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Reports on Linear Algebra Events Attended

Selected Forthcoming Linear Algebra Events

New and Forthcoming Publications in Linear Algebra

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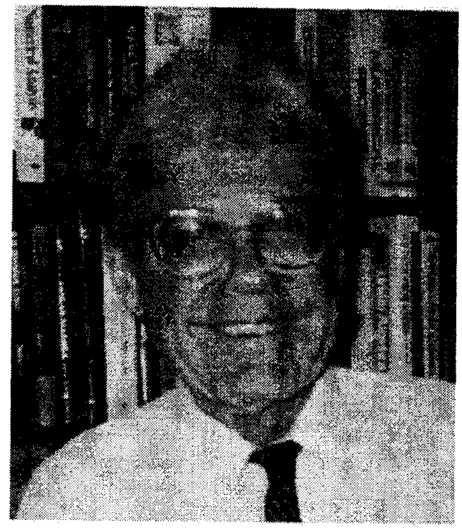
Kermit Sigmon: 1936–1997



Kermit Sigmon succumbed to liver cancer on January 14, 1997, after being ill only one month. He is survived by two sisters, his wife Ruth, daughter Kristina, and two grandchildren. His many friends, colleagues and students will greatly miss his cheerful and congenial company, generous spirit, clear-headed leadership and outstanding teaching. He received his Ph.D. from the University of Florida in 1966, working in topological algebra under the direction of Alexander Doniphan Wallace. He joined the faculty at the University of Florida, Gainesville, and remained there except for several summer consulting positions and sabbatical years elsewhere.

Kermit directed three Ph.D. theses and published 14 papers on topics in functional equations and Alexander cohomology. Over time his interests shifted and he wrote several papers in numerical linear algebra as well as the well-known handbook: *MATLAB Primer* [Fourth Edition, CRC Press, 1994]. He was an Associate Editor for *Aequationes Mathematicae* (1974–1980) and SIMAX (1989–present). He held a variety of offices in the Florida Section of the MAA and also supported the training of math teachers. He was a demanding but very popular teacher at Florida and won several teaching awards. Most recently he was selected in 1995 by the Department of Mathematics for a Teaching Incentive Program Award, which is given for teaching excellence and provides a substantial salary increase. He also won an University of Florida Teaching Award for the 1995/1996 academic year.

Kermit was one of the leaders of the ATLAST Project: An NSF Project to Augment the Teaching of Linear Algebra through the use of Software Tools. He served on the original planning team for the ATLAST workshops. During the period 1992–1995 he served as presenter for three workshops and did an outstanding job. ATLAST is an NSF-funded project which began in 1992 and has to date provided 16 workshops around the U.S. The purpose of these is to encourage and facilitate the use of software in teaching linear algebra and to assist college faculty to update their linear algebra courses.

Throughout his career Kermit has made many invaluable contributions to his department, including serving as Associate Chair, Undergraduate Coordinator, Faculty Mentor for minority students, and providing academic advising for hundreds of students. His work on curriculum development has been substantial. He has even written software to facilitate the department's record-keeping.

Kermit was a tennis player and avid biker; his enthusiasm for biking is probably what got him on the Metropolitan Planning Commission for Alachua County and kept him there for 20 years. He also served on the University's Transportation Committee, which developed a Master Plan for cooperation between the university, city and county to expand local bus service and make Gainesville a more biker-friendly city. These contributions led to a number of recognitions, including the Gainesville City Commission proclaiming August 5, 1985, as "Kermit Sigmon Day". Contributions may be made to the American Cancer Society or the League of American Bicyclists, 190 West Ostend Street, Suite 120, Baltimore, MD 21230, USA, and Ruth Sigmon may be contacted c/o Dept. of Mathematics, University of Florida, Gainesville, FL 32611-8105, USA.

STEVEN J. LEON
University of Massachusetts–Dartmouth

JANE DAY
San Jose State University

John Maybee: 1928–1997

It is with the deepest sadness that we announce that John Maybee passed away on May 2, 1997, after a sudden heart attack earlier that week in Florida. A full obituary will appear in the next issue of *Image*. [For a brief history of John Maybee's career, and for the *Proceedings* of a conference in his honor, see *Linear Algebra and Its Applications*, vol. 217 (March 1, 1995). —CHARLES R. JOHNSON.

ILAS Member's News

PETER ŠEMRL of the Faculty of Mechanical Engineering, University of Maribor (Maribor, Slovenia) received the National Award for Science of Slovenia on November 7, 1996. This award is given annually to the four or five most outstanding scientists of this small country, tucked away just south of the Alps below Austria. At 34, Peter is one of the youngest to have won this award, which was given for his significant research in stability studies, operator theory and linear algebra. It carries a considerable financial recognition, and has made him an overnight TV celebrity! In true fashion the prize was celebrated in a cozy cellar in Maribor, with seventeen close friends and fellow wine lovers. —ROBERT E. HARTWIG.

Inequalities Galore: One New Website and Two New Journals

We have set up a website on Matrix Inequalities in Science & Engineering: http://www.wm.edu/CAS/MINEQ/matrix.html. The purpose is to facilitate communication between researchers involved, in any way, with matrix inequalities. At the moment we are asking a few people for input. Please visit and give us: (1) Comments on the organization of the page, (2) Problems to post (or even solutions to the few we have posted!) and especially problems related to statistics, (3) Relevant reprints and preprints, (4) Any other suggestions. Do you want to be listed under "people interested in matrix inequalities"? —ROY MATHIAS AND CHI-KWONG LI.

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Mathematical Inequalities & Applications is a new journal to be published quarterly, in January, April, July and October, with the first issue to appear in January 1998. The Editor-in-Chief is Josip E. Pečarić (Faculty of Textile Technology, University of Zagreb, Pierottijeva 6, 10000 Zagreb, Croatia; apecaric@jagor.srce.hr). The journal is devoted to inequalities in all areas of mathematics, and their applications. The journal's policy is to publish high standard manuscripts rapidly. From time to time *Mathematical Inequalities & Applications* will publish invited survey articles. Short notes (maximum of four pages) with interesting results or open problems will also be considered.

Manuscripts should be submitted to any member of the Editorial Board: Ravi P. Agarwal, Tsuyoshi Ando, Marshall J. Ash, Adi Ben-Israel, Jonathan Borwein, Victor Burenkov, Zeev Ditzian, Takayuki Furuta, Moshe Goldberg, Frank Hansen, Don Hinton, Roger A. Horn, Murray S. Klamkin, Man Kam Kwong, Andrea Laforgia, Srinivasa G. Leela, Lászło Leindler, Lech Maligranda, Roy Mathias, Bertram Mond, Ingram Olkin, Bohumir Opic, B. G. Pachpatte, Zsolt Páles, Charles E. M. Pearce, Lars Erik Persson, Goran Peškir, Simo Puntanen, Kenneth B. Stolarsky, George P. H. Styan, Y. L. Tong, Vladimir Volenec, and Hans Joachim Werner. The Managing Editor is Neven Elezovič (Dept. of Applied Mathematics, Faculty of Electrical Engineering and Computing, University of Zagreb, Unska 3, 10000 Zagreb, Croatia; neven.elez@fer.hr). Associate Editor: Sanja Varošanec (Dept. of Mathematics, University of Zagreb, Bijenicka c. 30, 10000 Zagreb, Croatia; varosans@cromath.math.hr).

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Gordon and Breach Science Publishers have just announced the new *Journal of Inequalities and Applications*, with 4 issues per volume. The aims of this journal are to provide a multi-disciplinary forum of discussion in mathematics and its applications in which the essentiality of inequalities is highlighted. Areas covered include inequalities in analysis, approximation theory, calculus of variations, combinatorics, economics, geometry, mechanics, optimization, and probability theory. The Editor-in-Chief is Ravi P. Agarwal (Dept. of Mathematics, National University of Singapore, 101 Kent Ridge Crescent, Singapore 119260). The Editorial Board comprises: J. Aczel, C. Bandle, P. Bullen, W. Desmond Evans, W. N. Everitt, A. M. Fink, R. Ger, R. P. Gilbert, R. Glowinski, V. B. Kolmanovskii, M. A. Krasnosel'skii, A. Kufner, V. Lakshmikantham, P. L. Lions, L. Lozonci, E. R. Love, K. Masuda, J. Mawhin, R. Mennicken, G. V. Milovanovic, R. N. Mohapara, R. J. Nessel, T. M. Rassias, S. Saitoh, G. Talenti, K. L. Teo, W. Walter, and A. Zettl.

Book Reviews

Rajendra Bhatia: *Matrix Analysis*

Reviewed by S. W. Drury, McGill University, Montréal

Matrix Analysis by Rajendra Bhatia [Graduate Texts in Mathematics, vol. 169, Springer, xi + 347 pp., ISBN 0-387-94846-5, $49.95, 1997] is a very up-to-date research level book that would make a wonderful assigned text for a graduate course. The reader is expected to be thoroughly familiar with the basic concepts of linear algebra as they appear for example in the standard texts *Finite-Dimensional Vector Spaces* by Paul R. Halmos [Second Edition, Springer, viii + 199 pp., ISBN 0-387-90093-4, 1974] or *Linear Algebra* by Kenneth Hoffman and Ray A. Kunze [Second Edition, Prentice Hall, viii + 407 pp., ISBN 0-13-536797-2, 1971]. The first chapter is a crash course in some of the more advanced topics not treated in these texts such as tensor products, exterior and symmetric products. Then follow four chapters on basic matrix analysis. These cover majorization and doubly stochastic matrices, variational principles for eigenvalues, symmetric and unitarily invariant norms, and operator monotone and operator convex functions. This final topic includes a nicely detailed account of Loewner's Theorems. Then follow three chapters which reflect more particularly Bhatia's personal research interests. These cover spectral variation of matrices both normal and nonnormal and the perturbation of the spectral subspaces of normal matrices.

The book ends with two chapters, one giving a selection of matrix inequalities that did not fit neatly into the earlier chapters and one adding complementary material to the section on matrix functions. Each chapter ends with an extensive section giving attributions and additional references. This makes the book ideal for active researchers. One finds both exercises and problems scattered throughout the book. The exercises are intended for the reader to test his understanding of material he has just read—they should probably be mastered before proceeding further. The problems on the other hand serve a variety of purposes and they vary quite considerably in difficulty. Some are furnished with extensive hints and suggestions. The book is extraordinarily well written and its exposition seems to be both concise and leisurely at the same time. Some theorems are given more than one proof and Bhatia often takes the trouble to point out connections between seemingly unrelated topics that might easily be missed even by an attentive reader. This is a superb book, both as a reference book and as a source book for graduate students and researchers in Linear Algebra, Matrix Analysis and Operator Theory. The book is well produced and misprints were minimal.

Peter D. Lax: *Linear Algebra*

Reviewed by S. W. Drury, McGill University, Montréal

Linear Algebra by Peter D. Lax [Pure and Applied Mathematics, Wiley-Interscience Series of Texts, Monographs and Tracts, Wiley, xiv + 250 pp., ISBN 0-471-11111-2, $54.95, 1997] developed out of the author's course notes for advanced undergraduates and beginning graduate students at New York University. The book splits roughly into two equal halves. The first eight chapters cover the core material of linear algebra. In the second half of the book, Lax brings together some more advanced topics and some interesting applications to create, with his unique perspective, some fascinating reading. The basics are covered in the first four chapters—fundamentals, duality, linear mappings, matrices. Chapters 5 and 6 address the determinant, trace and spectral theory. Euclidean structure is introduced in chapter 7 and the spectral theory of self-adjoint mappings in chapter 8. This material is enlivened by a number of illuminating applications. These include an application of linear independence to quadrature, interpolation by polynomials and a discretized Dirichlet problem.

