of the form $u'(t) = F(u(t))$, $u(t_0) = u_0$, in a finite time interval $t \in [t_0, T]$, where F is a partial differential operator or its spatial discretization. The exponential Runge–Kutta methods are derived using a fixed linearization of F , and the exponential Rosenbrock-type methods are derived by using a continuous linearization at the current approximation of the solution. Error bounds are obtained for both types of methods. For the implementation, one needs to approximate vectors of the form $\phi(-\tau A)b$, where $\tau > 0$, A is a given large sparse matrix, and ϕ is the exponential function or a function defined through the exponential function. This is achieved by using the Cauchy integral formula and the Arnoldi algorithm for solving linear systems.

The summary by Benner *et al.* provides a crisp introduction to model order reduction (MOR) methods for large-scale linear time-invariant systems. Section 1 describes the basic idea of MOR and outlines the goals to be achieved by MOR methods. Section 2 is relatively long, providing some mathematical basics needed for the study of MOR. In the next four sections, they present the basic ideas of some MOR methods. In particular, balanced truncation and balancing related methods require the solution of Lyapunov equations or Riccati equations. Section 7 is then devoted to solving these equations. The alternating direction implicit (ADI) method plays an important role here. The Lyapunov equations can be solved by the low-rank ADI iteration and the Riccati equations can be solved by low-rank Newton–ADI iteration.

The lecture by R. Li is on eigenvalue problems which are related to the study of matrix equations. Four classes of eigenvalue problems are considered. The first and simplest one is about Hermitian matrix pencils $A - \lambda B$ with B being positive definite. The other three are: positive semidefinite pencils, linear response eigenvalue problems, and hyperbolic quadratic eigenvalue problems. All four classes admit min-max principles, upon which efficient numerical methods for extreme eigenpairs can be developed by optimizing the Rayleigh quotient functions. In this summary, Li uses most of the pages for the first class, explaining in some detail some important issues about the steepest descent/ascent methods and nonlinear conjugate gradient methods. For the other three classes, Li presents the min-max principles, noting that the numerical methods for the first class can be extended to these three classes.

The lecture by X. Li is about solving the linear system $Ax = b$, where A is nonsingular, but is supposed to be large and sparse. The topic is related to matrix function problems since the computation of $f(A)b$ by the Cauchy integral formula would require the solution of linear systems. The summary includes a discussion of parallel computing and the data structures used to store sparse matrices, but the emphasis is on high performance sparse factorization techniques. These techniques can be used to design sparse direct solvers, and used to obtain preconditioners for iterative solvers when the coefficient matrix A is ill-conditioned.

This book covers several aspects of matrix functions and matrix equations. The presentations are usually brief since they are just summaries of the lectures. However, by reading this book one can get a fairly good overview. The long lists of references at the end of the summaries are certainly very helpful for readers who want to learn more about this important research area.

Numerical Linear Algebra and Its Applications, Second Edition,
by Xiao-Qing Jin, Yi-Min Wei, and Zhi Zhao

Information and Computational Science, Vol. 73, Science Press, Beijing, 2015,
ISBN 978-7-03-046425-5 (hardcover), x+188 pages.

Reviewed by Fuzhen Zhang, Nova Southeastern University, zhang@nova.edu

This is an expanded version of the first edition of *Numerical Linear Algebra and Its Applications* by Xiao-Qing Jin, Yi-Min Wei, and Zhi Zhao, published by the acclaimed Science Press (Beijing) in the Information and Computational Science Series. Important features of the first edition have been updated and improved.

As a fundamental part of computational science, numerical linear algebra is widely applied in STEM (Science, Technology, Engineering and Math) areas such as image and signal processing, computational finance, structural biology, data mining, and fluid dynamics. Many practical problems boil down to problems in numerical linear algebra. Thus, the development, analysis, and implementation of state of the art algorithms for solving various numerical linear algebra problems are rather important. In just over 200 pages, this book gives a brief and insightful introduction to the field.

The second edition of the book consists of ten chapters. The contents are: Chapter 1, Introduction; Chapter 2, Gaussian Elimination; Chapter 3, Perturbation and Error Analysis; Chapter 4, Least Square Problems; Chapter 5, Classical Iterative Methods; Chapter 6, Krylov Subspace Methods; Chapter 7, Nonsymmetric Eigenvalue Problems; Chapter 8, Symmetric Eigenvalue Problems; Chapter 9, Applications in ODEs and DDEs; and Chapter 10, Applications in PDEs. Certain material and topics reflect the authors' advanced skills and research experience in the field.

The book is intended for undergraduate and graduate students in STEM, particularly in applied mathematics, computational mathematics, scientific computing, computer science, financial mathematics, and engineering. It is also a good reference for scientific researchers in engineering and other applied disciplines.

Linear Algebra and Matrices: Topics for a Second Course,
by Helene Shapiro

AMS Pure and Applied Undergraduate Texts, Vol 24, American Mathematical Society, Providence,
2015, ISBN 978-1-4704-1852-6 (hardcover); 978-1-4704-2272-1 (e-book), xvi+317 pages.

Reviewed by Rajesh Pereira, University of Guelph, pereirar@uoguelph.ca

Linear Algebra and Matrices: Topics for a Second Course by Helene Shapiro succeeds brilliantly at its stated purpose which is hinted at by the title. It provides some innovative new ideas of what to cover in the second linear algebra course that is offered at many universities. Many of the textbooks that are used for a second course are several decades old and predate, for instance, the regular inclusion of combinatorics in the undergraduate curriculum. *Linear Algebra and Matrices* has an extensive coverage of combinatorial topics including design theory, projective planes, Hadamard matrices, graph theory (including strongly regular graphs and digraphs) and coding theory. This book is especially valuable as a textbook if your university does not have a regular combinatorics course or a regular graph theory course, as this book shows how some of this important material can be covered in the second linear algebra course in a very natural and effective way.

Nonnegative matrices and the Perron-Frobenius theorem is another important topic which is well covered in this text. An earlier chapter on directed graphs and an earlier section on block cycle matrices are both specifically designed to facilitate the introduction of such concepts as irreducibility and imprimitivity. This theory is then applied to Markov chains and dynamical systems (both discrete and continuous) in the final chapter.

Traditional linear algebra topics are also covered. The Jordan canonical form, a staple of the second course in linear

algebra, is very well explained (and given that this review is appearing in *IMAGE*, it seems appropriate to note that Shapiro credits part of her treatment of the Jordan canonical form to a talk that Paul Halmos gave at the 1993 ILAS meeting). It shares its chapter with the lesser-known Weyr canonical form, for which an earlier article of the author is the authoritative modern reference. Hermitian and normal matrices also have their own chapters, in which are included topics such as Schur triangularization and the Courant-Fischer theorem which should be but are usually not in the syllabus of a second course.

There is more material in this book than can be covered in a single course. In the note to the reader, the author lists the chapters that should be covered for two possible courses that could be based on this textbook. Instructors can choose from the topics in this book to come up with many others; a flowchart listing which chapters are prerequisites for the later chapters would have been helpful for this but is alas not included. Each chapter has problems at the end, always a vital consideration when choosing a textbook. Students who successfully complete these problems will have a good grasp of the material.

Given the centrality of linear algebra to mathematics, several of the ideas in this book may be useful to other courses as well. The approach used for inner products, which involves first proving the formula for the projection onto a one-dimensional subspace and then using this formula to prove other results such as the Cauchy-Schwarz inequality, can be adapted to analysis courses. Ryser's theorem and a corollary, the one-dimensional case of Helly's theorem, are both covered in the 0-1 matrix chapter. They provide an elementary but nontrivial example of mathematical induction that is accessible to anyone who has covered matrix multiplication and which can be used in an introduction to pure mathematics course.

Linear Algebra and Matrices: Topics for a Second Course would be my personal choice for a textbook when I next teach the second course for linear algebra at my university. I highly recommend this book, not only for use as a textbook, but also as a source of new ideas for what should be in the syllabus of the second course. In my opinion, the ideas in this book deserve to catch on.

Send News for *IMAGE* Issue 58

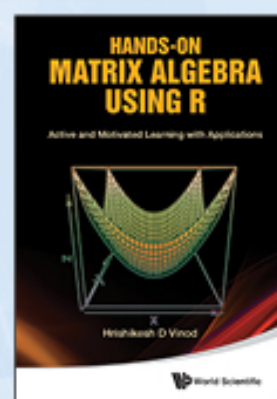
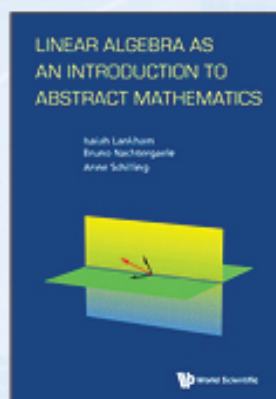
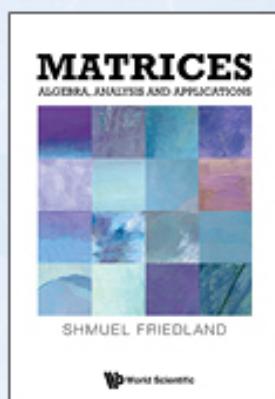
IMAGE Issue 58 is due to appear online on June 1, 2017. Send your news for this issue to the appropriate editor by April 2, 2017. *IMAGE* seeks to publish all news of interest to the linear algebra community. Photos are always welcome, as well as suggestions for improving the newsletter. Send your items directly to the appropriate person:

- problems and solutions to Rajesh Pereira (pereirar@uoguelph.ca)
- feature articles to Michael Cavers (mcavers@ucalgary.ca)
- history of linear algebra to Naomi Shaked-Monderer (nomi@tx.technion.ac.il)
- book reviews to Douglas Farenick (Doug.Farenick@uregina.ca)
- linear algebra education news to David Strong (David.Strong@pepperdine.edu)
- announcements and reports of conferences, workshops and journals to Minerva Catral (catralm@xavier.edu)
- interviews of senior linear algebraists to Carlos Fonseca (carlos@sci.kuniv.edu.kw)
- advertisements to Amy Wehe (awehe@fitchburgstate.edu).

