[I L / A S] *IMAGE* [I L / A S]

The Bulletin of the International Linear Algebra Society

Serving the International Linear Algebra Community

Issue Number 17, Summer 1996: pp. 1–32.

Joint Editors: Steven J. LEON and George P. H. STYAN

Department of Mathematics
University of Massachusetts–Dartmouth
Old Westport Road
North Dartmouth, MA 02747-2300, USA
e-mail: SLEON@UMASSD.EDU
FAX (1-508) 999-8901

Department of Mathematics and Statistics
McGill University, Burnside Hall
805 ouest, rue Sherbrooke Street West
Montréal, Québec, Canada H3A 2K6
e-mail: STYAN@MATH.MCGILL.CA
FAX (1-514) 398-3899

Printed by the McGill University Printing Service · Printed in Canada

ILAS President/Vice-President Annual Report: June 1996

1. The following have been elected to ILAS offices with terms that began on March 1, 1996:

President: RICHARD A. BRUALDI (three-year term ending February 28, 1999)

Secretary/Treasurer: JAMES R. WEAVER (four-year term ending February 29, 2000)

Board of Directors: RAJENDRA BHATIA, LUDWIG ELSNER (three-year terms ending February 28, 1999).

Jose Perdigao Dias da Silva has been appointed by the President to fill the vacancy on the Board created by the death of Robert C. Thompson. Jose's term ends on February 28, 1998. The following continue in their offices to which they were previously elected:

Vice-President: DANIEL HERSHKOWITZ (term ends February 28, 1998).

Board of Directors:

ANGELIKA BUNSE-GERSTNER (term ends February 28, 1997)

PETER LANCASTER (term ends February 28, 1998)

CHI-KWONG LI (term ends February 28, 1997)

HANS SCHNEIDER (one-year term of the ex-president, ending February 28, 1997).

2. The President has appointed his Advisory Committee. It consists of Shmuel Friedland (USA), Raphael Loewy (Israel), Volker Mehrmann (Germany), and Frank Uhlig (USA).

3. This year there will be elections for two positions on the Board that will become vacant on March 1, 1997. The President has appointed Thomas J. Laffey to serve as chair of the Nominating Committee. The other members of the Nominating Committee are: Miroslav Fiedler and Robert E. Hartwig (appointed by the Board), and Daniel Szyld and Pauline van den Driessche (appointed by the President's Advisory Committee).

4. The President has appointed a new Education Committee. It consists of Frank Uhlig (chair), David Carlson, Jane Day, Guershon Harel, Charles Johnson, and Jeffrey Stuart.

5. The President has appointed a new Corporate/Institutional Membership Committee. It consists of Carolyn Eschenbach (chair), David Lay, and George Styan.

6. A new category of ILAS membership, Institutional (Libraries) has now been created. Current annual dues is US$50. The other categories of membership are Individual (current annual dues is US$20) and Corporate (current annual dues is US$200). The benefits of each category of membership include *Image*, ILAS Information Center, ILAS Net, and *ELA*. Currently, there are 10 corporate members and 419 individual members. Interest in becoming an institutional member has been received from several sources.

7. The second Hans Schneider Prize in Linear Algebra has been awarded to Robert C. Thompson posthumously for his lifetime achievement and to Michael Boyle and David Handelman for their solution of the inverse eigenvalue problem for nonnegative matrices. The ILAS Linear Algebra Prize Committee that recommended these awards consisted of Richard A. Brualdi, Shmuel Friedland, Daniel Hershkowitz (chair), Thomas J. Laffey, Peter Lancaster, and Hans Schneider. Messieurs Boyle and Handelman will receive their award at the 6th ILAS conference in Chemnitz in August 1996.

8. In August 1995 the 5th ILAS Conference was held in Atlanta, Georgia (USA). There were more than 190 participants and 115 talks, including 17 main talks and 20 presentations in 4 minisymposia. The organizing committee consisted of Biswa N. Datta, Frank J. Hall (co-chair), Robert E. Hartwig, Daniel Hershkowitz, Charles R. Johnson, Volker Mehrmann, Alex Pothen, Hans Schneider, Frank Uhlig, Paul M. Van Dooren (co-chair), James R. Weaver, and Margaret H. Wright. Support for the meeting was obtained from Georgia State University, NSF, NSA, and the US Army. At the ILAS Business Meeting in Atlanta, a number of changes in our by-laws were approved and are now incorporated in a revised document, held by the Secretary/Treasurer James R. Weaver.