The exposition is generally excellent, if rather terse. A student trying to learn the material for the first time will find the book challenging—quotient spaces are introduced on page 5 and groups are mentioned without any formal definition being given. Consider also the theorem that every square matrix is similar to its transpose. In an exercise, the reader is invited to fill in the details of the proof. Over the complex field, the proof has already been sketched pretty well, but the reader will scramble to fill in the missing details in the real case.

The text is lacking substantial sets of exercises designed specifically to complement the material presented and to cover the many important topics Professor Lax has seen fit to omit. It is true that the book is sprinkled with exercises, but not nearly enough to satisfy the appetite of a student capable of handling this level of exposition. The second half of the book is a joy. Graduate students will find much that is fascinating and even experts may learn something new. Chapter 9 concerns the calculus of matrix-valued functions. The chapter ends with a discussion of the *avoidance of crossing* phenomenon which concerns the bizarre behaviour of the eigenvalues of the combination $B + tM$ of two Hermitian matrices B and M as the real number t varies over an interval. Along with the concavity of the smallest eigenvalue, this phenomenon is illustrated on the compellingly designed dust jacket of the book.

In chapter 10 we find a discussion of matrix inequalities, starting with the calculus of positive definite and self-adjoint linear mappings, leading on to monotone matrix functions. Then follow the Hadamard Inequality and the Wielandt-Hoffman Theorem. The chapter ends with a discussion of the polar decomposition and the singular value decomposition.

Chapter 11 is entitled "Kinematics and Dynamics". It illustrates, without the introduction of Lie groups and Lie algebras, how matrices can be used to give an elegant description of the motion of rigid bodies. Other topics covered in this chapter are fluid flow and the vibrations of mechanical systems.

The next four chapters form a group in which convexity and normed linear spaces are discussed. The presentation here makes a refreshing change from the sterility that usually accompanies abstract functional analysis. The convexity theorems of Carathéodory, Helly and König–Birkhoff are all included. The Minmax theorem and its application to economics is used to illustrate the concept of duality.

Chapter 16 discusses positive matrices and Perron's theorem. Chapter 17 describes the use of the method of steepest descent to solve systems of linear equations. A variation of this method which employs Chebyshev polynomials is also given. The book concludes with 8 marvellous appendices on a wide variety of topics. I personally prefer the treatment of Pfaff's Theorem in V. V. Prasolov's *Problems and Theorems in Linear Algebra* [Translations of Mathematical Monographs, vol. 134, American Mathematical Society, xviii + 225 pp., ISBN 0-8218-0236-4, 1994]. The explicit formula for the Pfaffian given there renders this seemingly mysterious topic completely transparent.

There are a few misprints, some mathematical and some textual. The most serious of these appears to be the mangling of the names of both Roger Horn and Charles Johnson in the bibliography. In the book received for review, the quality of the printing was not up to the standard we have come to expect from Wiley–Interscience. Despite these shortcomings, this is a book to be read and treasured.

Book Announcements

Peter van Overschee and Bart L. R. De Moor: *Subspace Identification for Linear Systems: Theory–Implementation–Applications*

Subspace Identification for Linear Systems: Theory–Implementation–Applications by Peter van Overschee and Bart L. R. De Moor [Kluwer, 272 pp. (+ floppy disk with Matlab files for subspace identification), ISBN 0-7923-9717-7, $105.00, 1996] focuses on the theory, implementation and applications of subspace identification algorithms for linear time-invariant finite-dimensional dynamical systems. These algorithms allow for a fast, straightforward, and accurate determination of linear multivariable models from measured input-output data.

The theory of subspace identification algorithms is presented in detail. Several chapters are devoted to deterministic, stochastic and combined deterministic-stochastic subspace identification algorithms. For each case, the geometric properties are stated in a main 'subspace' theorem. Relations between existing algorithms and literature are explored, as are the interconnections between different subspace algorithms. The subspace identification theory is linked to the theory of frequency weighted model reduction, which leads to new implementations and insights.

The implementation of subspace identification algorithms is discussed in terms of the robust and computationally efficient RQ and singular value decompositions, which are well-established algorithms from numerical linear algebra. The algorithms are implemented in combination with a whole set of classical identification algorithms, processing and validation tools in Xmath's ISID, a commercially available graphical user interface toolbox. The basic subspace algorithms in the book are also implemented in a set of Matlab files accompanying the book.

One application of ISID to an industrial glass tube manufacturing process is presented in detail, illustrating the power and user-friendliness of the subspace identification algorithms and of their implementation in ISID. The identified model allows for an optimal control of the process, leading to a significant enhancement of the production quality. The applicability of subspace identification algorithms in industry is further illustrated with the application of the Matlab files to ten practical problems. Since all necessary data and Matlab files are included, the reader can easily step through these applications, and thus get more insight in the algorithms.

David Carlson, Charles R. Johnson, David C. Lay, A. Duane Porter, Ann Watkins, and William Watkins, eds.:
Resources for Teaching Linear Algebra

Resources for Teaching Linear Algebra by David Carlson, Charles R. Johnson, David C. Lay, A. Duane Porter, Ann Watkins, and William Watkins [MAA Notes, 306 pp., ISBN 0-88385-150-4 (P), $34.95, 1997] grew out of the work of the Linear Algebra Curriculum Study Group (organized by David Carlson, Charles R. Johnson, David C. Lay, and A. Duane Porter), and the 1993 Special Issue on Linear Algebra of the College Mathematics Journal (then edited by Ann Watkins and William Watkins.) This book argues that the teaching of elementary linear algebra can be made more effective by emphasizing applications, exposition and pedagogy.

- Relevant applications serve as motivation for all students and as sources of stimulating and challenging problems.
- Effective exposition that finds the right way to communicate concepts is especially important in the teaching of linear algebra, often the first course in which students come to grips with abstraction and complexity, and with multiple representations of the same idea.
- Attention to Pedagogy that takes into account how students learn, technology, and new teaching ideas such as cooperative learning can go a long way toward improving the teaching of linear algebra.

This volume includes the recommendations of the Linear Algebra Curriculum Study Group, with their core syllabus for the first course, and the thoughts of mathematics faculty who have taught linear algebra using these recommendations. It includes elucidation of these ideas, trenchant criticism of them, and a report on putting them into practice.

Lots of Books on Linear Algebra and Related Topics

by Simo Puntanen, *University of Tampere* & George P. H. Styan, *McGill University*

Listed below are some more books on linear algebra and related topics that (1) have been published in 1996 or in 1997, or are scheduled for publication in 1997 or in 1998, and (2) that were published in 1867–1995; (P) denotes paperback and (H) hard cover. List prices (subject to change) are given in US dollars ($), UK Pounds Sterling (£) or Deutsche Mark (DM). These lists augment and update the lists published in *Image,* no. 14 (Winter 1995), pp. 23–26; no. 15 (Summer 1995), pp. 8–9; no. 16 (Winter 1996), pp. 20–21; and no. 17 (Summer 1996), p. 23, as well as *A Guide to Books on Matrices and Books on Inequalities, with Statistical and Other Applications* by George P. H. Styan & Simo Puntanen [Report A283, December 1993, ii + 65 pp., ISBN 951-44-3501-X (P)].

All additions and corrections are most welcome and should be sent to Simo Puntanen at sjp@uta.fi or to George Styan at styan@math.mcgill.ca. Many of the entries in these two lists were found by browsing through the user-friendly Amazon website http://www.amazon.com, which contains 2.5 million entries. Our thanks go to Marika Asimakopulos for her help in checking these lists, especially with respect to the Global Books in Print and Blackwell North America databases.

More Books on Linear Algebra and Related Topics: 1995–1998

Andersen, H. H.; Hojbjerre, M.; Sorensen, D., and Eriksen, P. S. (1995). *Linear and Graphical Models for the Multivariate Complex Normal Distribution.* Lecture Notes in Statistics, vol. 101. Springer, x + 183 pp., ISBN 0-387-94521-0 (P), DM 59.00.

Antsaklis, Panos J., and Michel, Anthony N. (*c.* March 1997). *Linear Systems.* McGraw-Hill Series in Electrical and Computer Engineering. McGraw-Hill, ISBN 0-07-041433-5 (H), $45.00, in press.

Apostol, Tom M. (*c.* June 1997). *Linear Algebra: A First Course with Applications to Differential Equations.* Wiley, ISBN 0-471-17421-1 (H), $64.95, in press.

Balakrishnan, V. K. (*c.* March 1997). *Schaum's Outline of Theory and Problems of Graph Theory: Including Hundreds of Solved Problems.* Schaum's Outline Series. McGraw-Hill, 288 pp., ISBN 0-07-005489-4 (P), $14.95.

Bapat, R. B., and Raghavan, T. E. S. (1997). *Nonnegative Matrices and Applications.* Encyclopedia of Mathematics and Its Applications, vol. 64. Cambridge University Press, 365 pp., ISBN 0-521-57167-7 (H), $64.95.

Barrett, Wayne W.; Johnson, Charles R., and Loewy, Raphael (1996). *The Real Positive Definite Completion Problem: Cycle Completability.* Memoirs of the American Mathematical Society, vol. 122, no. 584. American Mathematical Society, 69 pp., ISBN 0-8218-0473-1, $32.00.

Beineke, Lowell W., and Wilson, Robin J., eds. (1996). *Graph Connections: Relationships Between Graph Theory and Other Areas of Mathematics.* Oxford Lecture Series in Mathematics and Its Applications, vol. 5. Oxford University Press, 304 pp., ISBN 0-198-51497-2 (H), $65.00.

Bennett, Grahame (1996). *Factorizing the Classical Inequalities.* Memoirs of the American Mathematical Society, No. 576. American Mathematical Society, 130 pp., ISBN 0-8218-0436-7, $37.00.

Bertsimas, Dimitris, and Tsitsiklis, John (1997). *Introduction to Linear Optimization.* Athena Scientific (Belmont, MA), 608 pp., ISBN 1-886529-19-1 (H), $69.00.

Bhatia, Rajendra (1997). *Matrix Analysis.* Graduate Texts in Mathematics, vol. 169. Springer, xi + 347 pp., ISBN 0-387-94846-5 (H), $49.95. *Reviewed on page 4.*

Blum, Karl (1996). *Density Matrix Theory and Applications.* Second Edition. Physics of Atoms and Molecules. Plenum Press, xvi + 323 pp., ISBN 0-306-45341-X (H), $89.50.

Bolton, W. (1996). *Linear Equations and Matrices (Mathematics for Engineers).* Longman, ISBN 0-582-25633-X (P), $34.50.

Borse, Garold J. (1997). *Numerical Methods using MATLAB: A Resource for Scientists and Engineers.* PWS BookWare Companion Series. PWS-Kent Publishing, 672 pp., 0-534-93822-1 (H), $65.95.

Bretscher, Otto (1997). *Linear Algebra. With Applications.* Prentice Hall, xiv + 558 pp., ISBN 0-13-190729-8 (H), $70.67.

Carlson, David; Johnson, Charles R.; Lay, David C.; Porter, A. Duane; Watkins, Ann, and Watkins, William, eds. (1997). *Resources for Teaching Linear Algebra.* MAA Notes, 306 pp., ISBN 0-88385-150-4 (P), $34.95. *See announcement on page 6.*

Carroll, J. Douglas; Green, Paul E., and Chaturvedi, Anil (*c.* June 1997). *Mathematical Tools for Applied Multivariate Analysis.* Revised Edition. Academic Press, 448 pp., ISBN 0-12-160955-3 (P), $29.95.

Caswell, Hal (1997). *Matrix Population Models.* Revised Edition. Sinauer Associates, 328 pp., ISBN 0-87893-0965 (P), $38.95.

Chakravarthy, Srinivas R., and Alfa, Attahiru S., eds. (1997). *Matrix-Analytic Methods in Stochastic Models.* Lecture Notes in Pure and Applied Mathematics, vol. 183. Marcel Dekker, xiv + 375 pp., ISBN 0-8247-9766-3 (P), $150.00. [Papers from an International Conference held in Flint, Michigan]

Chen, W. K. (*c.* 1997). *Graph Theory and Its Engineering Applications.* Advanced Series in Electrical and Computer Engineering, vol. 5. World Scientific, 712 pp., ISBN 981-02185-91 (H), $58.00.