Send all other correspondence to Kevin N. Vander Meulen (kvanderm@redeemer.ca).

For past issues of *IMAGE*, please visit <http://www.ilasic.org/IMAGE/>.

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OBITUARY NOTICES

Obituary Notice: T.W. Anderson

Submitted by Francisco Carvalho, Simo Puntanen, and George P. H. Styan

Professor T.W. “Ted” Anderson of Stanford University passed away on September 17, 2016. The IWMS-1998 and IWMS-2008 celebrated his 80th and 90th birthdays in Fort Lauderdale (Florida, USA) and Tomar (Portugal), respectively. On his 98th birthday on June 5, 2016 we sent Ted congratulations just before the IWMS-2016 Workshop. He immediately replied and asked us to convey his greetings to the participants. He reminded us that he had spent a 9-month sabbatical leave in Madeira in the 1960s, working on his book *The Statistical Analysis of Time Series* (Wiley 1971).

As Kathleen J. Sullivan noted in her *Stanford News* obituary (available at <http://news.stanford.edu/2016/09/23/theodore-w-anderson-scholar-mathematical-statistics-econometrics-dies>):

“Amazingly, Ted submitted his last technical paper less than a month ago,” said Emmanuel Candès, chair of the Department of Statistics at Stanford, who said Anderson has been a towering intellectual figure in the department for nearly 50 years.

On October 10, 2016, *The New York Times* published an obituary about T. W. Anderson; see the online version with the headline *Theodore Anderson, Mathematician Who Advanced Data Analysis, Dies at 98* at <http://www.nytimes.com/2016/10/10/us/theodore-anderson-mathematician-who-advanced-data-analysis-dies-at-98.html>. A version of this obituary appeared in print October 11, 2016, on page B12 of the New York edition with the headline *Theodore W. Anderson, 98, an Econometrics Pioneer*.

Obituary Notice: T.S. Michael

Submitted by Richard Brualdi

It is with great sadness that I report the death on November 22, 2016 of my former Ph.D. student T.S. Michael.

T.S. received a Ph.D. from the University of Wisconsin-Madison in 1988, spent two years at Louisiana State University, and then joined the U.S. Naval Academy in 1990 where he remained for the rest of his career. He was a wonderful and precise mathematician with high standards, and a wonderful expositor. And a wonderful human being.

T.S. and I wrote three papers together.

His book *How to Guard an Art Gallery and Other Discrete Mathematical Adventures* was published in 2009 by the Johns Hopkins University Press. This book exemplifies T.S.’s expository skills. In 2012, the Mathematical Association of America awarded him the George Pólya Prize for his article “Guards, Galleries, Fortresses, and the Octoplex” (*College Mathematics Journal*, 42 (2011) 191–200).

T.S. was the founding coach of the Naval Academy’s triathlon team and also coached the swim team for many years.

The Naval Academy plans to name a Foyer in his honor.

JOURNAL ANNOUNCEMENT

LAMA Special Issue in Honor of Marvin Marcus

Please note that the deadline for the *Linear and Multilinear Algebra* Special Issue: Devoted to the memory of Marvin Marcus (<http://explore.tandfonline.com/cfp/est/glma-devoted-to-the-memory-of-Marvin-Marcus>) has been extended to December 31, 2016.

The guest editors for this issue are: Shmuel Friedland, University of Illinois at Chicago (friedlan@uic.edu); Thomas Pate, Auburn University (pate_tom@bellsouth.net); and Yiu-Tung Poon, Iowa State University (ytpoon@iastate.edu).

Submissions should be done through the website: <https://mc.manuscriptcentral.com/glma>.

UPCOMING CONFERENCES AND WORKSHOPS

Matrix Equations and Tensor Techniques Workshop Pisa, Italy, February 13–14, 2017

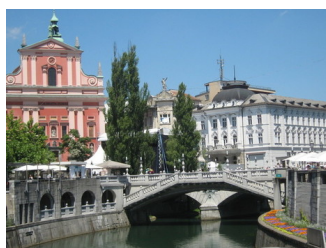
This workshop will be held in Pisa, Italy, on 13–14 February 2017. It is the seventh in a series of biennial workshops on matrix equations and tensor techniques. As in the previous meetings, the focus will be on the latest developments in the theory, computation and applications of linear and nonlinear matrix equations and tensor techniques.

For further information and registration, please visit <http://delone.dm.unipi.it/mett17>.

Deadlines:

- Abstract submission: December 4, 2016
- Acceptance notification: December 16, 2016
- Registration: January 27, 2017

The 8th Linear Algebra Workshop (LAW'17) Ljubljana, Slovenia, June 12–16, 2017



Ljubljana

The main theme of the 8th Linear Algebra Workshop will be the interplay between operator theory and algebra. The workshop will follow the usual format. A few hours of talks will be scheduled for the morning sessions, while afternoons will be reserved for work in smaller groups. The Workshop will be held at the Department of Mathematics, Faculty of Mathematics and Physics, University of Ljubljana. Ljubljana is the capital of Slovenia, a small country in central southeastern Europe. Slovenia has been a member state of the European Union since 2004, using the European currency since 2007. Those interested in attending should register by May 15, 2017. More information can be found at <http://www.law05.si/law17>.

The 6th International Conference on Matrix Analysis and Applications (ICMAA 2017) Da Nang City, Vietnam, June 15–18, 2017

The 6th International Conference on Matrix Analysis and Applications (ICMAA 2017) will be held at Duy Tan University, Da Nang City, Vietnam, June 15–18, 2017.

This meeting aims to stimulate research and interaction of mathematicians in all aspects of linear and multilinear algebra, matrix analysis, graph theory, and their applications and to provide an opportunity for researchers to exchange ideas and developments on these subjects. The previous conferences were held in China (Beijing, Hangzhou), United States (Nova Southeastern University), and Turkey (Selçuk University, Konya). Former keynote speakers are Roger Horn, Richard Brualdi, Chi-Kwong Li, Steve Kirkland, Alexander A. Klyachko (ILAS guest speaker), and Shmuel Friedland.

The keynote speaker of this ICMAA conference is Prof. Man-Duen Choi, University of Toronto, Canada.

The scientific organizing committee consists of Trung Hoa Dinh (Ho Chi Minh City University of Food Industry, Vietnam), Hiroyuki Osaka (Ritsumeikan University, Japan), Tin-Yau Tam (Auburn University, USA), Qing-Wen Wang (Shanghai University, China), and Fuzhen Zhang (Nova Southeastern University, USA).

The conference home page is <http://icmaa-2017.duytan.edu.vn> with mirror site <http://www.auburn.edu/~tamtiny/2017ICMAA.html>.

Contact: Fuzhen Zhang at zhang@nova.edu or any committee member.

The Householder Symposium XX on Numerical Linear Algebra Virginia Tech, Blacksburg, Virginia, USA, June 18–23, 2017

The Householder Symposium XX on Numerical Linear Algebra will be held at Virginia Tech in Blacksburg, Virginia, USA, June 18–23, 2017.

Attendance at the meeting is by invitation only. Accepted applicants will be notified by February 15, 2017. Each attendee will be given the opportunity to present a talk or a poster. Some talks will be plenary lectures, while others will be shorter presentations arranged in parallel sessions.

The Symposium is very informal, with the intermingling of young and established researchers a priority. Participants are expected to attend the entire meeting. It is expected that partial support will be available for some students, early career participants, and participants from countries with limited resources.

The sixteenth Householder Award for the best Ph.D. thesis in numerical linear algebra (Ph.D. earned between January 1, 2014 and December 31, 2016) will be presented. Nominations for the Householder Award are due by January 31, 2017.

The Householder Symposium takes place in cooperation with the Society for Industrial and Applied Mathematics (SIAM) and the SIAM Activity Group on Linear Algebra.

For further details, please visit the conference webpage: <http://www.math.vt.edu/HHXX>.

Preservers Everywhere **Szeged, Hungary, June 19–23, 2017**

Preservers Everywhere is an international conference on the dynamically developing topic commonly referred to as “Preserver Problems.” A preserver is a transformation between mathematical structures that leaves a certain quantity/operation/relation/set etc. invariant. The usual goal is to give a complete description of these transformations. Typical examples include homomorphisms of groups (i.e., maps which respect group operations) and isometries of metric spaces (i.e., maps preserving distances). The purpose of this meeting is to bring together mathematicians from various areas who are either working on or interested in such problems. Amongst others, we will have talks on preserver problems related to Algebra, Analysis, Functional Analysis, Geometry, Linear Algebra, Mathematical Physics and Operator Theory. We encourage everybody interested in this topic to participate in the meeting.