9. The following ILAS workshops/symposia and conferences are in various stages of preparation:

a. ILAS Conference, Technical Universität Chemnitz-Zwickau, Chemnitz, August 14–17, 1996. The organizing committee consists of: Bart De Moor, Graciano De Oliveira, Ludwig Elsner, Thomas J. Laffey, Volker Mehrmann (chair), Gerhard Michler, Michael Neumann, and Frank Uhlig. The local arrangements committee consists of: D. Happel, F. Lowke, C. Rost, and B. Silbermann.

b. ILAS Symposium on Fast Algorithms for Control, Signals, and Image Processing, University of Manitoba Institute of Industrial Mathematical Sciences, Winnipeg, Canada, June 6–9, 1997. The organizing committee consists of Pauline van den Driessche, Tom Kailath, Peter Lancaster, Dianne O'Leary, Robert Plemmons, Hans Schneider, P. N. Shivakumar (chair). The program committee consists of: Moody Chu, Biswa Datta, Brent Ellerbroek, Georg Heinig, Franklin Luk, Dianne O'Leary (co-chair), Haesun Park, Robert Plemmons (co-chair), Ali Sayed, Hans Schneider, P. N. Shivakumar, and Paul Van Dooren.

c. ILAS Conference, University of Wisconsin, Madison, Wisconsin, USA, June 3–6, 1998. The organizing committee consists of Richard A. Brualdi (chair), Bryan Cain, Biswa Datta, Jose Perdigao Dias da Silva, Shmuel Friedland, Moshe Goldberg, Uriel Rothblum, Jeffrey Stuart, Daniel Szyld, and Richard S. Varga.

d. ILAS Conference, Universitat Politecnica de Catalunya, Barcelona, Spain, July 19–22, 1999. The organizing committee consists of R. Bru, J. Ferrer, M. Isabel Garcia-Planas (co-chair), V. Hernandez, Nicholas Higham, Roger Horn, Thomas J. Laffey (co-chair), M. Dolors Magret, F. Puerta (co-chair for local arrangements), Paul Van Dooren, I. Zaballa.

e. ILAS Conference, Auburn University, 2002 (very tentative at this time)

10. ILAS has launched *ELA—The Electronic Journal of Linear Algebra*. The structure of the editorial board of *ELA* is: Editors-in-Chief: Daniel Hershkowitz (also serves as Managing Editor) and Volker Mehrmann. Advisory Editors: Chandler Davis, Israel Gohberg, Tom Laffey and Richard Varga. Associate Editor: Daniel B. Szyld (also serves as Associate Managing Editor). As of June 17, 1996, *ELA* has published 2 papers. *ELA*'s primary site is at the Technion. Mirror sites are located in Temple University, in the University of Chemnitz and in the University of Lisbon.

11. ILAS-NET: As of June 17, 1996, we have circulated 568 ILAS-NET announcements. ILAS-NET currently has 576 subscribers.

12. ILAS INFORMATION CENTER (IIC) has a daily average of 150 information requests (not counting FTP operations). IIC's primary site is at the Technion. Mirror sites are located in Temple University, in the University of Chemnitz and in the University of Lisbon.

RICHARD A. BRUALDI
brualdi@math.wisc.edu

Dept. of Mathematics
University of Wisconsin–Madison
Van Vleck Hall, 480 Lincoln Drive
Madison, WI 53706-1388, USA

Thoughts and Anecdotes Wanted about Bob Thompson

Morris Newman and I are preparing an article about Bob Thompson for the special issue of *Linear and Multilinear Algebra* which will be dedicated to his memory. We would like to include some thoughts and anecdotes about him from friends and colleagues, as well as an appreciation of his work.

If you have a favorite memory or story that involves Bob, or thoughts about his contributions to mathematics, please send them to me as soon as possible. Thank you.