Christensen, Ronald (1996). *Plane Answers to Complex Questions: The Theory of Linear Models.* Second Edition. Springer, xviii + 452 pp., ISBN 0-387-94767-1 (H), $57.95. [MR 97d:62115]

Cullen, Charles G. (1996). *Linear Algebra With Applications.* Second Edition. Scott Foresman, 432 pp., ISBN 0-673-99386-8 (H), $72.04.

Cvetkovic, Dragos; Rowlinson, Peter, and Simic, Slobodan (1997). *Eigenspaces of Graphs.* Encyclopedia of Mathematics and Its Applications, vol. 66. Cambridge University Press, 272 pp., ISBN 0-521-57352-1 (H), $69.95.

Das Gupta, Somesh; Ghosh, J. K.; Mitra, Sujit Kumar; Mukhopadhyay, A. C.; Prakasa Rao, B. L. S.; Rao, P. S. S. N. V. P.; Rao, S. B.; and Sarma, Y. R., eds. (*c.* 1997). *Selected Papers of C. R. Rao: Volume 4.* Wiley Eastern, ISBN 0-470-22094-5, $34.95, in press. [Apparently not yet published though publication scheduled for December 1996]

Das Gupta, Somesh; Ghosh, J. K.; Mitra, Sujit Kumar; Mukhopadhyay, A. C.; Prakasa Rao, B. L. S.; Rao, P. S. S. N. V. P.; Rao, S. B.; and Sarma, Y. R., eds. (*c.* 1997). *Selected Papers of C. R. Rao: Volume 5.* Wiley Eastern, ISBN 0-470-22095-3, $34.95, in press. [Apparently not yet published though publication scheduled for March 1997]

Davis, Artrice (*c.* 1998). *Linear Circuit Analysis.* PWS Publishing, 1072 pp., ISBN 0-534-95095-7, $81.95, in press.

Davis, M. H. A. (*c.* April 1997). *Linear Stochastic Systems.* Second Edition. Chapman & Hall, 256 pp., ISBN 0-412-31740-0 (H), $54.95, in press.

Demmel, James W. (*c.* August 1997). *Applied Numerical Linear Algebra.* SIAM, *c.* 450 pp., ISBN 0-898-71389-7 (P), $45.00, in press.

Diestel, Reinhard (*c.* June 1997). *Graph Theory.* Graduate Texts in Mathematics, vol. 173. Springer, ISBN 0-387-98210-8 (H), $59.00; ISBN 0-387-98211-6 (P), $29.00, in press.

Ellis, Wade, Jr.; Johnson, Eugene; Lodi, Ed, and Schwalbe, Daniel (1996). *Maple V Flight Manual: Tutorials for Calculus, Linear Algebra, and Differential Equations*. Second Edition. Brooks/Cole, xiv + 168 pp., ISBN 0-534-26202-3 (P), $32.95.

Felton, Lewis P., and Nelson, Richard B. (1996). *Matrix Structural Analysis*. Wiley, 700 pp., ISBN 0-471-12324-2 (H), $87.52.

Flury, Bernhard (*c*. August 1997). *A First Course in Multivariate Statistics*. Springer Texts in Statistics. Springer, ISBN 0-387-98206-X, in press.

Fox, John (1997). *Applied Regression Analysis, Linear Models, and Related Methods*. Sage Publications, 462 pp., ISBN 0-80394540X, $58.00.

Friedberg, Stephen H.; Insel, Arnold J., and Spence, Lawrence E. (1996). *Linear Algebra*. Third Edition. Prentice Hall, 557 pp., ISBN 0-13-233859-9 (H), $90.50.

Fuhrmann, Paul A. (1996). *A Polynomial Approach to Linear Algebra*. Universitext. Springer, xiv + 360 pp., ISBN 0-387-94643-8 (P), $39.00.

Gabriel, P. (1996). *Matrizen, Geometrie, lineare Algebra*. In German. Springer, ISBN 3-7643-5376-7.

Gasca, Mariano, and Micchelli, Charles A., eds. (1996). *Total Positivity and Its Applications*. Mathematics and its Applications, vol. 359, Kluwer, x + 518 pp., ISBN 0-7923-3924-X (H), $196.00. [Contains papers presented at the meeting on Total Positivity and its Applications, University of Zaragoza Guest House, Jaca, Spain, September 26–30, 1994]

Giri, Narayan C. (1996). *Multivariate Statistical Analysis*. Statistics: Textbooks and Monographs, vol. 149. Marcel Dekker, 392 pp., ISBN 0-8247-9338-2 (H), $135.00.

Giri, Narayan C. (*c*. May 1997). *Group Invariance in Statistical Inference*. World Scientific, viii + 167 pp., ISBN 981-021875-3 (P), $51.00, in press.

Girko, Vyacheslav L. (1996). *Theory of Linear Algebraic Equations with Random Coefficients*. Allerton Press, xxiv + 329 pp., ISBN 0-89864-078-4 (H), $120.00.

Gnanadesikan, R. (1997). *Methods for Statistical Data Analysis of Multivariate Observations*. Second Edition. Wiley Series in Probability and Statistics. Applied Probability and Statistics. Wiley, xvi + 353 pp., ISBN 0-471-16119-5, $69.95, in press.

Gohberg, I., and Langer, H. (1995). *Operator Theory and Eigenvalue Problems*. Operator Theory: Advances & Applications. Birkhäuser, x + 313 pp., ISBN 0-8176-5275-2, $123.00. [Proceedings of workshop in Vienna, Austria, July 1993, MR 96g:47003]

Golub, Gene H., and Van Loan, Charles F. (1996). *Matrix Computations*. Third Edition. Johns Hopkins Studies in the Mathematical Sciences. Johns Hopkins University Press, xxx + 698 pp., ISBN 0-8018-5413-X (H), $65.00; ISBN 0-8018-5414-8 (P), $29.95. [MR 97e:62004]

Gower, J. C., and Hand, D. J. (1996). *Biplots*. Monographs on Statistics and Applied Probability, vol. 54. Chapman & Hall, xvi + 277 pp., ISBN 0-412-71630-5 (H), $54.95.

Greenbaum, Anne (*c*. September 1997). *Iterative Methods for Solving Linear Systems*. SIAM, 250 pp., ISBN 0-89871-396-X, in press.

Griffiths, David F., and Higham, Desmond J. (1997). *Learning LATEX*. SIAM, x + 84 pp., ISBN 0-89871-383-8 (P), $15.50.

Gupta, Arjun K., and Girko, Vyacheslav L., eds. (1996). *Multidimensional Statistical Analysis and Theory of Random Matrices: Proceedings of the Sixth Eugene Lukacs Symposium, Bowling Green, OH, USA, 29–30 March 1996*. VSP International Science Publishers, Zeist (The Netherlands), xii + 386 pp., ISBN 90-6764-208-8 (H), $210.00.

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Huppert, Bertram; Schneider, Hans, eds. (1996). *Helmut Wielandt: Mathematical Works, Mathematische Werke—Volume 2: Linear Algebra and Analysis.* Walter de Gruyter, xx + 632 pp., ISBN 3-11-012453-X (H), $209.95.

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Zlatev, Z.; Wasniewski, J., and Schaumburg, K. (1997). *Y12M Solution of Large and Sparse Systems of Linear Algebraic Equations: Documentation of Subroutines.* Lecture Notes in Computer Science, vol. 121. Springer, ix + 128 pp., ISBN 3-540-10874-2 (P), DM 19.00.

24 Dover Books in Print on Linear Algebra and Related Topics

As we go to press, these 24 books are listed on the Amazon website http://www.amazon.com as being in print. On some books Amazon offers a 10% discount. MR denotes *Mathematical Reviews* and OV original version.

Akhiezer, Naum Il'ich & Glazman, Izrail' Markovich (1993). *Theory of Linear Operators in Hilbert Space.* In English. Translated from the Russian and with a preface by Merlynd K. Nestell. Dover, xiv + 147 & iv + 218 pp., two volumes bound as one, ISBN 0-486-67748-6 (P), $10.95. [MR 94i:47001, "Unabridged and unaltered republication" of the 1961, 1963 OVs in one volume]

Akivis, M. A. & Goldberg, V. V. (1977). *An Introduction to Linear Algebra & Tensors.* Revised English Edition. Translated from the Russian and edited by Richard A. Silverman. Dover, vii + 167 pp., ISBN 0-486-63545-7 (P), $6.95. [MR 58:22096. OV: Prentice-Hall, 1972; MR 50:13067]

Campbell, Stephen L. & Meyer, Carl D., Jr. (1991). *Generalized Inverses of Linear Transformations.* Corrected Reprint Edition. Dover, xii + 272 pp., ISBN 0-486-66693-X (P), $8.95. [MR 92a:15003. OV: 1979, MR 80d:15003.]

Crowe, Michael J. (1994). *A History of Vector Analysis: The Evolution of the Idea of a Vectorial System.* Corrected Reprint Edition. Dover, xvii + 270 pp., ISBN 0-486-67910-1 (P), $7.95. [MR 94j:01003. "Slightly corrected reprint of the Dover edition of 1985, which was an unabridged and corrected republication" of the OV: 1967, University of Notre Dame Press, "and which contained a new Preface by the author. The 1994 edition adds a Publishers Note."]

Cullen, Charles G. (1990). *Matrices and Linear Transformations*. Reprint of the Second Edition. Dover, xii + 318 pp., ISBN 0-486-66328-0 (P), $8.95. [MR 91f:15001. OV: 1972, Addison-Wesley, MR 49:10703; First Edition: 1966, Addison-Wesley, ix + 227 pp.]

Dettman, John W. (1986). *Introduction to Linear Algebra and Differential Equations*. Dover, xii + 404 pp., ISBN 0-486-65191-6 (P), $11.95. [MR 87m:34001]

Eves, Howard Whitley (1980). *Elementary Matrix Theory*. Reprint Edition. Dover, xvi + 325 pp., ISBN 0-486-63946-0 (P), $10.95. MR 83d:15001. [OV: 1966, Allyn & Bacon, MR 33:7347]

Faddeeva, V. N. (1959). *Computational Methods of Linear Algebra*. In English. Translated from the Russian by Curtis D. Benster. Dover, xi + 252 pp., ISBN 0-486-60424-1 (P), $7.95. [MR 20:6777. OV: 1950, Gosudarstv. Izdat. Tehn.-Teor. Lit., Moscow-Leningrad, 240 pp., MR 13:872g]

Gel'fand, Izrail' Moiseevich (1989). *Lectures on Linear Algebra*. With the collaboration of Z. Ya. Shapiro. In English. Translated from the Russian by A. Shenitzer. Reprint Edition. Dover, vi + 185 pp., ISBN 0-486-66082-6 (P), $7.95. [MR 90j:15001. "Unabridged & unaltered republication of the 1961 translation of the 1950 Revised Second Edition (in Russian) with the omission of two appendices; original English translation: 1961, Interscience, Huntington, NY, ix + 185 pp., MR 23:A152]

Gerrard, A., and Burch, J. M. (1994), *Introduction to Matrix Methods in Optics*, Dover, xii + 355 pp., ISBN 0-486-68044-4 (P), $9.95. [MR 95h:78001]

Goldberg, Seymour (1985). *Unbounded Linear Operators: Theory and Applications*. Dover, 199 pp., ISBN 0-486-64830-3 (P), $7.95. [MR 86k:47001]

Gould, S. H. (1995). *Variational Methods for Eigenvalue Problems: An Introduction to the Methods of Rayleigh, Ritz, Weinstein, and Aronszajn*. Dover, 179 pp., ISBN 0-486-68712-0 (P), $7.95. [MR 96f:49046]