The venue is the Bolyai Institute of the University of Szeged in Szeged, Hungary. The organizers are Lajos Molnár and György Pál Gehér (University of Szeged). If you have any questions or queries please contact György Pál Gehér (gehergyuri@gmail.com).

The conference website is <http://www.math.u-szeged.hu/~gehergy/conference.html>.

The Second Malta Conference in Graph Theory and Combinatorics (2MCGTC 2017) **University of Malta, Malta, June 26–30, 2017**

The Department of Mathematics, within the Faculty of Science, of the University of Malta is pleased to announce “The Second Malta Conference in Graph Theory and Combinatorics.” This conference will commemorate the 75th birthday of Professor Stanley Fiorini, who was the first to introduce graph theory and combinatorics at the University of Malta.

The Conference will be held at the seaside resort of Qawra in the north of the island, and will run from Monday 26 to Friday 30 June 2017. The aim of this conference is to bring together experts and researchers in all the areas of graph theory and combinatorics from across the world to share their research findings, and to enhance collaboration between researchers who are in different stages of their careers.

The Plenary Speakers are: Yair Caro (University of Haifa-Oranim, Israel), Peter Dankelmann (University of Johannesburg, South Africa), Patrick W. Fowler, F.R.S. (University of Sheffield, United Kingdom), Peter Frankl (Alfréd Rényi Institute of Mathematics, Hungarian Academy of Sciences, Hungary), Chris Godsil (University of Waterloo, Canada), Wilfried Imrich (Montanuniversität Leoben, Austria), Gyula O. H. Katona (Alfréd Rényi Institute of Mathematics, Hungarian Academy of Sciences, Hungary), Sandi Klavžar (University of Ljubljana, Slovenia), Mikhail Klin (Ben-Gurion University of the Negev, Israel), Imre Leader (University of Cambridge, United Kingdom), Brendan McKay (Australian National University, Australia), Karen Meagher (University of Regina, Canada), Raffaele Scapellato (Politecnico di Milano, Italy), and Slobodan Simic (Serbian Academy of Sciences and Arts, Serbia).

A number of parallel sessions for talks delivered by participants will be held. A special issue of *Discrete Applied Mathematics*, containing selected full-length papers, refereed according to the high standards of the journal, will be dedicated to the Conference.

The Organizing Committee consists of Peter Borg, John Baptist Gauci, Josef Lauri, and Irene Sciriha.

Further information can be found at <http://www.um.edu.mt/events/2mcgtc2017>; e-mail: 2mcgtc2017@um.edu.mt.

Rocky Mountain–Great Plains Graduate Research Workshop in Combinatorics 2017 (GRWC 2017) Denver, Colorado, USA, July 9–22, 2017

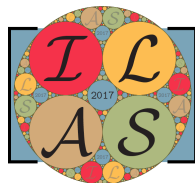
The Rocky Mountain–Great Plains Graduate Research Workshop in Combinatorics 2017 (GRWC 2017) will be held July 9–22, 2017, and will be hosted by the University of Colorado Denver and the University of Denver.

The GRWC is a 2-week collaborative research workshop for experienced graduate students and postdocs from all areas of combinatorics. Participants will work in collaborative groups with faculty and postdocs on research problems from across the discipline. The workshop will also host a variety of professional development workshops to prepare students and postdocs for industrial and academic careers.

The workshop will be centered on problems developed and presented by students and postdocs, who will work together with a faculty mentor from the organizing committee. We anticipate funding (travel, meal stipend and lodging) for up to 20 graduate students and postdocs from outside of the organizing institutions. Applications are encouraged from students at institutions not in the United States, but funding is extremely limited for international participants.

For application information and further details about the workshop, please visit <https://sites.google.com/site/rmgpgrwc>, and for inquiries, please e-mail grwc2016@gmail.com.

ILAS 2017: Connections Ames, Iowa, USA, July 24–28, 2017



The 21st conference of the International Linear Algebra Society, ILAS 2017: Connections, will be held July 24–28, 2017 at Iowa State University in Ames, Iowa, USA. The theme of the conference is connections between linear algebra and other areas of mathematics, science, and engineering, and talks about such connections as well as within linear algebra itself are welcome. At this conference we will celebrate the 30th birthday of ILAS, which was founded in 1987 as the International Matrix Group.

Deadlines:

- December 20, 2016 (extended) - Proposals for contributed mini-symposia
- March 1, 2017 - Submission of abstracts
- April 30, 2017 - Early registration rate ends

Invited Plenary Speakers:

- **Rajendra Bhatia**, Indian Statistical Institute, Hans Schneider Prize Speaker
- **Hal Caswell**, Woods Hole Oceanographic Institute
- **Chris Godsil**, University of Waterloo
- **Stefan Güttel**, The University of Manchester, SIAG-LA Lecturer
- **Willem Haemers**, Tilburg University
- **Tamara G. Kolda**, Sandia National Laboratories
- **Miklós Pálfi**, Kyoto University, Taussky-Todd Lecturer
- **Vern Paulsen**, University of Waterloo
- **Helena Šmigoc**, University College Dublin, LAMA Lecturer
- **Raf Vandebril**, KU Leuven, ILAS 30th Anniversary LAA Lecturer
- **Van Vu**, Yale University
- **Rachel Ward**, University of Texas

Invited Mini-Symposia (with organizers):

Combinatorial Matrix Theory (Minerva Catral, Louis Deaett), *Compressed sensing and matrix completion* (Simon Foucart, Namrata Vaswani), *Distance problems in linear algebra, dynamical systems and control* (Elias Jarlebring, Wim Michiels), *Linear Algebra and Geometry* (Gabriel Larotonda, Alejandro Varela), *Linear Algebra and Mathematical Biology* (Julien Arino, Natalia Kommarova), *Linear Algebra and Positivity with Applications to Data Science* (Dominique Guillot, Apoorva Khare, Bala Rajaratnam), *Linear Algebra and Quantum Information Science* (Chi-Kwong Li, Yiu Tung

Poon, Raymond Nung-Sing Sze), *Matrices, Tensors and Manifold Optimization* (Daniel Kressner, Bart Vandereycken), *Matrix Analysis: Inequalities, Means, and Majorization* (Fumio Hiai, Yongdo Lim), *Matrix Polynomials* (Froilán Dopico, Paul Van Dooren), *Numerical Linear Algebra* (Jared Aurentz, Karl Meerbergen), *Random matrix theory for networks* (Dustin Mixon, Rachel Ward), *Spectral Graph Theory* (Nair Abreu, Leonardo de Lima), *Linear Algebra Education* (Rachel Quinlan, Megan Wawro)

The Scientific Organizing Committee consists of: Leslie Hogben (chair), Fan Chung, Mark Embree, Stephen Kirkland, Wolfgang Kliemann, Bala Rajaratnam, Joachim Rosenthal, Peter Šemrl, Bryan Shader, Tatjana Stykel, Jared Tanner, Raf Vandebril and Pauline van den Driessche.

The Local Organizing Committee consists of: Leslie Hogben (chair), Cliff Bergman, Steve Butler, Stephen Kirkland, Wolfgang Kliemann, Ryan Martin, Yiu Tung Poon, Bryan Shader, Sung-Yell Song and Michael Young.

For further details, please visit the conference website at <https://ilas2017.math.iastate.edu>, or send e-mail to ilas2017@iastate.edu.

Preconditioning 2017 - International Conference on Preconditioning Techniques for Scientific and Industrial Applications Vancouver, Canada, July 31–August 2, 2017

This conference, to be held at the University of British Columbia, is a sequel to nine successful meetings on preconditioning (one every two years) which address complex issues related to the solution of general sparse matrix problems in large-scale applications and in industrial settings. The goal of the conference is to exchange ideas on recent developments in preconditioning techniques for sparse linear systems of equations, and to a lesser extent for eigenvalue problems.

Invited speakers include:

Michele Benzi (Emory University, USA);
Jed Brown (University of Colorado at Boulder, USA);
Jie Chen (IBM Research Center, USA);
Eric Darve (Stanford University, USA);
Tom Jonshovel (Schlumberger Abingdon Technology Centre, UK);
Alison Ramage (University of Strathclyde, UK);
Sander Rhebergen (University of Waterloo, Canada); and
Nicole Spillane (École Polytechnique, France).

The Scientific Committee includes: Zhong-Zhi Bai (Chinese Academy of Science, China); Edmond Chow (Georgia Tech, USA); Howard Elman (University of Maryland, USA); Martin Gander (University of Geneva, Switzerland); Scott MacLachlan (Memorial University of Newfoundland, Canada); Jennifer Pestana (University of Strathclyde, UK); Wil Schilders (Technical University of Eindhoven, Netherlands); Daniel Szyld (Temple University, USA); Raymond Tuminaro (Sandia National Laboratories, USA); and Kees Vuik (Technical University of Delft, Netherlands).

The conference chairs are: Chen Greif (University of British Columbia); Esmond Ng (Lawrence Berkeley National Laboratory); Yousef Saad (University of Minnesota); and Andy Wathen (Oxford University).

Important Dates: Mini-symposium proposals are due April 30, 2017; Contributed talks and posters are due May 31, 2017. More information can be found at <http://www.cs.ubc.ca/~greif/precon17>.