JANE DAY
day@sjsumcs.sjsu.edu

Dept. of Mathematics and Computer Science
San Jose State University
San Jose, CA 95192-0103, USA

ILAS Treasurer's Report: March 1, 1995–February 29, 1996

by James R. Weaver, *University of West Florida*

Balance on hand March 1, 1995			
Certificate of Deposits (CD)	8,500.00		
Vanguard	7,092.35		
Checking Account	19,608.88		35,201.23
Checking Account Balance on March 1, 1995			19,608.88
March 1995			
Income:			
Dues	180.00		
Interest (First Union)	27.37		
Contributions			
General	30.00	237.37	
Expenses:			
Sec. of State	70.00		
Production and Mail "IMAGE"	618.01	688.01	(450.64)
April 1995			
Income:			
Dues	198.00		
Interest on CD (FU)	10.60		
Interest on CD (OT/JT)	29.00		
Interest on CD (HS)	74.56		
Interest (First Union)	24.45		
Contributions			
Conference	50.00	386.61	
Expenses:	00.00	00.00	386.61
May 1995			
Income:			
Dues	198.00		
Interest (First Union)	26.70	224.70	
Expenses:			
Office Depot	40.63	40.63	184.07
June 1995			
Income:			
Dues	198.00		
Interest (First Union)	23.38		
Contributions			
Conference	50.00	271.38	
Expenses:			
Office Depot	24.04		
Preparation of ILAS Ballots			
Lisa M. Weaver	47.00		
Shipping Poste (Ballots)	279.25		
FNB of Santa Rosa towards			
the purchase of 1,500 CD	500.00		
Dixon Brothers Sporting Goods	238.19	1088.48	(817.10)
July 1995			
Income:			
Interest (First Union)	22.31		
Interest on CD (FU)	10.84	33.15	
Expenses:			
Postmaster (Mailing By-Laws)	15.91	15.91	17.24
August 1995			
Income:			
Dues	112.00		
Interest on CD (HS)	75.38		
Interest on CD (OT/JT)	29.32		
Interest (First Union)	22.04		

Contributions			
General	8.00		
Conference	200.00		
F. Uhlig Ed. Fund	30.00		
OT/JT Lec. Fund	120.00	596.74	
Expenses:			
Preparing Early Dues Notices			
Lisa M. Weaver	51.50		
Mailing Early Dues Notices			
The Shipping Poste	280.70		
300 Copies, UWF	16.38		
Conference Supplies			
B&B Bottle Shop Inc.	467.35		
Banquet Workers			
Radisson	65.00		
New Checks			
Clarke American Checks	41.65	922.58	(325.84)
September 1995			
Income:			
Dues	452.00		
Interest (First Union)	21.06		
4 Lunches, James R. Weaver	24.00		
Tote Bags	240.00		
Contributions			
General	40.00		
Conference	60.00		
H. Schneider Prize	30.00		
OT/JT Lec. Fund	500.00	1,367.06	
Expenses:			
Mailing By-Laws & Stamps			
Postmaster	40.42		
Producing & Mailing "IMAGE"			
George P. H. Styan	994.39	1,034.81	332.25
October 1995			
Income:			
Dues	1888.00		
Interest (First Union)	26.07		
Interest on CD (HS)	76.23		
Interest on CD (OT/JT)	29.64		
Interest on CD (FU)	23.63		
Tote Bag	10.00		
Contributions			
General	250.00		
H. Schneider Prize	199.00		
F. Uhlig Ed. Fund	36.00		
OT/JT Lec. Fund	136.00		
Conference	669.00	3,343.57	
Expenses:			
For Checking Currency Exc.	6.89	6.89	3,336.68
November 1995			
Income:			
Dues	1332.00		
Interest (First Union)	25.95		
Contributions			
General	20.00		
H. Schneider Prize	60.00		
OT/JT Lec. Fund	40.00		
Conference	973.97	2,451.92	
Expenses:			
Office Depot (Supplies)	154.03		
Deposit Slips, CHK Orders			
Clarke American	9.15	163.18	2,288.74