Householder, Alston Scott (1975). *The Theory of Matrices in Numerical Analysis*. Dover, xi + 257 pp., ISBN 0-486-61781-5 (P), $9.95. [MR 51:14539. OV: 1964, Blaisdell, MR 30:5475]

Marcus, Marvin & Minc, Henryk (1988). *Introduction to Linear Algebra*. Reprint Edition. Dover, x + 261 pp., ISBN 0-486-65695-0 (P), $8.95. [MR 90h:15002. OV: 1965, Macmillan, MR 32:5660]

Marcus, Marvin & Minc, Henryk (1992). *A Survey of Matrix Theory and Matrix Inequalities*. Second Reprint Edition. Dover, xii + 180 pp., ISBN 0-486-67102-X (P), $6.95. ["Unabridged, unaltered republication" of the First Reprint Edition (which incorporated minor typographical corrections): 1969, Prindle, Weber & Schmidt; OV: Allyn & Bacon, Boston, 1964, MR 29:112]

Mirsky, Leonid (1990). *An Introduction to Linear Algebra*. Second Corrected Reprint Edition. Dover, xi + 440 pp., ISBN 0-486-66434-1 (P), $12.95. [MR 91j:15001. "Republication of the 1972 printing of the corrected 1961 edition" of the OV: 1955, Oxford University Press, MR 17:573a; First Reprint Edition (unabridged & unaltered republication): 1982, Dover, MR 83f:15001]

Nef, Walter (1988). *Linear Algebra*. In English. Reprint Edition. Translated from the German by J. C. Ault. Dover, x + 305 pp., ISBN 0-486-65772-8 (P), $9.95. [MR 90g:15001. Original English translation: 1967, McGraw-Hill, MR 35:4235]

Neuts, Marcel F. (1995). *Matrix-Geometric Solutions in Stochastic Models: An Algorithmic Approach*. Dover, xiv + 332 pp., ISBN 0-486-68342-7 (P), $9.95. [MR 95k:60241; OV: 1981, Johns Hopkins, MR 82j:60177]

Perlis, Sam (1991). *Theory of Matrices*. Dover, New York, xiv + 237 pp., ISBN 0-486-66810-X (P). [OV: 1952, Addison-Wesley, MR 14:6]

Pettofrezzo, Anthony J. (1978). *Matrices and Transformations*. Dover, New York, 143 pp., ISBN 0-486-63634-8 (P), $6.95. [OV: 1966, Prentice-Hall, x + 133 pp]

Sagan, Hans (1989). *Boundary and Eigenvalue Problems in Mathematical Physics*. Dover, xviii + 381 pp., ISBN 0-486-66132-6 (P), $9.95.

Schneider, Hans & Barker, George Phillip (1989). *Matrices and Linear Algebra*. Revised Reprint [Third] Edition. Dover, xiv + 413 pp., ISBN 0-486-66014-1 (P). [MR 90g:15002. "Unabridged, slightly corrected republication of the 1973 second edition, xi + 413 pp., MR 50:2191; OV: 1968, xi + 385 pp., both pub. Holt, Rinehart & Winston]

Shilov, George E. (1977). *Linear Algebra*. Dover, 387 pp., ISBN 0-486-63518-X (P), $11.95.

Wilkinson, James H. (1994). *Rounding Errors in Algebraic Processes*. Dover, 161 pp., ISBN 0-486-67999-3 (P), $6.95. [OV: 1963, Prentice Hall, MR 28:4661]

Reports on Linear Algebra Events Attended

Western Canada Linear Algebra Meeting
Kananaskis Village, Alberta, Canada: June 10–11, 1996

Report by Douglas R. Farenick and Stephen J. Kirkland

The Western Canada Linear Algebra Meeting (W-CLAM) provides an opportunity for mathematicians in Western Canada working in linear algebra and related fields to meet, present accounts of their recent research, and to have informal discussions. Although this meeting has a regional base, W-CLAM also attracts researchers from outside the area who come to the meetings and develop contacts. The first two of these meetings were held in Regina in 1993 and Lethbridge in 1995. The third meeting was held this past June in Kananaskis Village, Alberta, and attracted about 25 participants from the region and other parts of Canada, and also from the United States and Austria. Lectures at this meeting were presented by J. Bondar, S. Fallat, D. R. Farenick, G. C. Hua, S. Kirkland, I. Krupnik, M. Krupnik, P. Lancaster, B. Li, J. J. McDonald, M. Neumann, D. D. Olesky, L. Rodman, Pauline van den Driessche, and P. Zizler. The presentations at the meeting involved research in linear algebra, matrix theory, operator theory, combinatorics, mathematical chemistry, numerical analysis, and matrix polynomials. The next meeting of W-CLAM is tentatively planned for 1998 in Victoria, British Columbia.

From left to right: Bishan Li, Michael Neumann, Judi McDonald, Peter Zizler, Steve Kirkland, Shaun Fallat, Pauline van den Driessche, Leiba Rodman, Leroy Beasley, Hadi Kharagani, Paul Binding, Michael Tsatsomeros, Peter Lancaster, Dale Olesky, James Bondar, Doug Farenick, Barry Monson, Ahmed Sourour, Mark Krupnik, and Guo Chun Hua.

3rd Workshop on Numerical Ranges and Numerical Radii Sapporo, Japan: August 6–9, 1996

Report by Kazuyoshi Okubo

The Third Workshop on Numerical Ranges and Numerical Radii was held in the Sapporo Guest House, Sapporo, Japan, on August 6–9, 1996. This Workshop was organized by T. Ando and K. Okubo and was jointly sponsored by Hokkaido University of Education, Sapporo International Communication Plaza and WONRA Foundation. The aim of this Workshop was to bring together researchers on numerical ranges and numerical radii from different areas to exchange ideas on the subject. The First Workshop in this series was held at The College of William and Mary, Williamsburg, Virginia, in August 1992 and the Second at the University of Coimbra, Coimbra, Portugal, in August 1994. The Fourth Workshop will take place at the University of Wisconsin–Madison on June 1–2, 1998.

In this Third Workshop 23 talks (9 at 45 minutes, 10 at 30 minutes and 4 at 20 minutes) were given by C. K. Li (College of William and Mary), M.-D. Choi (University of Toronto), S.-G. Lee (Sung Kyun Kwan University), P. Y. Wu (National Chiao Tung University), J. da Providencia (University of Coimbra), M. Uchiyama (Fukuoka University of Education), M. Takaguchi (Hirosaki University), I. Valusescu (Romanian Academy), C. R. Johnson (College of William and Mary), T.-G. Lei (Beijing Normal University), B.-S. Tam (Tamkang University), M. Cho (Kanagawa University), T. Yamamoto (Hokkai-Gakuen University), N.-K. Tsing (University of Hong Kong), H. Nakazato (Hirosaki University), B. Cain (Iowa State University), M.-T. Chien (Soochow University), N. Bebiano (University of Coimbra), M. Fujii (Osaka Kyoiku University), F. Hansen (University of Copenhagen), I. Suciu (Romanian Academy), T. Ando (Hokusei Gakuen University) and K. Okubo (Hokkaido University of Education).

2nd China Matrix Theory and Its Applications Conference Jilin, China: August 12–16, 1996

Report by Bit-Shun Tam

The Second China Matrix Theory and Its Applications Conference was held at a summer resort near the famous Songhua River in Jilin, China, on August 12–16, 1996. (The First China Matrix Theory Conference was held at Huangshan in Anhui Province, China, in August 1994.) This Second China Matrix Theory Conference was organized by a national committee, and was jointly sponsored by the Mathematics Departments at Jilin Normal College and at the University of Science and Technology of China, under the support of the Chinese Mathematical Society. There were eighty-one participants coming from various parts of the country, including almost all the internationally known matrix theorists. Abraham Berman (Technion–Haifa) also attended the conference.

The program consisted of 16 forty-five minute talks, together with 25 twenty-minute contributed talks in two parallel sessions. The forty-five minute talks were presented by: Abraham Berman, Gong-Ning Chen, Chongguang Cao, Hua Dai, Liping Huang, Tian-Gang Lei, Jiongsheng Li, Wen Li, Zhongxiao Jia, Erxiong Jiang, Bit-Shun Tam, Wenting Tong, Boying Wang, Guorong Wang, Moucheng Zhang, and Zhong Xu. These talks covered various topics of matrix theory and its applications and were mainly focused on the following areas: numerical linear algebra, matrix analysis, combinatorial matrix theory, and matrices over rings or fields. An enjoyable visit to Songhua Lake was arranged in the afternoon of the third day of the conference.

As originally planned, the Chinese Linear Algebra Society (CLAS) was successfully established during the conference. The aim of this Society is to promote linear algebra activities in China and to establish connections with ILAS and also linear algebraists in other countries. By election the first President of CLAS is Erxiong Jiang of Fudan University (Shanghai). There are four Vice-Presidents: Jiongsheng Li (University of Science and Technology of China), Bit-Shun Tam (Tamkang University), Wenting Tong (Nanjing University), and Boying Wang (Beijing Normal University). The secretary is Mingxian Pang (Jilin Normal College). Zhexian Wan (Institute of Mathematics, Chinese Academy of Sciences) was invited to become the Honorary President of the society.

Some 142 papers (mostly in synopsis form) were submitted to the conference and were carefully reviewed by an academic committee. From these, 94 papers were selected and appeared in the Proceedings of the Second China Matrix Theory and Its Applications Conference, published by Jilin University Press. Participants of the Conference were glad to receive prior to the conference sixty free copies of the 1996 summer issue No. 17 of *Image*, in which there appear several articles on Linear Algebra in China.

6th ILAS Conference — Chemn

Germany: August 14–17, 1996

6th ILAS Conference—Chemnitz, Germany: August 14–17, 1996

Report by Volker Mehrmann

The Sixth Conference of the International Linear Algebra Society (ILAS) took place in Chemnitz (formerly Karl-Marx-Stadt), Germany, at the Technical University Chemnitz-Zwickau, August 14-17, 1996.

Altogether 189 participants from 32 countries enjoyed a stimulating conference that covered a wide range of topics. Special emphasis was laid on Numerical Linear Algebra and Computational Algebra. The conference featured 18 invited plenary lectures and 4 minisymposia with together 14 lectures. Furthermore, 101 contributed talks in 10 different topics were given and a panel discussion on "Aspects of Teaching Linear Algebra in the USA and Europe" was held.

Highlights of the meeting were the presentations of the Hans Schneider prize lecture by Michael Boyle, who shares the prize with David Handelman and Bob Thompson, the Olga Taussky-Todd lecture given by Robert Guralnick on "Traces and Generations of Matrix Algebras", and the illuminating plenary lectures which discussed several recent developments in various areas of linear algebra such as symbolic methods, eigenvalue problems, finite difference equations, combinatorial matrix theory, geometric optimization, matrix inequalities, perturbation theory, computer algebra, iterative methods, and linear algebra in control theory.

Four minisymposia and many interesting contributed talks completed the program. The plenary lectures, as well as many of the other talks, demonstrated that Linear Algebra is a very active area of research both in the basic theoretical and the applied direction.

The social program consisted of a reception (sponsored by Elsevier Science), an excursion to the Castle Augustusburg (which unfortunately suffered from heavy rain), and a farewell party and banquet at the historic Chemnitzer Hof. Bertram Huppert delivered a very interesting after-dinner talk covering topics from Linear Algebra notes on American toilet paper at the end of World War II to local Saxonian art, in particular sculptures in some of the churches in the Chemnitz region.