Matrix Analysis and its Applications — A Special Session for PRIMA 2017 Oaxaca, Mexico, August 14–18, 2017

The 3rd Pacific Rim Mathematical Association (PRIMA2017) Congress will take place in Oaxaca, Mexico, August 14–18, 2017. PRIMA is an association of mathematical sciences institutes, departments and societies from around the Pacific Rim. The previous PRIMA conferences were held in Sydney (2009) and in Shanghai (2013).

A special session on “Matrix Analysis and its Applications” will be held for PRIMA2017 and will feature up to 16 invited talks by the experts and leaders in the field. The purpose of this special session of PRIMA is to present and showcase the current trends and developments in matrix analysis and various aspects of linear and multilinear algebra and applications. Topics include matrices and graphs, matrix equations and matrix inequalities, matrix computation, and applications of matrix theory in many other fields such as quantum information theory.

To know more about PRIMA2017, please visit <http://www.primath.org/congress/2017> (see also <http://prima2017.math.unam.mx>).

Organizers of Matrix Analysis and its Applications at PRIMA2017:

- Qing-Wen Wang (Shanghai University, China)
- Fuzhen Zhang (Nova Southeastern University, USA)
- Yang Zhang (University of Manitoba, Canada)

MAT-TRIAD'2017 - International Conference on Matrix Analysis and its Applications Będlewo, Poland, September 25–29, 2017

The 7th conference in the MAT-TRIAD series will be held in Będlewo (a neighborhood of Poznań, Poland) at the Mathematical Research and Conference Center of the Polish Academy of Sciences.

MAT-TRIAD provides an opportunity to bring together researchers sharing an interest in a variety of aspects of matrix analysis and its applications. Researchers and graduate students interested in recent developments in matrix theory and computation, operator theory, applications of linear algebra in statistics, matrices in graph theory, as well as combinatorial matrix theory are particularly encouraged to attend.

The format of the meeting will involve plenary sessions, sessions with contributed talks, and a poster session. The list of Invited Speakers includes winners of Young Scientists Awards of MAT-TRIAD'2015. We are also planning courses delivered by leading experts. Thematic workshops are welcome.

The work of young scientists will receive a special consideration in MAT-TRIAD'2017. The best poster as well as the best talk by a graduate student or scientist with a recently-completed Ph.D. will be awarded. Prize-winning works will be widely publicized and promoted by the conference.

Conferences from the MAT-TRIAD series attract a number of national and international participants and provide a high quality scientific program as well as a friendly atmosphere for the discussion and exchange of ideas.

The Scientific Committee consists of Tomasz Szulc (Poland) Chair, Natália Bebiano (Portugal), Ljiljana Cvetković (Serbia), Heike Faßbender (Germany) and Simo Puntanen (Finland).

The Organizing Committee is chaired by Augustyn Markiewicz (Poland) and includes Francisco Carvalho (Portugal), Katarzyna Filipiak (Poland), Jan Hauke (Poland) and Dominika Wojtera-Tyrakowska (Poland).

For more information, please visit <https://mattriad.wmi.amu.edu.pl>.

CONFERENCE REPORTS

2016 Western Canada Linear Algebra Meeting (WCLAM) Winnipeg, Manitoba, Canada, May 14–15, 2016

Report by Stephen Kirkland

The Western Canada Linear Algebra Meeting (WCLAM) is a series of biennial meetings that has been running since 1993, with the meetings being held at various sites throughout western Canada. Each WCLAM provides an opportunity for researchers in linear algebra and allied fields to meet, present accounts of their research, and hold informal discussions. Although WCLAM has a regional base, it routinely attracts both national and international participants. WCLAM enjoys a reputation not only for its high quality scientific program but also its welcoming atmosphere.

WCLAM 2016 attracted upwards of 40 participants, and featured 18 talks in total. There were three invited speakers: Rajesh Pereira (University of Guelph), Rachel Quinlan (National University of Ireland Galway) and Kevin Vander Meulen (Redeemer University College, and an ILAS Lecturer). The meeting was sponsored by ILAS, the Pacific Institute for the Mathematical Sciences, and the University of Manitoba. Details of the program may be found at the WCLAM webpage <http://server.math.umanitoba.ca/~kirkland/wclam#home>.

The 25th International Workshop on Matrices and Statistics (IWMS-2016) Funchal, Madeira, Portugal, June 6–9, 2016

Report by Francisco Carvalho, Simo Puntanen, and George P. H. Styan

The 25th International Workshop on Matrices and Statistics (IWMS-2016) was held in the city of Funchal on the beautiful Madeira Island, the Pearl of the Atlantic, on 6–9 June 2016.

The purpose of this workshop was to bring together researchers sharing an interest in a variety of aspects of statistics and its applications as well as matrix analysis and its applications to statistics, and to offer them an opportunity to discuss current developments in these subjects. The workshop would bridge the gap among statisticians, computer scientists and mathematicians in understanding each other's tools.

The Local Organizing Committee was chaired by Francisco Carvalho (Tomar, Portugal), with help from Katarzyna Filipiak (Poznań, Poland), Ana Maria Abreu (Madeira, Portugal), and Daniel Klein (Košice, Slovakia).

The International Organizing Committee for the Madeira Workshop comprised Simo Puntanen (Tampere, Finland) – Chair, George P. H. Styan (Montréal, Québec, Canada) – Honorary Chair, Júlia Volaufová (New Orleans, Louisiana, USA) – Vice-Chair, S. Ejaz Ahmed (St. Catharines, Ontario, Canada), Katarzyna Filipiak (Poznań, Poland), Jeffrey J. Hunter (Auckland, New Zealand), Augustyn Markiewicz (Poznań, Poland), Dietrich von Rosen (Uppsala, Sweden), and Hans Joachim Werner (Bonn, Germany).

IWMS-2016 was organized by Instituto Politécnico de Tomar and Universidade da Madeira, and was supported by: CMA - Centro de Matemática e Aplicações (FCT, UNL), CIMA - Centro de Investigação em Matemática e Aplicações (UE), PSE - Produtos e Serviços de Estatística, INE - Instituto Nacional de Estatística, FLAD - Fundação Luso-Americana para o Desenvolvimento, Delta Cafés, and the Associação de Promoção da Madeira.

The invited speakers were Alan Agresti (Gainesville, Florida, USA): “Some perspectives about generalized linear modelling”, Rosemary A. Bailey (St. Andrews, Scotland, UK): “Association schemes in designed experiments”, Radosław Kala (Poznań, Poland): “A new look at combining information from stratum submodels”, Alexander Kovačec (Coimbra, Portugal): “The 123 Theorem of probability theory and copositive matrices”, and Jianxin Pan (Manchester, England, UK): “Joint mean-covariance modelling and its R package: jmcm”.



Jeffrey J. Hunter



Britannia with Stephen Hawking leaving Funchal

A *Special Session to Celebrate Jeffrey J. Hunter's 75th Birthday* was organized and chaired by Peter G. Taylor (Melbourne, Australia), with additional speakers: Stephen Kirkland (Winnipeg, Manitoba, Canada), Tuğrul Dayar (Ankara, Turkey), and Guy Latouche (Brussels, Belgium). Jeff himself gave a presentation entitled “A fifty-year journey with colleagues, generalized matrix inverses and applied probability”.

One day after the Workshop, George and Simo (accompanied by Evelyn and Soile) were relaxing in the Design Centre Nini Andrade Silva Restaurant in Funchal and enjoying the harbour view. While admiring the fabulous family-friendly cruise ship *Britannia* of P & O Cruises leaving the harbour majestically, they were told by a couple of ship-spotters that one of the passengers on the ship was Stephen Hawking. How about that! He had been in Funchal on a previous day when we were completing our Workshop. We wish he could have attended our Workshop!

Hans Joachim Werner organized a *Memorial Session for Ingram Olkin (1922–2016)*, with additional speakers: Jeffrey J. Hunter, Simo Puntanen, and George P. H. Styan. The Session ended with an interesting video by Michael Greenacre (Barcelona, Spain).

The Madeira Magic Minisymposium on “Magic Squares, Prime Numbers and Postage Stamps” (organized by Ka Lok Chu and George P. H. Styan) was held in Blandy's Wine Lodge, Avenida Arriaga 28, in Funchal, 6 June 2016, and

featured:

- [1] Se-tenant philatelic Machin-definitive blocks with selected total face-values, with special emphasis on the Royal Mail “Stamps for Cooks” Prestige Booklet *by* Nathan Hin Shun Chu, Ka Lok Chu, and George P. H. Styan.
- [2] Some comments on two sensational pandiagonal magic squares and on two philatelic magic-carpet dinner-placemats, *by* George P. H. Styan, Walter Trump, and Ka Lok Chu.
- [3] Some comments on Sophie Germain prime numbers, *by* George P. H. Styan, and Ka Lok Chu.
- [4] Some comments on Margaret Kepner’s 2010 “Magic Square 25 Study” *by* Reijo Sund, Ka Lok Chu, and George P. H. Styan.

Several other Invited Special Sessions and Mini-symposia were arranged: (1) Estimation and Testing in Linear Models (organized by Roman Zmysłony), (2) Methods for Modelling Correlated and Complex Data (organized by Jianxin Pan), (3) Multivariate Linear Models (organized by Katarzyna Filipiak), and (4) Probability and Matrix Inequalities (organized by Alexander Kovačec).