December 1995			
Income:			
Dues	760.00		
Interest (First Union)	25.04		
Contributions			
OT/JT Lec. Fund	50.00		
Conference	25.00	860.04	
Expenses:			
UWF 2000 Brochures	89.56		
Postmaster-Stamps	51.20		
Preparing 2nd Dues Notice			
UWF Mathematics Assoc.	45.00		
Postmaster-Stamps(Dues Notice)	127.76		
Postmaster-Stamps(Brochure)	287.04		
Postmaster-Stamps(Brochure)	61.80		
Preparing and Sending Brochure			
Lisa M. Weaver	103.50	765.86	94.18
January 1996			
Income:			
Dues	1092.00		
Interest (First Union)	24.26		
Interest on CD (HS)	76.23		
Interest on CD (OT/JT)	29.64		
Interest on CD (FU)	23.37		
Contributions			
Conference	60.00		
General	1.00		
Banquet	30.00	1,336.50	
Expenses:	00.00	00.00	1,336.50
February 1996			
Income:			
Dues	660.00		
Interest (First Union)	13.23		
Contributions			
General	45.00		
H. Schneider Prize	10.00		
OT/JT Lec. Fund	15.00		
Banquet	60.00		
Conference	110.00	913.23	
Expenses:			
FNB of Santa Rosa (CD)	10,000.00	10,000.00	(9,086.77)
**********			
February 29, 1996			16,904.80
Account Balance			
Checking Account	16,904.80		
Certificate of Deposit (FU)	1,500.00		
Certificate of Deposit (Gen.)	10,000.00		
Certificate of Deposit (72% HS & 28% OT/JT)	7,500.00		
Vanguard (72% HS & 28% OT/JT)	7,962.20		43,867.00
General Fund	16,462.73		
Frank Uhlig Educational Fund	2,107.25		
Hans Schneider Prize	13,323.37		
Olga Taussky Todd/John Todd Fund	6,772.77		
Conference Fund	4,950.88		
6th ILAS Conference	250.00		43,867.00
**********			

James R. Weaver
5/25/96

ILAS Treasurer's Report Supplement: March 1, 1995–February 29, 1996

by Volker Mehrmann and James R. Weaver

DM = Deutsche mark

Account opened September 1995

	DM	DM	DM
September 1995			
Income:	00.00	00.00	
Expenses:			
Fees	6.00	6.00	(6.00)
October 1995			
Income:	00.00	00.00	
Expenses:	00.00	00.00	
November 1995			
Income:			
Donation to ILAS Conference	100.00	100.00	
Expenses:	00.00	00.00	100.00
December 1995			
Income:	00.00	00.00	
Expenses:			
Fees	9.30		
Int.	.18	9.48	(9.48)
January 1996			
Income:			
ILAS Conference 1996	195.00	195.00	
Expenses:	00.00	00.00	195.00
February 1996			
Income:			
ILAS Conference 1996	135.00	135.00	
Expenses:	00.00	00.00	135.00

****

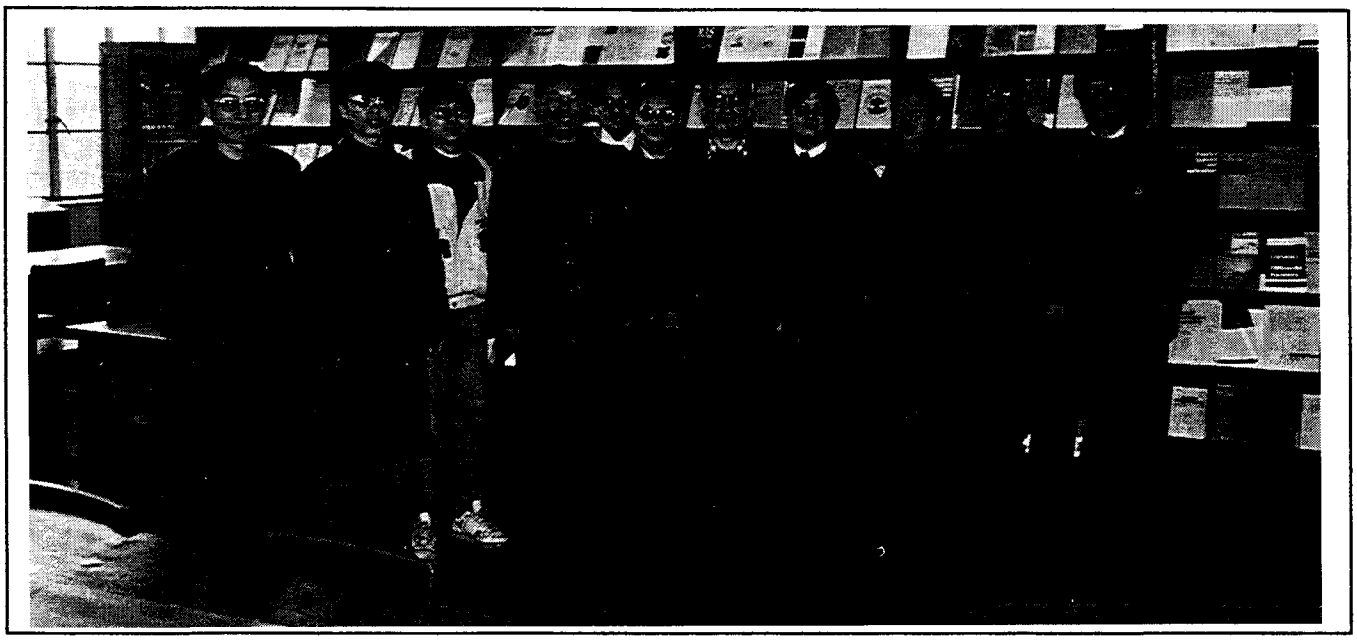
Account Balance (ILAS Conference 1996) 414.52 DM