Selected Forthcoming Linear Algebra Events

ILAS Symposium on Fast Algorithms for Control, Signals and Image Processing & IIMS/CMS Session on Linear Algebra

Winnipeg, Manitoba, Canada: June 6–9, 1997

The ILAS Symposium on Fast Algorithms for Control, Signals and Image Processing will be held in Winnipeg, Manitoba, Canada, June 6–8, 1997, followed by the ILAS/IIMS Session on Linear Algebra for the Canadian Mathematical Society (CMS), June 9, 1997, organized by Institute of Industrial Mathematical Sciences (IIMS) at the University of Manitoba. Participating Institutions of IIMS are: Manitoba Hydro, Atomic Energy of Canada Ltd., Faneuil ISG Inc. and the Red River Community College. The objective of this meeting is to bring together people from the areas of Control Theory, Signal and Image Processing, and Computational Linear Algebra to discuss recent advances, trends, and future directions for research on fast algorithms. This will offer a unique opportunity for interaction among these groups and will provide a forum of interdisciplinary communication that should encourage researchers to develop a new sense of participation and a new perception of these areas as closely related scientific disciplines. The Symposium will feature a special emphasis on modern methods in scientific computing and linear algebra relevant to digital control, signal and image processing. For such applications it is important to consider ingredients such as (1) sophisticated mathematical models of the problems, including a priori knowledge, (2) rigorous mathematical theories to understand the difficulties of solving problems which are often ill-posed, and (3) fast algorithms for either real-time or data-massive computations. Aspects of each of these three ingredients will be discussed by speakers in the Symposium by way of short courses, invited and contributed lectures, and invited and contributed mini-symposia on relevant topics. On June 6 a set of tutorial short courses will be given.

The Summer Meeting of the Canadian Mathematical Society (CMS) is being held in Winnipeg on June 7–9, 1997, and hence overlaps with the ILAS Workshop on June 7–8. A CMS Session on Linear Algebra organized by ILAS/IIMS will be held on June 9, 1997. The Winnipeg Symposium and short courses are the first of their kind for ILAS. On June 6 there will be an ILAS Workshop which will be open to participants of CMS. The main speakers are Roger Horn and Paul Van Dooren. The Registration Fee is $150.00. An additional $60.00 will enable ILAS participants to attend the CMS Summer Meeting.

Sponsors: Institute of Mathematics and its Applications (IMA), The Fields Institute, Centre de Recherches Mathématiques (CRM), Manitoba HVDC Research Center.

Invited Speakers: Eleanor Chu (Guelph), M. Hanke (Germany), Simon Haykin (McMaster), Linda Kaufman (Bell Labs), Christopher Paige (McGill), Haesun Park (Minnesota), Ali Sayed (UCSB), G. W. Stewart (Maryland).

Short Courses: Stephen Boyd (Stanford), Raymond Chan (Chinese University of Hong Kong), Tom Kailath (Stanford), Byron Welsh (Air Force Institute of Technology).

Invited Mini-Symposia: N. Nichols (Reading), B. Datta (NIU), G. Heinig (Kuwait), J. Nagy (SMU), P. Van Dooren (Belgium), F. Luk (RPI).

Program Committee Co-Chairs: Dianne O'Leary (Maryland), Robert J. Plemmons (Wake Forest); *Members:* Moody Chu (NCSU), B. Datta (NIU), Brent Ellerbroek (Air Force Phillips Lab.), G. Heinig (Kuwait), Franklin Luk (RPI), Haesun Park (Minnesota), Ali Sayed (UCSB), P. N. Shivakumar (Manitoba), Paul Van Dooren (Université Catholique de Louvain, Belgium)

Organizing Committee Chair: P. N. Shivakumar, Director, IIMS (Manitoba); *Members:* Tom Kailath (Stanford), Peter Lancaster (Calgary), Dianne O'Leary (Maryland), Bob Plemmons (Wake Forest), Hans Schneider (Wisconsin).

Local Organizing Committee Chair: P. N. Shivakumar, IIMS, Members: S. Kocabiyik (Applied Mathematics), Q. Ye (Applied Mathematics)

Accommodation: Holiday Inn South, 1330 Pembina Highway, Winnipeg, Manitoba, Canada R3T 2B4; tel: (204) 452-4747 (call collect), FAX (204) 284-2751: $75.00 per night, single/double Please make your reservations directly with the hotel. For registered hotel guests to use the free Holiday Inn South shuttle from and to the Airport please contact the hotel in advance.

All inquiries regarding the meeting, including those on contributed papers, should be addressed to: P. N. Shivakumar, Director. Registration forms should be sent to: Mrs. S. Henderson, Conference Coordinator. Address for both is as follows: Institute of Industrial Mathematical Sciences, University of Manitoba, 420 Machray Hall, Winnipeg, Manitoba, Canada R3T 2N2; tel: (204) 474-6724, FAX (204) 275-0019, insmath@cc.umanitoba.ca; http://www.iims.umanitoba.ca.

ATLAST Linear Algebra Workshop

Madison, Wisconsin, USA: July 30– August 2, 1997

The ATLAST Linear Algebra Workshop will be held at the University of Wisconsin, Madison, Wisconsin, USA, July 30–August 2, 1997. The Workshop Presenter is Lila Roberts. ATLAST is an NSF Project to Augment the Teaching of Linear Algebra through the use of Software Tools. This is the sixth year of the ATLAST workshops. So far over 400 faculty nationwide have participated in 14 ATLAST workshops and approximately 50 of these faculty have also participated in one of two invited ATLAST Developers Workshops held during the summers of 1994 and 1996. A third Developers Workshop is planned for June 25-28 at the University of California, San Diego. Workshop participants learn about existing software for linear algebra and are trained in the use of the MATLAB software package. Attendees will design classroom lessons that incorporate computer software making use of ATLAST materials that were developed in previous workshops. These materials are included in *ATLAST Computer Exercises for Linear Algebra* by Steven Leon, Eugene Herman and Richard Faulkenberry [Prentice Hall, xxii + 219 pp., ISBN 0-13-270273-8 (P), $10.00, 1996]. A selection of the lesson plans that are developed will be included on the ATLAST Web page and some may also be included in the next edition of the ATLAST book. The first two days of the workshop will be devoted to learning to use MATLAB and learning how to incorporate software into linear algebra classes. There will also be discussions on general teaching issues and linear algebra curriculum. The last two days of the workshop will be spent working in teams to design lesson plans. The ATLAST Project provides room and board for participants attending the workshops. The ATLAST Project Director is Steven J. Leon and the Assistant Director is Richard Faulkenberry. Both are in the Mathematics Dept. of the University of Massachusetts–Dartmouth. The ATLAST project has been supported by two National Science Foundation Faculty Enhancement grants and an Education Seed Grant from the International Linear Algebra Society. Royalties from the ATLAST book are also used to support the project. All teachers of undergraduate linear algebra courses at colleges or universities in the USA are invited to apply for the workshop.

The workshop is limited to thirty participants and late applications will be accepted on a space available basis. More information about the ATLAST Project and an application form are available from the ATLAST web page: www.umassd.edu/SpecialPrograms/ATLAST or by contacting Steven J. Leon, ATLAST Project Director, Dept. of Mathematics, University of Massachusetts–Dartmouth, North Dartmouth, MA 02747-2300, USA; FAX (508) 910-6917, ATLAST@UMASSD.edu.

Sixth International Workshop on Matrix Methods for Statistics

Istanbul, Turkey: August 16–17, 1997

The Sixth International Workshop on Matrix Methods for Statistics will be held in The Marmara Hotel, Istanbul, Turkey, on Saturday, August 16 and Sunday, August 17, 1997, the weekend immediately preceding the 51st Session of the International Statistical Institute (ISI). For their support of this Workshop we are grateful to the Turkish Scientific and Technical Council (TUBITAK), the Turkish Statistical Society, and the International Linear Algebra Society (ILAS). The Scientific Programme Committee for this Workshop comprises R. William Farebrother (Victoria University of Manchester, England), Simo Puntanen (University of Tampere, Tampere, Finland), George P. H. Styan (McGill University, Montréal, Québec, Canada), and Hans Joachim Werner (University of Bonn, Bonn, Germany; chair). The Local Organizing Committee comprises Fikri Akdeniz (Cukurova University, Adana, Turkey; chair), Ömer L. Gebizlioğlu (University of Ankara, Ankara, Turkey), and Cemil Yapar (Karadeniz Technical University, Trabzon, Turkey). This Workshop is the sixth in a series. The previous five Workshops were held as follows: (1) Tampere, Finland: August 1990, (2) Auckland, New Zealand: December 1992, (3) Tartu, Estonia: May 1994, (4) Montréal, Québec, Canada: July 1995, and (5) Shrewsbury, England: July 1996.

The purpose of this Sixth Workshop is to stimulate research and, in an informal setting, to foster the interaction of researchers in the interface between matrix theory and statistics. This Workshop will provide a forum through which statisticians working in the areas of linear algebra and matrix theory may be better informed of the latest developments and newest techniques and may exchange ideas with researchers from a wide variety of countries. Selected fully-refereed papers from this Workshop will be published in a Special Issue on Linear Algebra and Statistics of *Linear Algebra and Its Applications*.

The Workshop will include invited and contributed talks. The number of talks may be restricted by limitations of time. These talks and the informal workshop atmosphere will guarantee an intensive exchange of ideas. The official language of the Workshop is English. The Marmara Hotel Istanbul is one of the best venues for incentive and congress gatherings with its extensive meeting, business and conference facilities and is situated right in the centre of Istanbul. The Marmara provides all the services expected from a leading five-star international hotel. The roof-top Panorama Restaurant serves high-quality food and offers breath-taking views, while the Lobby Bar is a pleasant place for afternoon tea and evening drinks. The Marmara has 390 well decorated rooms and 32 suites. The hotel also runs the Esma Sultan Yali, a marvelous banqueting venue by the edge of the Bosphorus.

Istanbul, the only city in the world built on two continents, encompasses a range of people who fully embody the diversity of cultures as well as the friendliness and hospitality found throughout the land. With the transfer of the Roman capital from Rome to Byzantium, Istanbul entered world history. From then on it has enjoyed great fame as the capital, first of the Byzantine Empire and then of the Ottoman Empire. The precious relics of the three Empires is reflected in its museums, ancient churches, and mosques. Istanbul is the only centre in the world to unite spiritual universality and the beauties of nature and art as manifested in the holy relics of Islam. Mighty mosques, churches of highest artistic value, the old temple remains, magnificent luxury palaces, patriarchates and synagogues make Istanbul a centre of universal religion. Both as a magnificent historical center and as a fascinating and lively modern city, Istanbul is also a unique link between the exotic Orient and modern Occident. The colourful Grand Bazaar with 4000 shops is bewitching with its wide selection of goods, from simple handicrafts to the most sophisticated jewelry. Come and join us in this fascinating centre of culture and see for yourself how very enjoyable it is to be in Istanbul. "Hos geldiniz!", that is "Welcome to Turkey."

You are also invited to visit our website http://eos.ect.uni-bonn.de/werner.html, where all available information about this Workshop will be updated frequently. To receive or to send an attractive postcard from Turkey visit http://www.turkey.org/postcard/postcards.html. Requests for more information concerning the scientific program, as well as any organizational questions, should be directed to: Hans Joachim Werner (Chair of the Workshop Programme Committee), Institute for Econometrics and Operations Research, Econometrics Unit, University of Bonn, Adenauerallee 24-42, D-53113 Bonn, Germany; or470@unitas.or.uni-bonn.de; FAX +49 228 739189 or Fikri Akdeniz (Chair of the Local Organizing Committee) Dept. of Mathematics, Çukurova University, 01330 Adana, Turkey; akdeniz@pamuk.cc.cu.edu.tr, FAX +90 322 3386070.