The IWMS-2016 *Book of Abstracts* ([http://www.iwms.ipt.pt/download/book%2009Jun2016%20\(v04\).pdf](http://www.iwms.ipt.pt/download/book%2009Jun2016%20(v04).pdf)), edited by Daniel Klein and Francisco Carvalho, includes not only the abstracts of the talks and the program, but also

“Ingram Olkin (1924–2016)—Some personal memories” by Simo Puntanen and George P. H. Styan, available at <http://people.uta.fi/~simo.puntanen/Obituary-of-Olkin-by-Puntanen-and-Styan-Madeira.pdf>, and

“Many happy returns, Jeffrey Joseph Hunter! Personal Glimpses for your 75th Birthday” by Simo Puntanen, available at <http://people.uta.fi/~simo.puntanen/Many-Happy>Returns-Jeffrey-Hunter-75.pdf>.

The final program is available at <http://www.iwms.ipt.pt/download/program%2007Jun2016.pdf>, and further details can be found at the IWMS-2016 website: <http://www.iwms.ipt.pt/?page=home>. Selected refereed papers presented in the Workshop will be published in an e-book *Proceedings* to be published by Springer.

For previous IWMS workshops, visit our IWMS website (<http://www.sis.uta.fi/tilasto/iwms>), from where, for example, “A short history of the International Workshop on Matrices and Statistics” (<http://www.sis.uta.fi/tilasto/iwms/IWMS-history.pdf>) can be downloaded. The 26th International Workshop on Matrices and Statistics will be held in 2018, the venue to be announced.



IWMS 2016 Group Photo

The 2016 International Workshop on Matrix Inequalities and Matrix Equations Shanghai University, China, June 8–10, 2016

Report by Chi-Kwong Li and Qing-Wen Wang

The 2016 International Workshop on Matrix Inequalities and Matrix Equations took place on June 8–10, 2016 at the Shanghai University. Founded in 1922, Shanghai University is a public research university located in Shanghai, China. The 2016 workshop was sponsored by Gaoyuan Discipline of Shanghai, and the First-class Shanghai Discipline. The organizing committee consists of Delin Chu (National University of Singapore), Chi-Kwong Li (College of William & Mary), Tin-Yau Tam (Auburn University), Qing-Wen Wang (Shanghai University), and Fuzhen Zhang (Nova Southeastern University).

The study of matrix inequalities and matrix equations is an active research area. The topic has connections and implications to many pure and applied problems. With the support and hospitality of colleagues at Shanghai University, participants were able to exchange ideas and experiences on the subject in a friendly atmosphere. There were 104 participants from different regions including Canada, China, Greece, Hong Kong, Japan, Poland, the USA, and Taiwan. There were 31 talks arranged in the two-day workshop. Workshop pictures, talk schedule, and titles and abstracts are available at the workshop website: <http://cklixx.people.wm.edu/mime2016.html>.



Participants of the 2016 International Workshop on Matrix Inequalities and Matrix Equations

Southeast Asian Mathematical Society (SEAMS) School Diliman on Topics in Matrix Analysis and Applications Diliman, Quezon City, Philippines, June 27 – July 7, 2016

Report by Jose Maria P. Balmaceda

The Southeast Asian Mathematical Society (SEAMS) School Diliman on Topics in Matrix Analysis and Applications was held on 29 June to 07 July 2016 at the University of the Philippines Diliman (UPD). It was organized by the UPD Institute of Mathematics and the Mathematical Society of the Philippines with support from the Commission on Higher Education, the UP Office of International Linkages, and the Centre Internationale Mathématiques Pures et Appliquées (CIMPA). The school is part of the SEAMS series of summer schools across Southeast Asia that provide undergraduate and master's-level students knowledge of more advanced material in mathematics.

The school consisted of 45 hours of intensive lectures, problem solving and computer laboratory sessions. The lecturers introduced the participants to topics in matrix analysis (normal matrices, Hermitian matrices, canonical forms and matrix factorizations, nonnegative matrices), combinatorial matrix theory (graphs and matrices, sign patterns), and numerical linear algebra (iterative solutions of linear systems and multi-grid methods).



Participants and Lecturers of the SEAMS School Diliman on Topics in Matrix Analysis and Applications

There were 40 participants from the Philippines, Indonesia, Vietnam, Thailand, and Nepal. The speakers were Agnes T. Paras, Jose Ernie C. Lope, Ma. Nerissa M. Abara, Ralph John L. Dela Cruz, Arrianne C. Velasco (all from UPD), and Minerva R. Catral (Xavier University, Ohio, USA). The organizers were Jose Maria P. Balmaceda and Agnes T. Paras. The school website and full activity report may be accessed at <http://www.math.upd.edu.ph/seamsdiliman>.

The 2016 Workshop on Numerical Ranges and Numerical Radii Soochow University, Taiwan, June 28–30, 2016

Report by Mao-Ting Chien and Chi-Kwong Li

The 2016 Workshop on Numerical Ranges and Numerical Radii took place at Soochow University, Taiwan, June 28–30, 2016. Soochow University was founded in 1900 in Suzhou. It was the first western-style university in China. After the government of the Republic of China moved to Taiwan, some of the former alumni of Soochow University worked hard to establish Soochow University in Taiwan. The Ministry of Education approved the reestablishment plan in 1954, and Soochow University became the first private university in Taiwan.



Participants of the 2016 Workshop on Numerical Ranges and Numerical Radii

The study of numerical range and its generalizations has a long and distinguished history. The subject has connections and applications to many branches of the pure and applied sciences. In particular, researchers have used numerical techniques to study problems in quantum computation and quantum information science. In the 1970s, there were workshops devoted to the topic. Since 1992, a new series of workshops on the topic has been held biennially in different countries including the USA, Japan, Portugal, Greece, Germany, Poland, and Taiwan.

The 2016 workshop was sponsored by the Mathematics Research Promotion Center and the Ministry of Science and Technology, Taiwan. With the support and hospitality of colleagues at Soochow University, participants were able to exchange ideas and experiences on the subject. The workshop has stimulated interaction and fostered the collaboration of researchers from different backgrounds and regions. There were 40 participants from different regions, including Australia, Canada, Greece, Hong Kong, Japan, Poland, and the USA. There were 25 talks arranged in the two-day workshop. A workshop picture, talk schedule, and titles and abstracts are available at the workshop website: <http://cklixx.people.wm.edu/wonra16.html>.

2016 Workshop on Matrices and Operators Jeju Island, Korea, July 3–6, 2016

Report by Chi-Kwong Li and Yongdo Lim

The 2016 Workshop on Matrices and Operators took place at the Suites Hotel Jeju, Jeju Island, Korea. Jeju is Korea's largest island, situated just 64 kilometers south of the Korean Peninsula. This is the eleventh workshop of the series, sponsored by KIAS, AORC and MEST (No. 2015R1A3A2031159).

The purpose of the workshop was to stimulate research and foster the interaction of researchers interested in matrix theory, operator theory, and their applications. The organizers of the workshop series have always been trying to provide a friendly, informal workshop atmosphere for participants to exchange research ideas and problems on different research topics.

There were about 57 participants from different regions including China, Canada, Hong Kong, Japan, Korea, the USA, Taiwan, etc. There were 29 talks in the workshop. One may see <http://shb.skku.edu/mao2016> for a workshop photo, participant list, schedule, titles, abstracts, and pdf/ppt files of the talks.

The 2017 workshop will be at Hunan University, June 9–12, 2017; visit <http://cklixx.people.wm.edu/mao2017.html> for details.



Participants of the 2016 Workshop on Matrices and Operators

The 20th ILAS Conference Leuven, Belgium, July 11–15, 2016

Report by Raf Vandebril



The 20th conference of the International Linear Algebra Society took place in Leuven from the 11th until the 15th of July. The Department of Computer Science, KU Leuven, hosted the conference and welcomed 440 participants from more than 45 countries. The conference was locally organized by Raf Vandebril, Pierre-Antoine Absil, Thomas Mach, Karl Meerbergen, Wim Michiels, Leonardo Robol, Wim Vanroose, and Marc Van Barel. The conference venue was located in the centre of Leuven, in a pedestrian area with a nice square between the various buildings of the conference.

The conference was opened by the *LAA* speaker, Pablo A. Parrilo from the Massachusetts Institute of Technology, discussing “Convex sets, matrix factorizations and positive semidefinite rank.” The second day we listened to André Ran from VU Amsterdam discussing “Eigenvalue perturbation theory of classes of structured matrices under generic structured small rank perturbations” and Monique Laurent from CWI Amsterdam and Tilburg University presenting “On completely positive semidefinite matrices and their applications”. Wednesday was a half day where the *LAMA* Speaker Lajos Molnar from the University of Szeged presented work on “Preservers on positive matrices and operators” followed by Stefano Serra Capizzano from the Università dell’Insubria discussing “Spectral Analysis and Fast Solvers for Hidden Structures”. Paul Van Dooren from the Université catholique de Louvain, the Hans Schneider Prize winner, opened Thursday with a lecture on “Polynomial Matrices and Dual Minimal Bases.” He was followed by the SIAG/LA speaker Fernando De Teran from the Universidad Carlos III de Madrid discussing “Solution of Sylvester-like equations and systems: Consistency, Uniqueness, and some applications.” The final day of the conference, Lieven De Lathauwer from KU Leuven presented “Between linear and nonlinear: an introduction to tensor methods”. The last plenary of the conference was reserved for Elizabeth S. Meckes from Case Western Reserve University, who presented “Random orthogonal and unitary matrices”.