****

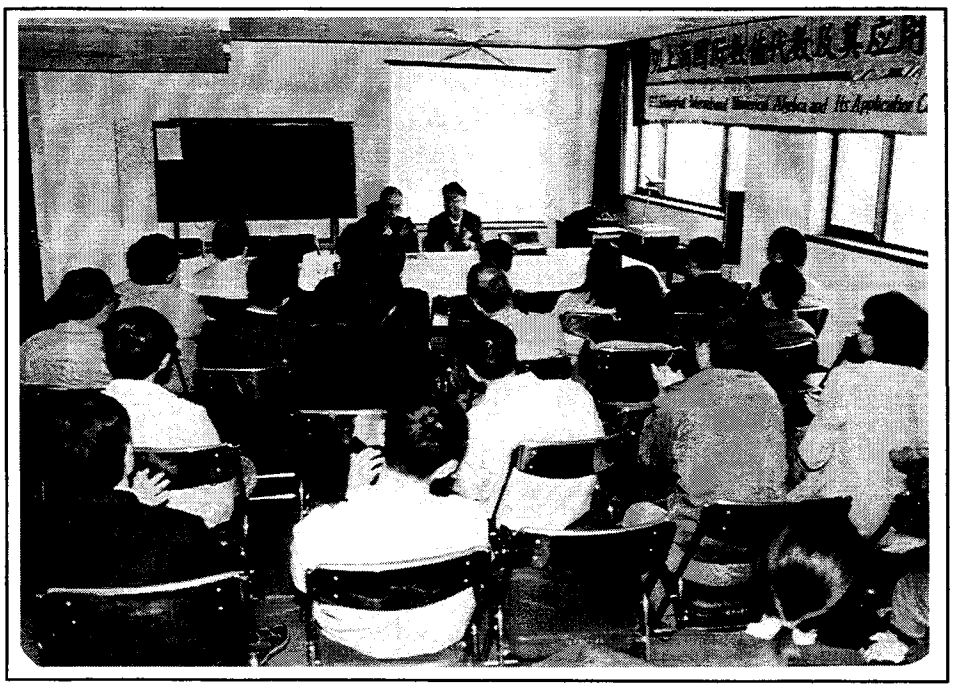
James R. Weaver
6/4/96

ELA—The Electronic Journal of Linear Algebra

The first paper to be published in *ELA—The Electronic Journal of Linear Algebra* is by C. K. Li, N. K. Tsing and F. Uhlig; entitled "Numerical ranges of an operator on an indefinite inner product space" [*ELA*, vol. 1, pp. 1–17 (1996)], it is now posted in ELA's homepage: `http://www.math.technion.ac.il/iic/ela/`.



Fudan Group on Numerical Linear Algebra— From left to right:
Dr. Daxun Zhu, Dr. Jungong Xue, Mr. Xinzhi Zhan, Prof. Erxiong Jiang,
Dr. Fengguang Zhao, Dr. Jianjun Xie, Prof. Zhihao Cao,
Dr. Chonghua Yu, Mr. Weiguo Gao, Mr. Yimin Wei, Mr. Yongyang Cie.



The 1992 Shanghai International Numerical Algebra and Its Applications Conference held at Fudan University, Shanghai.

Linear Algebra in Mainland China[1]

ERXIONG JIANG

Dept. of Mathematics, Fudan University, Shanghai 200433, P. R. China

I know very little about Linear Algebra in ancient China. The book "Jin Zhang Suan Shu" (Nine Chapters of Arithmetic) dates from the second century BC. How to solve systems of linear algebraic equations is discussed in its 8th chapter.