4th Kalamazoo Symposium on Matrix Analysis and Applications

Kalamazoo, Michigan, USA: October 24–25, 1997

The Fourth Kalamazoo Symposium on Matrix Analysis and Applications will be held at Western Michigan University, Kalamazoo, Michigan, USA, October 24–25, 1997. Principal Speakers: G. W. Stewart, University of Maryland; N. J. Higham, University of Manchester; Charles R. Johnson, The College of William & Mary; Charles F. Van Loan, Cornell University; Henry Wolkowicz, University of Waterloo. We invite the participation of both specialists and non-specialists interested in matrix analysis and its applications to other fields. Abstracts for 20-minute contributed talks should arrive by 15 August 1997. E-mail submission (TeX, LaTeX or PostScript) is welcome. Graduate students are encouraged to submit abstracts for consideration. Preceding the symposium, at 4pm on Thursday, 23 October 1997, will be a University Visiting Scholar lecture by G. W. Stewart (University of Maryland). A banquet is planned for the Friday evening, October 24, 1997. *Organizing Committee:* Nil Mackey, John Petro and Tom Richardson (Western Michigan University). To submit abstracts or for further information contact: Niloufer Mackey, Dept. of Mathematics & Statistics, Western Michigan University, Kalamazoo, MI 49008-5152; nil. mackey@wmich.edu; tel: 616-387-4594, FAX 616-387-4530.

4th Workshop on Numerical Ranges and Numerical Radii

Madison, Wisconsin, USA: June 1–2, 1998

The Fourth Workshop on Numerical Ranges and Numerical Radii will be held in the Dept. of Mathematics, University of Wisconsin–Madison, June 1 (Monday)–June 2 (Tuesday), 1998, in conjunction with the Seventh ILAS meeting (June 3-6, 1998). The aim of the workshop is to bring researchers on numerical ranges and numerical radii from different (research and geographic) areas together to exchange ideas on the subject. In particular, we would like to: (a) Study and explore applications of the results on various kinds of generalized numerical ranges and numerical radii in different branches of science. (b) Discuss existing mathematical tools and techniques and try to generate new methods to handle problems on numerical ranges and numerical radii. (c) Develop possible research projects or computer projects on numerical ranges and numerical radii appropriate for the undergraduate or graduate level. (d) Exchange research problems, ideas and experience on the subject. The organizer will try to apply financial support for the participants. Updated information of the workshop will be posted on: http://www.math.wm.edu/~ckli/wonra.html. If you plan to attend the workshop or if you want to receive more information by e-mail, please contact Chi-Kwong Li, Dept. of Mathematics, The College of William and Mary, Williamsburg, VA 23187, USA; ckli@math.wm.edu, tel. (757) 221-2042, FAX (757) 221-2988.

2nd International Conference on Matrix-Analytic Methods in Stochastic Models

Winnipeg, Manitoba, Canada: July 24–25, 1998

The Second International Conference on Matrix-Analytic Methods in Stochastic Models will be held in Winnipeg, Manitoba, Canada, July 24–25, 1998. Sponsorship has been requested from TR Labs, BNR, U of M, GM, Ford, GMI, and NSF. This Conference will provide an international forum for the presentation of recent results on Matrix-Analytic Methods in Stochastic Models and the related algorithmic analysis and implementation with special emphasis on applications in communications engineering, production and manufacturing engineering. Specifically, the topics of interest include but are not limited to: Matrix-Analytic Methods in queueing models, telecommunications, modelling reliability problems, risk analysis, production and inventory models. There will be several tutorials conducted by leading researchers covering several topics ranging from phase type distributions to current trends in matrix-analytic methods including fitting distributions. Prospective authors are invited to submit FIRST extended abstracts (between 3 and 5 pages in length) to: Dr. A. S. Alfa, Dept. of Mechanical and Industrial Engineering, University of Manitoba, Winnipeg, Manitoba, Canada R3T 5V6; tel: (204) 474-9803, FAX (204) 275-7507, alfa@cc.umanitoba.ca. Based on these extended abstracts, full papers will be solicited from the authors. Manuscripts will be refereed and only papers of high quality will be accepted for presentation at the conference and for inclusion in the *Proceedings*, which will be published.

Deadline for Paper Submission: August 15, 1997. *Notification of Acceptance:* January 15, 1998. *Camera Ready Paper Due:* April 15, 1998. *Conference Chairmen:* A. S. Alfa, S. Chakravarthy, alfa@cc.umanitoba.ca, schakrav@nova.gmi.edu; tel: (204) 474-9803, (313) 762-7906; FAX (204) 275-7507, (810) 762-9796. *Conference Secretary:* Bev Dunlop, tel: (204) 474-6630, FAX (204) 275-7507, bdunlop@bldgeng.lan1.umanitoba.ca. *Scientific Advisory Committee:* A. S. Alfa, B. Meini, S. Asmussen, R. Nadarajan, S. Chakravarthy, V. Naoumov, J. E. Diamond, M. F. Neuts, S. Hantler, V. Ramaswami, M. Johnson, B. M. Rao, U. Krieger, H. Schellhaas, V. G. Kulkarni, B. Sengupta, G. Latouche, D. H. Shi, D. Liu, P. G. Taylor, D. M. Lucantoni, K. S. Trivedi, F. Machihara, and Y. Q. Zhao.

International Calendar of Events in Linear Algebra & Related Topics

For more information visit the ILAS Information Center (IIC) Database, http://math.technion.ac.il/iic, and the Netlib Conferences Database: http://www.netlib.org/confdb/Conferences.html. For more information please contact the address(es) in square brackets.

1997

June 6–8: Winnipeg, Manitoba. International Linear Algebra Society (ILAS) Symposium: Fast Algorithms for Control, Signals and Image Processing. [P. N. Shivakumar, Institute of Industrial Mathematical Sciences, University of Manitoba, 420 Machray Hall, Winnipeg, Manitoba, Canada R3T 2N2; insmath@cc.umanitoba.ca; http://www.iims.umanitoba.ca/june678program.html]

June 9: Winnipeg, Manitoba. Canadian Mathematical Society Special Session on Linear Algebra. Speakers include Q. Ye, R. Horn, P. Van Dooren, J. McDonald, B. Shader & S. Kirkland. [P. N. Shivakumar, Institute of Industrial Mathematical Sciences, University of Manitoba, 420 Machray Hall, Winnipeg, Manitoba, Canada R3T 2N2; http://camel.math.ca, insmath@cc.umanitoba.ca]

June 24–27: Dundee, Scotland. 17th Biennial Conference on Numerical Analysis. University of Dundee. Special Invited Lecture in Honour of A. R. Mitchell to be given by Gil Strang. [http://www.mcs.dundee.ac.uk:8080/~naconf/]

June 24–30: St. Petersburg, Russia. International Algebraic Conference dedicated to the 90th birthday of Dmitri Konstantinovich Faddeev (1907–1989). Special session dedicated to the memory of Vera Nikolaevna Faddeeva (1906–1983). [A. V. Yakovlev, Chairman of Coordination Committee Doctor of Physics and Mathematics, St Petersburg Branch of the Steklov Mathematical Institute (POMI), Fontanka 27, 191011 St Petersburg; lurje@pdmi.ras.ru]

July 14–18: Stanford, California. SIAM: 45th Anniversary and Annual Meeting. Stanford University. Organized by Gene H. Golub & William M. Coughran. [SIAM, 3600 University City Science Center, Philadelphia, PA 19104-2688; meetings@siam.org, http://www.siam.org/meetings]

July 30–August 2: Madison, Wisconsin. ATLAST Linear Algebra Workshop. [Steven J. Leon, ATLAST Project Director, Dept. of Mathematics, Univ. of Massachusetts–Dartmouth, North Dartmouth, MA 02747-2300; http://www.umassd.edu/ATLAST/welcome.html, ATLAST@UMASSD.edu]

August 16–17: Istanbul, Turkey. Sixth International Workshop on Matrix Methods for Statistics. Marmara Hotel Istanbul. [Hans Joachim Werner (Chair of the Workshop Programme Committee), Institute for Econometrics and Operations Research, Econometrics Unit, Universität Bonn, Adenauerallee 24-42, D-53113 Bonn, Germany; or470@unitas.or.uni-bonn.de; http://eos.ect.uni-bonn.de/werner.html]

August 18–26: Istanbul, Turkey. 51st Biennial Session of the International Statistical Institute (ISI). Lütfi Kırdar Istanbul International Congress Center. [National Organizing Committee, State Institute of Statistics, Necatibey Cad. No. 114, 06100 Ankara; isi97@die.gov.tr, http://www.die.gov.tr/ISI/isi-i.html]

August 20–23: Odessa, Ukraine. Mark Krein International Conference on Operator Theory and Applications. [Vadim Adamyan, Institute of Mathematics, University of Odessa, ul. Petra Velikogo 2, 270100 Odessa, Ukraine; FAX (380) 482-238200, krein@imem.odessa.ua] *See Image 17:19.*

September 24–26: Kaiserslautern, Germany. Operators, Systems and Linear Algebra: Three Decades of Algebraic Systems Theory—In Honour of Professor Paul Fuhrmann on the Occasion of his 60th Birthday. [Eva Zerz, Dept. of Mathematics, University of Kaiserslautern, D-67663 Kaiserslautern; zerz@mathematik.uni-kl.de]

October 6–8: San Jose, California. MATLAB Conference. Opportunity to learn new features and capabilities of MATLAB 5, Simulink 2, and toolboxes. [Karen Tuttle, Conference Manager: http://www.mathworks.com/conf]

October 23–25: Kalamazoo, Michigan. University Visiting Scholar lecture by G. W. Stewart & 4th Kalamazoo Symposium on Matrix Analysis and Applications. [Niloufer Mackey, Dept. of Mathematics & Statistics, Western Michigan University, Kalamazoo, MI 49008-5152; nil.mackey@wmich.edu]

October 29–November 1: Snowbird, Utah. Sixth SIAM Conference on Applied Linear Algebra. Snowbird Ski and Summer Resort. [SIAM, 3600 University City Science Center, Philadelphia, PA 19104-2688; meetings@siam.org, http://www.siam.org/meetings/la97/la97home.htm]

1998

January 5–9: Haifa, Israel. Tenth Haifa Matrix Theory Conference. Dept. of Mathematics & Institute for Advanced Studies in Mathematics, Technion. Organizing Committee: Avi Berman, Moshe Goldberg, Danny Hershkowitz (Chair), Leonid Lerer, Raphael Loewy, and Abraham Zaks. [Dept. of Mathematics Technion–Israel Institute of Technology, Haifa 32000; hershkow@tx.technion.ac.il, http://math.technion.ac.il/iic]

January 10–13: Baltimore, Maryland. Joint Mathematics Meetings: American Mathematical Society (AMS) & Mathematical Association of America. [H Daly, AMS, PO Box 6887, Providence, RI 02904-6887; meet@math.ams.org]

June 1–2: Madison, Wisconsin. Fourth Workshop on Numerical Ranges and Numerical Radii. Dept. of Mathematics, University of Wisconsin. [Chi-Kwong Li, Dept. of Mathematics, The College of William and Mary, Williamsburg, VA 23187; http://www.math.wm.edu/~ckli/wonra.html]

June 3–6: Madison, Wisconsin. International Linear Algebra Society (ILAS) Conference. [R A Brualdi, Dept. of Mathematics, Univ. of Wisconsin, Van Vleck Hall, 480 Lincoln Drive, Madison, WI 53706-1388; brualdi@math.wisconsin.edu]

July 24–25: Winnipeg, Manitoba. Second International Conference on Matrix-Analytic Methods in Stochastic Models. [A. S. Alfa, Dept. of Mechanical and Industrial Engineering, University of Manitoba, Winnipeg, Manitoba R3T 5V6; alfa@cc.umanitoba.ca]

August 18–27: Berlin, Germany. International Congress of Mathematicians 1998 (ICM'98).