ILAS 2016 Conference Photo (taken by Rob Stevens)

There was an excellent set of nine invited mini-symposia: Data-Driven Model Reduction by Athanasios Antoulas; Matrix Equations by Peter Benner and Beatrice Meini; Tropical Algebra in Numerical Linear Algebra by James Hook, Jennifer Pestana, and Françoise Tisseur; Matrix Inequalities and Operator Means by Jean-Christophe Bourin and Takeaki Yamazaki; Linear Algebra and Quantum Computation by Chi-Kwong Li, Raymond Nung-Sing Sze, and Yiu Tung Poon; Multivariate Polynomial Computations and Polynomial Systems by Bernard Mourrain, Vanni Noferini, and Marc Van Barel; Image Restoration and Reconstruction by Marco Donatelli and James G. Nagy; Matrix Methods in Network

Analysis by Dario Fasino and Francesco Tudisco; and Low Rank Tensor Approximation by André Uschmajew and Bart Vandereycken.

In total, we had 391 lectures, of which many were located in the 19 contributed mini-symposia (293 talks) ranging from theoretical to application-oriented research linked to linear algebra. There was a large number (93) of contributed lectures. To be able to host all the lectures we had at most 11 parallel sessions. In total, approximately 10,000 minutes of mathematics were offered to the audience.

The proceedings of the conference will be published in *Linear Algebra and its Applications*, for which manuscript submissions will be open until the 15th of December.

For their excellent work in selecting the plenary speakers and mini-symposia, we thank the scientific organizing committee: Dario Bini (University of Pisa, Italy), Froilan Dopico (Universidad Carlos III de Madrid, Spain), Douglas Farenick (University of Regina, Canada), Heike Faßbender (Technische Universität Braunschweig, Germany), Fumio Hiai (Tohoku University, Japan), Steve Kirkland (University of Manitoba, Canada), Wim Michiels (KU Leuven, Belgium), Peter Šemrl (University of Ljubljana, Slovenia), Françoise Tisseur (The University of Manchester, UK), Raf Vandebril (KU Leuven, Belgium), and Hugo Woerdeman (Drexel University, United States).



P. Van Dooren receiving the Hans Schneider Prize from R. Brualdi and P. Šemrl

Participants enjoyed the social program offering two receptions, one in the beautiful Halls of the University and the other in the City Hall of Leuven. The weather was mostly great, except unfortunately for the rain during the guided tours through Leuven. The conference banquet was held at the Faculty Club of the university and a highlight during the dinner was the ceremony where the Hans Schneider Prize was offered to Paul Van Dooren for his contributions to the linear algebra society over the years. We thank Richard Brualdi for his nice words, and Paul Van Dooren and David Watkins for their speeches. The conference ended on the 15th with a barbeque, granting us plenty of time to say goodbye to colleagues.



ILAS NEWS

ILAS Member Honored by AMS

The American Mathematical Society has recently announced its 2017 AMS Fellows. Among those named is ILAS member Daniel B. Szyld of Temple University. Dr. Szyld is cited for his contributions to numerical and applied linear algebra.

2017 ILAS Taussky-Todd Lecturer

Miklós Pálfi of Sungkyunkwan University, Korea, will be the Taussky-Todd Lecturer at the ILAS Conference in Ames in 2017. The 2017 Taussky-Todd Lecture Selection Committee consisted of Rajendra Bhatia, Shaun Fallat, Peter Šemrl, and Paul Van Dooren.

ILAS and IWOTA introduce the Israel Gohberg Lecture

In recognition of his tremendous contributions to both Linear Algebra and Operator Theory, ILAS has joined together with the International Workshop on Operator Theory and its Applications (IWOTA) to introduce The Israel Gohberg ILAS-IWOTA Lecture. Israel Gohberg was a Hans Schneider Prize winner in 1993, the first year this prize was awarded. In addition, he was the visionary and driving force of IWOTA. This series of lectures will be delivered at both IWOTA and ILAS Conferences, in different years, in the approximate ratio of two-thirds at IWOTA and one-third at ILAS. Contributions to support this series are welcome and can be submitted via the ILAS webpage (<http://www.ilasic.org>) using the “ILAS Funds & Donations” tab, or at <http://www.ilasic.org/misc/fund.html>.

ILAS Elections: Nominations

Contributed announcement from Hugo Woerdman

The Nominating Committee for the ILAS elections has completed its work. Nominated for a three-year term, beginning March 1, 2017, as ILAS President is: Peter Šemrl. Nominated for the two open three-year terms, beginning March 1, 2017, as “at-large” members of the ILAS Board of Directors are: Naomi Shaked-Monderer (Israel), Eugene Tyrtyshnikov (Russia), James Nagy (USA), and Rachel Quinlan (Ireland).

Many thanks to the Nominating Committee, Heike Faßbender (chair), Shmuel Friedland, Sang-Gu Lee, Chi-Kwong Li, and Luis Verde-Star, for their important service to ILAS.

We would also like to thank the nominees for agreeing to stand for election.

ILAS Elections and Membership

Contributed announcement from Leslie Hogben

Voting in the next ILAS election (for terms starting March 1, 2017) will take place January 12, 2017 - February 16, 2017. This represents a change from prior years (see discussion of the reasons for this change below). The election will be called the 2017 ILAS election, and in order to vote you will need to be a 2017 member as of January 10, 2017. If you are not already a 2017 member you are encouraged to renew (or join) prior to the the winter break season, December 10 - January 8, during which time ILAS will be unable to process memberships. The online ILAS membership list will be updated to include only 2017 members in late December, 2016.

Determining your ILAS membership status:

1. Obviously, all life members are 2017 members.
2. If you are not listed on the current online list of members at <http://www.ilasic.org/misc/membership.html>, you are not a 2017 member.
3. Anyone whose membership was processed September 1, 2016 or later was automatically credited as a 2017 member.
4. Each dues-paying member who is not a 2017 member will have received an individual renewal e-mail before the end of October. Such members should also have received a thank you e-mail that lists how long the membership is valid for at the time of the most recent payment.
5. Fee-waiver members whose membership was processed before September 1, 2016 are not 2017 members, since it is

impossible to obtain a fee-waiver membership for more than 1 year (actually 1 year and a few months, since in the fall we automatically credit the next calendar year). Fee-waiver members are not sent individual reminders or confirmation e-mails, although we do plan to send a bulk e-mail to current fee-waiver members who are not 2017 members (but if your e-mail provider blocks bulk e-mails you may not receive it). 6. Receiving ILAS-net messages does not imply you are an ILAS member. Questions about your membership status should be directed to ILAS@iastate.edu, but replies will be slow if a large volume of inquiries are received. Please verify whatever information you can, as described above.

Rationale for the change in election timing: Many years ago ILAS elections were conducted with paper ballots that required a long time window for their return. Since 2011, ILAS has been using electronic voting with Votenet, and such a long time window is not necessary, although the period mid-November to mid-January was used for several years out of tradition. Last year Votenet upgraded the software. These changes were mainly improvements, including allowing the sending of reminder e-mails only to those who had not voted. We used this feature last year and election participation hit an all-time high of 64% in the ILAS 2015 election (previous turnouts with electronic voting were 40-50%). However, the software upgrade did not permit elections to run across two calendar years. As a result, the 2015 ILAS election was held November 12 - December 31. Another result of this change was that the ILAS Executive Board discussed the optimal timing for an ILAS election. Since most members are on an academic year calendar, it is better for the nomination process to start in late August and the election to be held in January - February for terms starting March 1, rather than requiring the nomination process to start in the summer. The ILAS Board approved this change and a resulting minor modification of the ILAS bylaws that was announced at the 2016 ILAS Business Meeting and in the ILAS-net message "ILAS 2117 - 2016 ILAS Business Meeting Minutes."

ANNOUNCEMENT

2020 Householder Symposium

The Householder Committee seeks a team to organize the 2020 Householder Symposium on Numerical Linear Algebra. The deadline for submitting a proposal is April 1, 2017. Guidelines for preparing a proposal can be found at http://www.math.vt.edu/HHXX/HH_Meeting_Proposal_Guidelines.pdf

Questions and completed proposals can be sent to: Jim Nagy, Chair of the Householder Committee, jnagy@emory.edu.

BOOK ANNOUNCEMENT

Infinite Matrices and Their Recent Applications by P.N. Shivakumar, Y. Zhang and K.C. Sivakumar

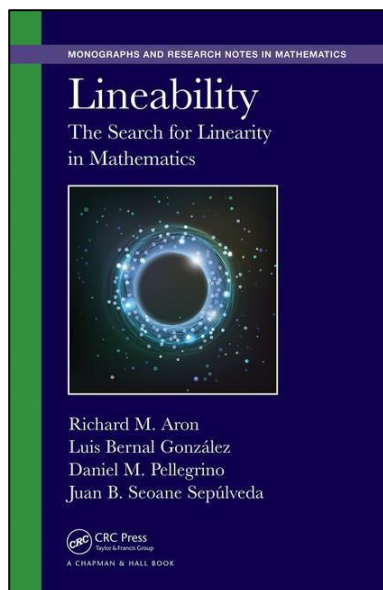
Springer International Publishing, 2016;
e-book ISBN 978-3-319-30180-8; hardcover ISBN 978-3-319-30179-2.