Turning to the 20th century, early in the 1930s, there was a Chinese scholar studying Linear Algebra. By extending the Moore generalized inverse to Hilbert spaces, Y. Y. Tseng (1933) introduced [1] the Tseng generalized inverse of linear operators on a Hilbert space. Before the 1980s, however, there was little Linear Algebra research in China. In order of time, we mention the following: Ji Geng's estimation of the bounds for matrix eigenvalues [2]; Boying Wang's method for computing the matrix inverse [3]; Erxiong Jiang's improvement on the p-condition number of real symmetric matrices [4]; Zhongci Shi's estimation of the bounds for the p-condition number [5]; Zhongci Shi and Boying Wang's estimation of the bounds for determinants, eigenvalues, and condition numbers [6]; Wenting Tong [7] on the distribution of eigenvalues; Xuchu He [8] on numerical dependence; and Erxiong Jiang's algorithms [9] for computing transformation matrices of Jordan canonical forms.

Since the 1980s, Linear Algebra research has been thriving in China. First we mention Ji-guang Sun's many important contributions to the theory of matrix eigenvalue perturbations. Sun studies the perturbation of both ordinary and generalized eigenvalues and of singular values [10], [11], [12]. In 1987 he published his monograph *Matrix Perturbation Analysis* (Academic Press, Beijing, in Chinese), based on which, Stewart and Sun wrote *Matrix Perturbation Theory* (Academic Press, 1990, in English). More on eigenvalue perturbation theory was contributed by Erxiong Jiang and his students [13], [14], [15].

Erxiong Jiang has made a series of contributions to numerical linear algebra, in particular, to the QL algorithm. He and his student Zhenyue Zhang proposed a new shift for the QL algorithm [16]. For symmetric tridiagonal matrices, this shift guarantees global and asymptotically cubic convergence. The new shift was called "China shift" by W. Gragg. Erxiong Jiang also proved that the Francis QL algorithm with double shifts converges for the symmetric or antisymmetric case [17], [18]. Erxiong Jiang founded the Numerical Linear Algebra Group at Fudan University. Twelve students have received their doctoral degree under Jiang's guidance. Zhaojun Bai, Chunyang He, Hongyuan Zha and Guodong Zhang, who all work in America now, are amongst Jiang's PhD students. Under the direction of Jiang, Hongguo Xu's PhD thesis "Solving the Algebraic Riccati Equation via Skew Hamilton Matrices" won the 6th Householder Prize (1993). The paper, which contains the main results of his thesis, appeared in [19]. Another of Jiang's PhD students, Jianjun Xie, solved "the $\sqrt{2}$ problem" raised by W. Kahan in 1967 in his PhD thesis, see [20]. In the Fudan Group we should also mention Zhi-Hao Cao, who has done much work on iterative algorithms for algebraic linear systems [21], [22], [23]. The 1992 Shanghai International Numerical Algebra and Its Applications Conference [24] held at Fudan turned out to be a success (for the details see the paper by B. N. Datta in *SIAM News*, March 1993).

Some other Chinese numerical linear algebra specialists have also done notable work. Guo-chen Feng of Jilin University and Wen-da Wu of the Municipal Computing Center, Beijing, converted some non-linear system problems to matrix eigenvalue problems [25], [26]. Musheng Wei of East China Normal University studied least squares problems and total least squares problems [27], [28]. Dao-sheng Zheng, also of East China Normal University, studied the minimal p-condition number [29] and matrix extension problems [30]. Guorong Wang of Shanghai Normal University works on matrix generalized inverses [31], while Jiaoxun Kuang, of the same university, first suggested the TOR iterative algorithm [32]. In China there are also many specialists who have done excellent work on matrix inverse eigenvalue problems, for example, Ji-guang Sun [33], Shu-Fang Xu [34], Jicheng Chen, Luoluo Li [35], Shuquan Zhou [36] and Dai Hua [37].

Finally we would like to mention Jia-yu Shao of Tongji University and Qiao Li of Shanghai Jiao-Tong University, who have done very nice work on combinatorial matrix analysis. They resolved seven conjectures and open problems raised in the literature, among which are an open problem in the book *Boolean Matrix Theory and Applications* by K. H. Kim, and three problems on the exponent set of a primitive digraph raised by J. Ross. See [38], [39], [40], [41]. Jiong-Sheng Li of University of Science and Technology of China and his coauthors studied tournament matrices and digraphs [42], [43].