1999

July 19–22: Barcelona, Spain. International Linear Algebra Society (ILAS) Conference. Organizing Committee: M. Isabel Garcia-Planas (Co-chair), Thomas J. Laffey (Co-chair), Paul Van Dooren, Nicholas Higham, Roger Horn, M. Dolors Magret, Josep Ferrer, Fernando Puerta, Rafael Bru & Ion Zaballa. [Richard A. Brualdi, Dept. of Mathematics, Univ. of Wisconsin, Van Vleck Hall, 480 Lincoln Drive, Madison, WI 53706-1388; brualdi@math.wisconsin.edu]

August 7–8: Tampere, Finland. International Workshop on Matrix Methods for Statistics. [Simo Puntanen, Dept. of Mathematical Sciences, University of Tampere, P.O. Box 607, FIN-33101 Tampere, Finland; sjp@uta.fi]

August 10–18: Helsinki, Finland. 52nd Biennial Session of the International Statistical Institute (ISI). [Simo Puntanen, Dept. of Mathematical Sciences, University of Tampere, P.O. Box 607, FIN-33101 Tampere, Finland; sjp@uta.fi, http://www.sta.fi/isi99 after *c.* mid-June 1997.]

2002

Dates TBA: **Auburn, Alabama.** International Linear Algebra Society Conference: Challenges. [Frank Uhlig, Dept. of Mathematics, Auburn University, Alabama, AL 36849-5310; uhligfd@mail.auburn.edu] *See Image 16:28.*

Why do I want to be a linear algebraist?

CHI-KWONG LI has asked the editors of *Image*, following an idea of Paul Halmos, to solicit answers to the question: "Why do I want to be a linear algebraist?" Sample answers are: (1) I like the linear algebra community, (2) Doing linear algebra makes me rich, (3) I like the subject because: (a) it has applications in XXX, (b) there are many interesting theoretical questions such as YYY, (c) the problems are easy to understand and formulated, (d) different techniques can be used, etc. The editors of *Image* will do a statistical analysis of the answers received, and will report the result(s) in the next issue(s) of *Image*. In particular, we would like to see what is (are) the most popular and most peculiar answer(s). Please send all solutions by e-mail to George Styan at styan@math.mcgill.ca.

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Linear Algebra

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Image Problem Corner

We present solutions to 4 problems appearing in our previous two Problem Corners: Problems 16-3, 17-1, 17-2 and 17-3 [*Image*, no. 16 (Winter 1996), p. 32, and no. 17 (Summer 1996), p. 32] and 6 new problems. We invite readers to submit solutions, as well as new problems, for publication in *Image*. Please send all material to George Styan in LaTeX and by e-mail to styan@math.mcgill.ca.

Problem 16-3: Algebraic Characterization of the Least Squares Estimator [*Image*, no. 16 (Winter 1996), p. 32]
Proposed by R. WILLIAM FAREBROTHER, *Victoria University of Manchester, Manchester, England.*

Let $\mathbf{X}$ be an arbitrary $n \times p$ real matrix and let $\mathbf{y}$ be an arbitrary $n \times 1$ matrix. Let f be a p-element function of these matrices satisfying the linearity conditions

$$\begin{aligned} f(\mathbf{X}, s\mathbf{y}) &= sf(\mathbf{X},\mathbf{y}) \quad \text{for all scalars } s \\ f(\mathbf{X},\mathbf{y}+\mathbf{X}\mathbf{b}) &= f(\mathbf{X},\mathbf{y})+\mathbf{b} \quad \text{for all } p \times 1 \text{ matrices } \mathbf{b}. \end{aligned}$$

Suggest additional conditions which identify this function as the least squares function

$$f(\mathbf{X},\mathbf{y}) = (\mathbf{X}'\mathbf{X})^{-1}\mathbf{X}'\mathbf{y}$$

when $\mathbf{X}$ has full column rank.

Solution 16-3.1 by HANS JOACHIM WERNER, *Universität Bonn, Bonn, Germany.*

Under the given conditions it is easy to see that for all $(\mathbf{X},\mathbf{y})$ we have $f(\mathbf{X},\mathbf{y}-\mathbf{X}f(\mathbf{X},\mathbf{y})) = \mathbf{0}$. Therefore, in order to guarantee that $f(\mathbf{X},\mathbf{y})$ be the least-squares function when $\mathbf{X}$ has full column rank, it is necessary and sufficient to add the condition that

$$\mathbf{X}'\mathbf{z} = \mathbf{0} \quad \text{whenever} \quad f(\mathbf{X},\mathbf{z}) = \mathbf{0}. \qquad \square$$

Other solutions were also received from JÜRGEN GROß & SVEN-OLIVER TROSCHKE *(Universität Dortmund) and from the proposer.*

Problem 17-1: On the sum of the largest two entries in a matrix [*Image*, no. 17 (Summer 1996), p. 32]
Proposed by R. B. BAPAT, *Indian Statistical Institute–Delhi Centre, New Delhi, India.*

Let A be an $n \times n$ real matrix with $n \geq 2$. Suppose that the sum of the largest two entries in any row of A is α and that the sum of the largest two entries in any column of A is β. Show that $\alpha = \beta$.

As observed by SHAYLE R. SEARLE *(Cornell University), "any row" and "any column" should here be interpreted, respectively, as "every row" and "every column".*

Solution 17-1.1 by AGATA SMOKTUNOWICZ, *University of Warsaw, Warsaw, Poland.*

Let us select from each row of A its largest entry and then order them: $\alpha_1 \geq \alpha_2 \geq \cdots \geq \alpha_n$. Observe that $\alpha_i \geq \alpha/2$ for $i = 1, \ldots, n$. Note that α_n , $\alpha - \alpha_n$ are in the same row and that the sum of any two elements of the set $\{\alpha_1, \alpha_2, \ldots, \alpha_n, \alpha-\alpha_n\}$ is greater than or equal to α. Because two of them are in the same column, we must have that $\beta \geq \alpha$. The same proof remains valid for the transpose A^T. Thus $\alpha \geq \beta$ and hence, $\alpha = \beta$. $\square$

Solution 17-1.2 by S. W. DRURY, *McGill University, Montréal, Québec, Canada.*

Consider the pattern made up from the largest two entries in each row of A. Then, using elementary combinatorics, since this pattern contains $2n$ elements it necessarily contains a cycle C say of $2k$ elements. Let s be the sum of the elements of A in C. Then $s = k\alpha$, by splitting C horizontally. On the other hand, splitting C vertically yields $s \leq k\beta$. Hence $\alpha \leq \beta$. An exactly similar argument establishes the reverse inequality.

By a cycle, we mean a cyclical arrangement of distinct elements obtained by moving alternately along rows and columns in the matrix and with the additional property that there are at most 2 elements of the cycle in each row and column. For the combinatorial assertion, we show that a $p \times q$ pattern S with $p+q$ elements must necessarily contain a cycle by induction on $p+q$.

The cases $p = 1$ and $q = 1$ start the induction easily — for instance, there cannot be $p+1$ elements in a $p \times 1$ matrix. Now if S has at least 2 elements in each row and column, then it contains a cycle. To prove this simply pick an element of S and proceed alternately along rows and columns, always, at each step, revisiting if possible a previously selected element and thus completing a cycle. Since we are dealing with finite matrices, this procedure must eventually terminate and yield a cycle.

Now for the induction step. If there is a row or column with 0 elements of S we can reduce p or q by 1. If there is a row or column with exactly 1 element of S, we can delete this row or column and the unique element that it contains. Again this reduces the size of the problem by 1. □

Solution 17-1.3 by HANS JOACHIM WERNER, *Universität Bonn, Bonn, Germany.*

For convenience, let R and C, respectively, denote the assumed row and column property of A. Without loss of generality, we may assume that $\alpha \leq \beta$. It suffices to show that $\alpha < \beta$ cannot occur. To prove this, suppose for the moment that $\alpha < \beta$. Property C clearly tells us that each column of A contains at least one entry greater than or equal to $\beta/2$. Since $\alpha < \beta$, it then follows from property R that in each row and in each column there is exactly one entry greater than $\beta/2$ while all other entries are less than $\alpha - \beta/2$. Now observe that R and C are preserved under row and column permutations. Without loss of generality we may assume, therefore, that all of the n entries greater than $\beta/2$ are found in increasing order along the main diagonal of the matrix $A = (a_{ij})$. In view of property C, clearly $a_{j1} = \beta - a_{11}$ for some $j > 1$. But then $a_{j1} + a_{jj} = \beta - a_{11} + a_{jj} \geq \beta > \alpha$. Since this is is contradictory to property R, our proof is complete. □

Solution 17-1.4 by OLEG PIKHURKO, *Trinity College, Cambridge, England,* and JORMA KAARLO MERIKOSKI, *University of Tampere, Tampere, Finland.*

Denote by $R_i(A)$ and $C_i(A)$ the sum of the largest two entries in the ith row and in the ith column of A, respectively. We generalize the result as follows:

PROPOSITION. Let A be an $n \times n$ real matrix with $n \geq 2$. Then

$$R_i(A) > C_j(A) \qquad \text{for all } i, j = 1, \ldots, n \tag{1}$$

is false.

Proof. By induction. The case $n = 2$ is trivial. Let M denote the maximal element of A. Obviously, the property (1), call it $Q(A)$, is not affected if we permute some rows and/or columns. So we can assume $a_{nn} = M$ and that the nth row and column of A are ordered non-decreasingly. Denote by B the matrix obtained from A by deleting its last row and column. Our proof will be complete if we show that $Q(A)$ implies $Q(B)$. Obviously, $C_i(B) \leq C_i(A)$ for all $i = 1, \ldots, n-1$. The similar inequality is true for rows, but we can do more. We claim that for $1 \leq i \leq n-1$ we have $R_i(B) = R_i(A)$. Consider the ith row of B and suppose that $a_{ik} \leq a_{il}$ are two largest entries of it. Suppose on the contrary that $R_i(B) < R_i(A)$. Then $a_{in} > a_{ik}$ and $a_{in} + a_{il} = R_i(A) > C_n(A) = a_{n-1,n} + a_{nn}$. This is a contradiction, since $a_{in} \leq a_{n-1,n}$ and $a_{il} \leq M = a_{nn}$. Finally,

$$R_i(B) = R_i(A) > C_j(A) \geq C_j(B) \qquad \text{for all } i, j = 1, \ldots, n-1,$$

and so $Q(B)$ holds. The Proposition is proved.

Now applying the Proposition to A and A^T yields $\alpha \leq \beta$ and $\beta \leq \alpha$, respectively. Therefore $\alpha = \beta$. □

COMMENT. The counter-example

$$A = \begin{pmatrix} 3 & 0 & 2 & 2 \\ 3 & 0 & 2 & 2 \\ 0 & 3 & 2 & 2 \\ 0 & 3 & 2 & 2 \end{pmatrix}$$

shows that the corresponding result is not valid for sums of the largest three entries.

Solution 17-1.5 by ALEXANDER KOVAČEC, *Universidade de Coimbra, Coimbra, Portugal.*

Visit the entries of A successively on a largest-entries-first basis. Let $\ell \geq \ell'$ be the values of the entries seen respectively in visits number n and $n+1$. Of course there exists a row *not* visited during visits $1, 2, \ldots, n-1$, so the sum of its two largest entries is $\leq \ell + \ell'$, and there exists also a row twice visited during visits $1, 2, \ldots, n+1$, so the sum of its two largest entries is $\geq \ell + \ell'$. So the hypothesis concerning these sums implies $\alpha = \ell + \ell'$. Reasoning similarly for columns, one gets $\beta = \ell + \ell'$, and thus the proof. □

SUPPLEMENT. *If $\ell > \ell'$ then there exists a permutation matrix whose support coincides with the set of addresses of the entries $\geq \ell$.*

Proof. Not visiting some row i during visits $1, 2, \ldots, n$ is equivalent to visiting some other row j twice during the same period. But in such a case row j would have sum of the two largest rows $\geq 2\ell$ while row i would have this sum $\leq 2\ell'$, a contradiction; similarly for the columns. So each line of the matrix is visited exactly once during the n first visits and the claim follows. □

COMMENT. The theorem cannot be extended by replacing in it the words 'two largest' with 'three largest', for example. The sums of the three largest entries in each row of the 5×5 matrix on the left below is 22, the sums of the three largest entries in each column is 24 (blanks are zeros). The supplement if formulated with $\ell = \ell'$ instead, is also not true. The matrix on the right satisfies the hypothesis of the theorem with $\alpha = \beta = 2$, but $\ell = \ell' = 1$ and indeed there does not exist even a permutation with support within the support of the matrix.

$$\begin{bmatrix} 4 & & 6 & & 12 \\ & 10 & & 12 & \\ 10 & & 8 & & 4 \\ 7 & 7 & 8 & 6 & 6 \\ 7 & 7 & 8 & 6 & 6 \end{bmatrix} \text{ and } \begin{bmatrix} 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 & 1 \\ 1 & 1 & & & \\ 1 & 1 & & & \\ 1 & 1 & & & \end{bmatrix}.$$

The theorem, and in fact its proof, generalizes to the following purely combinatorial statement (and thus extends also in various forms to diagonals, to multidimensional matrices etc.).