This monograph covers the theory of finite and infinite matrices over the fields of the real numbers, the complex numbers, and over the quaternions. Emphasizing topics such as sections or truncations and their relationship to the linear operator theory on certain specific separable and sequence spaces, the authors explore techniques like conformal mapping, iterations, and truncations that are used to derive precise estimates in some cases and explicit lower and upper bounds for solutions in other cases.

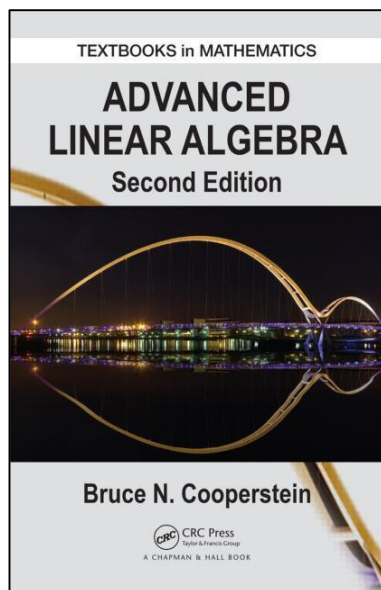
Most of the matrices considered in this monograph have typically special structures like being diagonally dominated or tridiagonal, possess certain sign distributions, and are frequently nonsingular. Such matrices arise, for instance, from solution methods for elliptic partial differential equations. The authors focus on both theoretical and computational aspects concerning infinite linear algebraic equations, differential systems and infinite linear programming, among others. Additionally, the authors cover topics such as Bessel's and Mathieu's equations, viscous fluid flow in doubly connected regions, digital circuit dynamics and eigenvalues of the Laplacian.



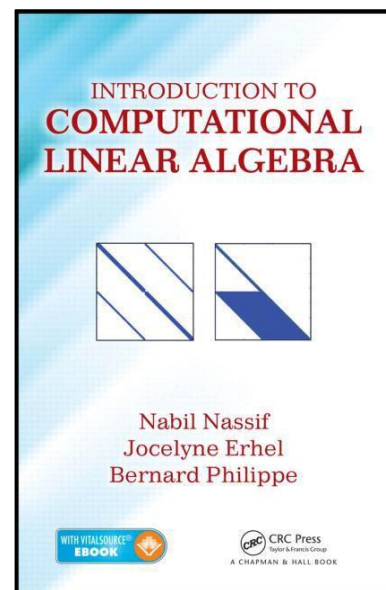
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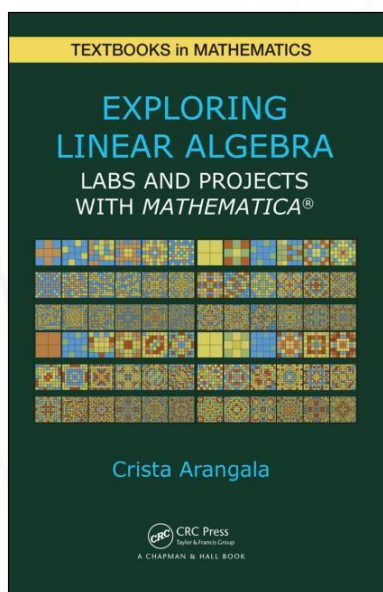
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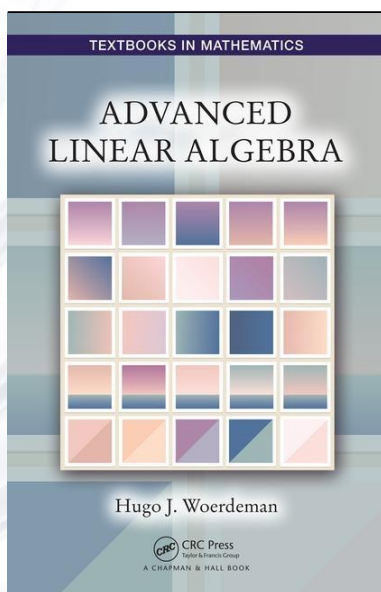
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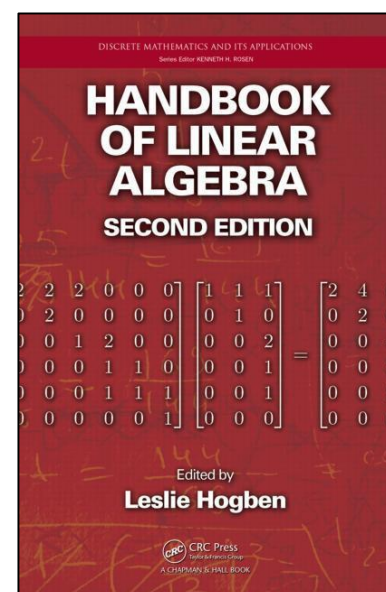
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IMAGE PROBLEM CORNER: OLD PROBLEMS WITH SOLUTIONS

We present a solution to Problem 56-3, and solutions to the main parts of Problems 56-1 and 56-4. Six new problems are on the last page; solutions are invited for the last sentences of Problems 56-1 and 56-4 as well as for Problems 56-2, 56-5 and 56-6, and all of the problems of Issue 57.

Problem 56-1: Minimizing Problem

Proposed by Janko BRAČIČ, *University of Ljubljana, IMFM, Slovenia*, janko.bracic@fmf.uni-lj.si
and Cristina DIOGO, *Lisbon University Institute, Portugal*, cristina.diogo@iscte.pt

Let $A \in M_n(\mathbb{C})$ be a normal matrix with eigenvalues $\lambda_1, \dots, \lambda_n$, and let $\|\cdot\|$ be the spectral norm. Show that for a complex number $\lambda \neq \lambda_j$ ($j = 1, \dots, n$) there exists a complex number μ such that

$$\|(A - \lambda I)^{-1}(A - \mu I)\| < 1 \quad (*)$$

if and only if λ is not a convex combination of the eigenvalues $\lambda_1, \dots, \lambda_n$. In case of a general matrix $A \in M_n(\mathbb{C})$, find a necessary and sufficient condition for λ such that $(*)$ holds for some complex number μ .

Solution 56-1.1 by Eugene A. HERMAN, *Grinnell College, Grinnell, Iowa, USA*, eaherman@gmail.com

(Normal Matrix Part) Let U be a unitary matrix that diagonalizes A . Thus

$$\begin{aligned} U^{-1}(A - \lambda I)^{-1}(A - \mu I)U &= \text{diag}\left(\frac{1}{\lambda_1 - \lambda}, \dots, \frac{1}{\lambda_n - \lambda}\right) \text{diag}(\lambda_1 - \mu, \dots, \lambda_n - \mu) \\ &= \text{diag}\left(\frac{\lambda_1 - \mu}{\lambda_1 - \lambda}, \dots, \frac{\lambda_n - \mu}{\lambda_n - \lambda}\right). \end{aligned}$$

Since a unitary transformation is an isometry and since the spectral norm equals the norm induced by the l_2 -norm on vectors, we have

$$\|(A - \lambda I)^{-1}(A - \mu I)\| = \left\| \text{diag}\left(\frac{\lambda_1 - \mu}{\lambda_1 - \lambda}, \dots, \frac{\lambda_n - \mu}{\lambda_n - \lambda}\right) \right\| = \max_{1 \leq j \leq n} \left| \frac{\lambda_j - \mu}{\lambda_j - \lambda} \right|.$$

We also used the fact that, for a normal matrix, the singular values are the absolute values of the eigenvalues. Therefore, a necessary and sufficient condition for the desired inequality to hold is

$$|\lambda_j - \mu| < |\lambda_j - \lambda|, \quad j = 1, \dots, n.$$

The convex hull of the eigenvalues $\lambda_1, \dots, \lambda_n$ is a (possibly degenerate) filled-in polygon P whose vertices are among these eigenvalues. If $\lambda \notin P$, then some edge of P is part of a line L dividing the plane into two half-planes such that λ lies in one half-plane and P lies in the other. Drop a perpendicular from λ to L and choose μ to be the foot of this perpendicular. Then μ is closer to each point in the other half-plane than is λ . Conversely, if $\lambda \in P$, construct a circle at each vertex v of P with radius $|v - \lambda|$. If $|\lambda_j - \mu| < |\lambda_j - \lambda|$, $j = 1, \dots, n$, then μ is inside all these circles. But λ is the only point on or inside all the circles. $\square$

Problem 56-3: On Areas of Some Related Triangles

Proposed by László LAJOS, *Eötvös Loránd University, Budapest, Hungary*, laszlo@numanal.inf.elte.hu

Let $\text{Vert}(a, b)$ be the triangle with vertices $(a_i, b_i) \in \mathbb{R}^2$, $i = 1, 2, 3$, let $\text{Side}(a, b)$ be the triangle with vertices at crosspoints of lines $y = a_i x + b_i$, $i = 1, 2, 3$, and let $\text{Vand}(a)$ be the Vandermonde determinant of the a_i 's. Prove the formula

$$|\text{Vand}(a)| \cdot \text{Area}(\text{Side}(a, b)) = 2 \cdot \text{Area}(\text{Vert}(a, b))^2$$

for the area of triangles with vertices at points (a_i, b_i) and with side lines $y = a_i x + b_i$, $i = 1, 2, 3$.