[1] This is another in a series of articles on Linear Algebra Around The World that we are publishing in *Image*; recall the articles by Juan M. Gracia and Vincente Hernández on Linear Algebra in Spain [*Image* 8 (January 1992): 6–8] and by B. N. Datta on his Visit to Japanese and other Asian Universities [*Image* 10 (January 1993): 8–12]. We would certainly welcome other views and viewpoints on the state of Linear Algebra in China and elsewhere. Many thanks go to Frank Uhlig for making this article available to us. –Eds.

In a word, there are and have been many specialists studying Linear Algebra in mainland China. Limited by my knowledge, it would be impossible to review all the important Chinese contributions to Linear Algebra without the risk of omitting some. Hence my sincere apologies to those whose work has not been mentioned in this survey. The 1st China Matrix Theory Conference was held in Huang Mountain, Anhui Province, in 1994. The 2nd China Matrix Theory Conference will take place in Jilin, a city in the northeast of China this August 1996. The Chinese Linear Algebra Society (CLAS) will be founded at this conference.

References

[1] Ya Yu Tseng, *The characteristic value problem of Hermitian functional operators in a non-Hilbert space*, Doctoral Dissertation in Mathematics, University of Chicago (1933).

[2] Ji Geng, Bounds for the eigenvalues of matrices (I), *Advances in Mathematics (China)*, Vol.4, No.3 (1958).

[3] Boying Wang, A note on a method for computing matrix inverses, *Advances in Mathematics (China)*, Vol.5, No.1 (1962).

[4] Erxiong Jiang, Improvement on the p-condition number of symmetric positive definite matrices, *J. of Fudan Univ. (Natural Science Ed.)*, Vol.9, No.1 (1963).

[5] Zhongci Shi, Estimation of the bounds for p- condition numbers of matrices whose eigenvalues are positive, *Acta Math. Sinica*, Vol.14, No.6 (1964).

[6] Zhongci Shi and Boying Wang, Some estimation of the bounds for the determinants, eigenvalues and condition numbers of certain matrices, *Acta Math. Sinica*, Vol.15, No.3 (1965).

[7] Wen Ting Tong, On the distribution of the eigenvalues of certain kinds of matrices, *Acta Math. Sinica*, Vol.20, No.4 (1977).

[8] Xu Chu He, The theory of numerical linear dependence and its applications, *Numer. Math.: A Journal of Chinese Univ.*, Vol.1, No.1, 11–19 (1979) [MR 81h:65041].

[9] Erxiong Jiang, An algorithm for computing a transformation matrix of the Jordan canonical form of any matrix, *Numer. Math. J. Chinese Univ.*, Vol.1, No.1, 1–10 (1979) [MR 81h:15008].

[10] Ji-Guang Sun, Perturbation analysis for the generalized eigenvalue problem and the generalized singular value problem, in *B. Kågström and A. Ruhe, editors, Matrix Pencils*, Springer Verlag, New York, pp. 221–244 (1983) [MR 85i:15017].

[11] Ji-Guang Sun, Perturbation analysis for the generalized singular value problem, *SIAM J. Numer. Anal.*, 20, 611–625 (1983) [MR 85i:15017].

[12] Ji-Guang Sun, The perturbation bounds for eigenspaces of a definite matrix-pair, *Numer. Math. J. Chinese Math.*, 41, 321–343 (1983) [MR 85c:65045].

[13] Erxiong Jiang, On spectral variation of a nonnormal matrix, *Linear Algebra Appl.*, 42, 223–241 (1982) [MR 85b:15021].

[14] Erxiong Jiang, Bounds for the smallest singular value of a Jordan block with an application to eigenvalue perturbation, *Linear Algebra Appl.*, 197/198: 691–707 (1994) [MR 96a:15018].

[15] Zhenyue Zhang, On the perturbations of the eigenvalues of a nondefective matrix, (In Chinese) *Math. Numer. Sinica* 8, 106–108 (1986) [MR 87k:65048].

[16] Erxiong Jiang and Zhenyue Zhang, A new shift of the QL algorithm for irreducible symmetric tridiagonal matrices, *Linear Algebra Appl.*, 65, 261–272 (1985) [MR 86g:65082].