THEOREM. *Let $\Omega = A_1 \uplus \cdots \uplus A_n$ be a partition of a finite multiset of reals. Assume the sum of the two largest elements of each A_i is equal to α. Then α equals the sum of (the values of) the n-th and $n+1$-th largest element of Ω.*

We note that a multiset is by definition a function assigning to each element its multiplicity; partition means above that the function Ω is the sum of the functions A_i. A proof not making use of the informal concept of visits or a similar concept is possible but seems to lead to quite heavy notation and/or lengthy explanations. Critical readers would note that without such explanations crucial ambiguities can occur in the way one would use the words 'decreasingly arranged sequence ...' or so; these are by the way similar to the type of confusion arising by saying 'the two largest elements' etc. when the multiplicities of their values are not all 1.

Other solutions were also received from ABRAHAM BERMAN *(Technion)*, LUDWIG ELSNER *(Universität Bielefeld)*, CHI-KWONG LI *(College of William and Mary)* & FUZHEN ZHANG *(Nova Southeastern University)*, HENRY WOLKOWICZ *(University of Waterloo), and from the proposer.*

Problem 17-2: On a characterization associated with the matrix arithmetic and geometric means [*Image*, no. 17, p. 32]
Proposed by JÜRGEN GROß, GÖTZ TRENKLER & SVEN-OLIVER TROSCHKE, *Universität Dortmund, Dortmund, Germany.*

Find the well-known class of complex square matrices characterized by

$$\tfrac{1}{2}(A + A^*) = (AA^*)^{1/2}, \qquad (2)$$

where A^* denotes the conjugate transpose of A and $(AA^*)^{1/2}$ the unique Hermitian non-negative definite square root of AA^*.

Solution 17-2.1 by AGATA SMOKTUNOWICZ, *University of Warsaw, Warsaw, Poland.*

We prove that $\frac{1}{2}(A + A^*) = (AA^*)^{\frac{1}{2}}$ if and only if A is Hermitian and non-negative definite. Observe that $(A + A^*)^2 = 4AA^*$, so that $\|A - A^*\|_F^2 = \mathrm{tr}\left((A - A^*)^*(A - A^*)\right) = 2\mathrm{tr}(A^*A - AA^*) = 2(\mathrm{tr}(A^*A) - \mathrm{tr}(AA^*)) = 0$. Thus $A = A^*$ and $A = \frac{1}{2}(A + A^*) = (AA^*)^{\frac{1}{2}}$ is non-negative definite. □

Solution 17-2.2 by LUDWIG ELSNER, *Universität Bielefeld, Bielefeld, Germany.*

These are exactly the class of hermitian positive semidefinite matrices (psd). Obviously psd-matrices satisfy (2). Now let A satisfy (2). Define $K = A + A^*$ and $C = i(A - A^*)$. Then

$$4AA^* = K^2 \leq K^2 + C^2 = 2AA^* + 2A^*A. \tag{3}$$

This implies $AA^* \leq A^*A$, so $D = A^*A - AA^* \geq 0$ and $tr(D) = 0$. Thus $D = 0$, showing that in (3) we have equality and hence $C = 0$. Thus $A = A^*$ and from (2) $A \geq 0$. So A is a non-negative definite matrix. □

Solution 17-2.3 by CHI-KWONG LI, *The College of William and Mary, Williamsburg, Virginia,* and FUZHEN ZHANG, *Nova Southeastern University, Fort Lauderdale, Florida, USA.*

One only needs to consider $A = H + iG$ with $H = (A + A^*)/2$. The given condition implies that $H^2 = AA^* = H^2 + G^2 + i(GH - HG)$. In the matrix case, one can compare the trace on both sides and conclude that the trace of G^2 is 0. It follows that all the eigenvalues of the positive semi-definite matrix G^2 are zero. Hence $G = 0$, and $A = H = (AA^*)^{1/2}$ is positive semi-definite. In the general C^*-algebra context, one can use the fact that $G^2 = i(HG - GH)$ to deduce $G^4 = -(HG - GH)^2$, which is both positive and negative semi-definite. Hence $G = 0$, and $A = H = (AA^*)^{1/2}$ is positive semi-definite. □

Solution 17-2.4 by HANS JOACHIM WERNER, *Universität Bonn, Bonn, Germany.* We prove that (2) holds if and only if A is Hermitian non-negative definite. The 'if' part of this statement is obviously true. To prove the converse, let $\mathcal{R}(.)$ denote the range (column space) and let (2) hold for a given matrix A. It is then clear that the matrix $H = \frac{1}{2}(A + A^*)$ is a Hermitian non-negative definite matrix with $\mathcal{R}(H) = \mathcal{R}(A)$. This set identity even implies that $\mathcal{R}(A) = \mathcal{R}(A^*)$. Now consider any singular value decomposition of A, say $A = PDQ^*$, where P and Q are column-unitary matrices and D is a positive definite diagonal matrix. From $\mathcal{R}(A) = \mathcal{R}(A^*)$ we see that $\mathcal{R}(P) = \mathcal{R}(Q)$ and hence $Q = PL$ for some unitary matrix L. It is easy to see that 2 is equivalent to $\frac{1}{2}[(LD)^* + LD] = D$, which holds if and only if $L = I$, and so $A = PDP^*$ as desired. □

A solution was also received from the proposers.

Problem 17-3: When does $AA^* = BB^*$? [*Image*, no. 17 (Summer 1996): 32]
Proposed by JÜRGEN GROß, *Universität Dortmund, Dortmund, Germany.*

Let A and B be two complex matrices with the same number of rows. Show that $AA^* = BB^*$ if and only if $\mathcal{R}(A) = \mathcal{R}(B)$ and $A^*(BB^*)^-A$ is idempotent for some $(BB^*)^-$. Here A^*, A^- and $\mathcal{R}(A)$ denote, respectively, the conjugate transpose, an arbitrary generalized inverse (inner inverse), and the range of the complex matrix A.

Solution 17-3.1 by HANS JOACHIM WERNER, *Universität Bonn, Bonn, Germany.* The 'only if' part is trivial. In order to prove the 'if' part, let the range (column space) $\mathcal{R}(A) = \mathcal{R}(B)$ and let $P = A^*(BB^*)^-A$ be idempotent for some $(BB^*)^-$. Notice that, in view of $\mathcal{R}(A) = \mathcal{R}(B)$, the matrix P is not only invariant for any choice of generalized inverse $(BB^*)^-$ but also has the same rank as A. The matrix P thus coincides with the orthogonal projector onto $\mathcal{R}(A^*)$. But then $A^* = PA^*$, which in turn implies that $AA^* = APA^* = AA^*(BB^*)^-AA^*$ holds for every choice of generalized inverse $(BB^*)^-$. So we have $\{(BB^*)^-\} \subseteq \{(AA^*)^-\}$. But in view of $\mathcal{R}(A) = \mathcal{R}(B)$ this happens if and only if $AA^* = BB^*$ and so our proof is complete. □

COMMENT. We note that this result may be extended as follows: Let A and B be complex $m \times n$ matrices. Then $A = B$ if and only if $A =^s B$ and B^-A is idempotent for some generalized inverse $B^- \in \{B^-\}$; here $A =^s B$ indicates that $\mathcal{R}(A) = \mathcal{R}(B)$ and $\mathcal{R}(A^*) = \mathcal{R}(B^*)$. We invite the interested reader to verify this!

As pointed out by by CHI-KWONG LI (College of William and Mary) and FUZHEN ZHANG (Nova Southeastern University), readers may like to look at the related article by R. A. Horn and I. Olkin, "When does $A^*A = B^*B$ and why does one want to know?", *Amer. Math. Monthly,* vol. 103, no. 6, pp. 470–482 (1996).

A solution was also received from the proposer.

New Problems

Problem 18-1: 5×5 **Complex Hadamard Matrices**
Proposed by S. W. DRURY, *McGill University, Montréal, Québec, Canada.*

The proposer has not yet found a solution to this problem!

Show that every 5×5 matrix U with complex entries $u_{j,k}$ of constant absolute value one that satisfies $U^*U = 5I$ can be realized as the matrix $(\omega^{jk})_{j,k}$ where ω is a complex primitive fifth root of unity by applying some sequence of the following:

1. A rearrangement of the rows.
2. A rearrangement of the columns.
3. Multiplication of a row by a complex number of absolute value one.
4. Multiplication of a column by a complex number of absolute value one.

Problem 18-2: 7×7 **Complex Hadamard matrices**
Proposed by S. W. DRURY, *McGill University, Montréal, Québec, Canada.*

Show that there exist two 7×7 nonzero complex matrices U and V with the following bizarre properties.

1. For all j, k with $1 \leq j \leq 7$ and $1 \leq k \leq 7$, either $|u_{j,k}| = 1$ and $v_{j,k} = 0$ or $|v_{j,k}| = 1$ and $u_{j,k} = 0$.
2. For every complex number z of absolute value 1, the matrix $W = U + zV$ satisfies $W^*W = 7I$.

Problem 18-3: A further matrix version of the Cauchy-Schwarz inequality
Proposed by SHUANGZHE LIU, *Universität Basel, Basel, Switzerland.*

Prove that $(X'AX)^+ \leq X^+A^+X'^+$, where $A \geq 0$ and $\mathcal{R}(XX'A) \subset \mathcal{R}(A)$; here $\mathcal{R}(.)$ denotes range (column space) and $(.)^+$ the Moore-Penrose inverse.

Problem 18-4: Bounds for a ratio of matrix traces
Proposed by SHUANGZHE LIU, *Universität Basel, Basel, Switzerland.*

Let $\Sigma > 0$ be an $n \times n$ matrix with eigenvalues $\lambda_1 \geq \cdots \geq \lambda_n$, X be an $n \times k$ matrix such that $X'X = I$ and $n \geq 2k$. Show that

$$1 \leq \frac{trX'\Sigma^2X}{tr(X'\Sigma X)^2} \leq \frac{\Sigma_{j=1}^{k}(\lambda_j + \lambda_{n-j+1})^2}{4\Sigma_{j=1}^{k}\lambda_j\lambda_{n-j+1}}.$$

Problem 18-5: Eigenvalues and eigenvectors of a patterned matrix
Proposed by I. S. ALALOUF & K. BRENDA MACGIBBON, *Université du Québec à Montréal, Montréal, Québec, Canada.*

Find the eigenvalues and eigenvectors of the $n \times n$ patterned matrix $A = \{a_{ij}\} = \{i - j\} \quad (i, j = 1, 2, \ldots, n)$.

Problem 18-6: Two imaginary sisters of the vector cross-product
Proposed by GÖTZ TRENKLER, *Universität Dortmund, Dortmund, Germany.*

Let a be a non-zero vector from $\Re^3$. Show that there are just two square matrices A with purely imaginary entries which satisfy

$$A^2x = a \times (a \times x) \quad \text{for all } x \in \Re^3$$

and identify them!

Please submit solutions, as well as new problems, to George Styan in LaTeX and by e-mail to `styan@math.mcgill.ca`.