Solution 56-3.1 by Eugene A. HERMAN, *Grinnell College, Grinnell, Iowa, USA*, eaherman@gmail.com

We assume that a_1, a_2, a_3 are all distinct so no two side lines are parallel. Since the area of any triangle ABC equals half the length of the cross product $\vec{AB} \times \vec{AC}$,

$$\text{Area}(\text{Vert}(a, b)) = \frac{1}{2} |(a_2 - a_1)(b_3 - b_1) - (a_3 - a_1)(b_2 - b_1)|$$

Since the intersections of the three side lines are

$$\left(\frac{b_2 - b_1}{a_1 - a_2}, \frac{a_1 b_2 - b_1 a_2}{a_1 - a_2}\right), \quad \left(\frac{b_3 - b_1}{a_1 - a_3}, \frac{a_1 b_3 - b_1 a_3}{a_1 - a_3}\right), \quad \text{and} \quad \left(\frac{b_3 - b_2}{a_2 - a_3}, \frac{a_2 b_3 - b_2 a_3}{a_2 - a_3}\right),$$

we also have

$$\begin{aligned} \text{Area}(\text{Side}(a, b)) &= \frac{1}{2} \left| \left(\frac{b_2 - b_1}{a_1 - a_2} - \frac{b_3 - b_2}{a_2 - a_3} \right) \left(\frac{a_1 b_3 - b_1 a_3}{a_1 - a_3} - \frac{a_1 b_2 - b_1 a_2}{a_1 - a_2} \right) \right. \\ &\quad \left. - \left(\frac{b_2 - b_1}{a_1 - a_2} - \frac{b_3 - b_1}{a_1 - a_3} \right) \left(\frac{a_2 b_3 - b_2 a_3}{a_2 - a_3} - \frac{a_1 b_2 - b_1 a_2}{a_1 - a_2} \right) \right|. \end{aligned}$$

It is straightforward to confirm that

$$\begin{aligned} &(a_1 - a_2)(a_2 - a_3)(a_3 - a_1) \cdot \left(\left(\frac{b_2 - b_1}{a_1 - a_2} - \frac{b_3 - b_2}{a_2 - a_3} \right) \left(\frac{a_1 b_3 - b_1 a_3}{a_1 - a_3} - \frac{a_1 b_2 - b_1 a_2}{a_1 - a_2} \right) \right. \\ &\quad \left. - \left(\frac{b_2 - b_1}{a_1 - a_2} - \frac{b_3 - b_1}{a_1 - a_3} \right) \left(\frac{a_2 b_3 - b_2 a_3}{a_2 - a_3} - \frac{a_1 b_2 - b_1 a_2}{a_1 - a_2} \right) \right) \\ &= ((a_2 - a_1)(b_3 - b_1) - (a_3 - a_1)(b_2 - b_1))^2. \end{aligned}$$

Taking the absolute value of each side and multiplying by $1/2$ yields the desired formula. □

Also solved by Juntong LIU.

Problem 56-4: A Determinant Inequality

Proposed by Minghua LIN, *Shanghai University, Shanghai, China*, mlin87@ymail.com

Let A, B be $n \times n$ positive semidefinite Hermitian matrices. Show that

$$\left| \det(A^{1/2} B^{1/2} + B^{1/2} A^{1/2}) \right| \leq \det(A + B).$$

Under the same assumptions, does it hold that $|\det(A^\nu B^{1-\nu} + B^\nu A^{1-\nu})| \leq \det(A + B)$ for each $0 \leq \nu \leq 1$?

Solution 56-4.1 by Juntong LIU, *Fuyang Normal College, Fuyang, China*, juntongliu82@163.com

($\nu = 1/2$ part) Since A and B are $n \times n$ positive semidefinite matrices,

$$\begin{pmatrix} A & A^{1/2} B^{1/2} \\ B^{1/2} A^{1/2} & B \end{pmatrix} \geq 0, \quad \text{and} \quad \begin{pmatrix} B & B^{1/2} A^{1/2} \\ A^{1/2} B^{1/2} & A \end{pmatrix} \geq 0.$$

Further, we have

$$\begin{pmatrix} A + B & A^{1/2} B^{1/2} + B^{1/2} A^{1/2} \\ A^{1/2} B^{1/2} + B^{1/2} A^{1/2} & A + B \end{pmatrix} \geq 0.$$

By applying [1, Theorem 10.20], we get

$$\left| \lambda(A^{1/2} B^{1/2} + B^{1/2} A^{1/2}) \right| \prec_{w \log} \lambda(A + B).$$

Therefore

$$\left| \det(A^{1/2} B^{1/2} + B^{1/2} A^{1/2}) \right| \leq \det(A + B).$$

Reference

[1] F. Zhang, *Matrix theory: Basic results and techniques*. 2nd Ed. Universitext, Springer-Verlag, New York, 2011.

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IMAGE PROBLEM CORNER: NEW PROBLEMS

Problems: We introduce 6 new problems in this issue and invite readers to submit solutions for publication in *IMAGE*. **Solutions:** We present solutions to three problems in the previous issue [*IMAGE* 56 (Spring 2016)] **Submissions:** Please submit proposed problems and solutions in macro-free L^AT_EX along with the PDF file by e-mail to *IMAGE* Problem Corner editor Rajesh Pereira (pereirar@uoguelph.ca).

NEW PROBLEMS:

Problem 57-1: Perfect Condition Number

Proposed by Bojan KUZMA, *University of Primorska, Slovenia*, bojan.kuzma@famnit.upr.si

Recall that the *condition number* of an invertible matrix A , relative to a norm $\|\cdot\|$ is $\text{cond } A := \|A\| \cdot \|A^{-1}\|$. Show that invertible matrices with condition number equal to one with respect to some multiplicative norm are diagonalizable.

Problem 57-2: A Matrix Proof of an Exercise in Calculus

Proposed by Meiyue SHAO, *Lawrence Berkeley National Laboratory, Berkeley, California, USA*, myshao@lbl.gov

Present a matrix proof of the integral

$$\int_0^\pi \ln(2 + \cos x) dx = \pi \ln \frac{2 + \sqrt{3}}{2}.$$

Problem 57-3: A PSD Matrix Decomposition

Proposed by Rajesh PEREIRA, *University of Guelph, Guelph, Canada*, pereirar@uoguelph.ca

Let $A \in M_n(\mathbb{C})$ be a positive semidefinite matrix and let $\|\cdot\|$ be the Euclidean norm on $\mathbb{C}^n$. Show that there exist n not necessarily distinct vectors $\{v_k\}_{k=1}^n$ in $\mathbb{C}^n$ such that $\|v_k\|^2 = a_{kk}$ for all k with $1 \leq k \leq n$ and

$$A = \sum_{k=1}^n v_k v_k^*.$$

Problem 57-4: Factors of a Determinantal Polynomial

Proposed by Roger A. HORN, *University of Utah, Salt Lake City, Utah, USA*, rhorn@math.utah.edu and Jeffrey STUART, *Pacific Lutheran University, Tacoma, Washington, USA*, jeffrey.stuart@plu.edu

Let $A \in M_n(\mathbb{C})$. Show that

$$\det(xA + yA^T) = c(xy)^\ell (x+y)^m (x-y)^p \prod_{i=1}^q ((x + \mu_i y)^{r_i} (y + \mu_i x)^{r_i}), \quad (1)$$

in which ℓ, m, p, q are nonnegative integers; $r_1, r_2, \dots, r_q$ are positive integers if $q > 0$; the μ_i are distinct and each $\mu_i \in \mathbb{C} \setminus \{0, \pm 1\}$; and $c \in \mathbb{C}$ does not depend on x or y . If $\text{null } A \cap \text{null } A^T \neq \{0\}$, then $c = 0$. However, if

$$A = \begin{bmatrix} 0 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix}, \quad (2)$$

then $c = 0$ but $\text{null } A \cap \text{null } A^T = \{0\}$. Find a necessary and sufficient condition such that $c = 0$.

Problem 57-5: Eisenstein Circulant Matrices

Proposed by Rajesh PEREIRA, *University of Guelph, Guelph, Canada*, pereirar@uoguelph.ca

An Eisenstein integer is a complex number of the form $a + b\omega$ where a and b are integers and $\omega = \frac{-1 + \sqrt{3}i}{2}$. The Eisenstein integers form a commutative ring with identity. Let A be a three by three invertible Hermitian circulant matrix all of whose entries are Eisenstein integers. Show that $\text{Tr}(A^n) \neq 0$ for all natural numbers $n \geq 2$.

Problem 57-6: A Commuting Matrix Problem

Proposed by Roger A. HORN, *University of Utah, Salt Lake City, Utah, USA*, rhorn@math.utah.edu

Let A and B be $n \times n$ complex matrices. Suppose that (a) B is nonderogatory, and (b) $Ax = \lambda x$ whenever $Bx = \lambda x$. Show that if A and B commute, then they have the same eigenvalues with the same algebraic multiplicities, that is, they have the same characteristic polynomial.

Solutions to Problems 56-1 (first part), 56-3 and 56-4 are on pages 29–30.