[17] Erxiong Jiang, A note on the double-shift QL algorithm, *Linear Algebra Appl.*, 171, 121–132 (1992) [MR 93e:65059].

[18] Erxiong Jiang and Peter C. B. Lam, Francis QL algorithm for finding the eigenvalues of antisymmetric matrices, *Numer. Math. J. Chinese Univ.*, 3, 202–215 (1994) [MR 96a:65052].

[19] Hong Guo Xu and Lin Zhang Lu, Properties of a quadratic matrix equation and the solution of the continuous-time algebraic Riccati equation, *Linear Algebra Appl.*, 222, 127–145 (1995) [MR 96e:65033].

[20] Zhi-Hao Cao, Jianjun Xie and Rencang Li, A sharp version of Kahan's theorem on clustered eigenvalues, *Linear Algebra Appl.*, to appear.

[21] Zhi-Hao Cao, On convergence of nested stationary iterative methods, *Linear Algebra Appl.*, 221, 159–170 (1995) [MR 96d:65053].

[22] Zhi-Hao Cao, Convergence of two-stage iterative methods for the solution of linear systems, (in Chinese) *Math. Numer. Sinica*, 17 (1995).

[23] Zhi-Hao Cao, Avoiding breakdown in variants of the BI-CG algorithm, *Linear Algebra Appl.*, to appear.

[24] *Numerical Algebra*, Proceedings of 1992 Shanghai International Numerical Algebra and its Applications Conference, E. Jiang, editor, China Science and Technology Press, 185 pp. (1994).

[25] Guo-chen Feng, Wen-Da Wu and Kai Huang, The computation of eigenvalue problem equivalent to multivariate polynomial system and Groebner basis, *Advances in Mathematics (China)*, Vol.22, No.3 (1993).

[26] Guo-chen Feng, Wen-Da Wu and Shu-gong Zhang, The eigenvalue problem equivalent to multivariate polynomial system, *Northeastern Math.*, Vol.9, No.1 (1993).

[27] Mu Sheng Wei, The analysis for the total least squares problem with more than one solution, *SIAM J. Matrix Anal. Appl.*, 13, 746–763 (1992) [MR 93j:65057].

[28] Mu Sheng Wei, Perturbation theory for the rank- deficient equality constrained least squares problem, *SIAM J. Numer. Anal.*, 29, 1462–1481 (1992) [MR 93i:65046].

[29] Cheng Wang, Dao Sheng Zheng, Guo-Liang Chen and Shu-Qin Zhao, Structures of p-isometric matrices and rectangular matrices with minimum p-norm condition number, *Linear Algebra Appl.*, 184, 261–278 (1993) [MR 94f:65049].

[30] Dao Sheng Zheng, Further study and generalization of Kahan's matrix extension theorem, *SIAM J. Matrix Anal. Appl.*, to appear.

[31] Guorong Wang, *Generalized Inverses of Matrices and Operators*, Academic Press, Beijing, 1994.

[32] Jiaoxun Kuang, On the two-parameter overrelaxation method for numerical solution of large linear systems (in Chinese), *J. Shanghai Teacher's Univ.*, 4(1983), 1-11.

[33] Ji-Guang Sun, The unsolvability of multiplicative inverse eigenvalue problems almost everywhere, *J. Comput. Math.*, 4, 227–244 (1986) [MR 88m:65062].

[34] Shu Fang Xu, A stability analysis of the Jacobi matrix inverse eigenvalue problem, *BIT*, 33, 695–702 (1993) [MR 96b:65040].

[35] Luoluo Li, Some sufficient conditions for the solvability of inverse eigenvalue problems, *Linear Algebra Appl.*, 148, 225–236 (1991) [MR 92h:15009].

[36] Shu Quan Zhou and Dai Hua, *Inverse Algebraic Eigenvalue Problems*, Henan Scientific and Technical Publishers, China, 1991.

[37] Dai Hua, Inverse eigenvalue problems for Jacobi matrices and symmetric tridiagonal matrices, (in Chinese) *Numer. Math. J. Chinese Univ.*, 12, 1–13 (1990) [MR 91f:15015].

[38] Jia-yu Shao, Matrices permutation equivalent to primitive matrices, *Linear Algebra Appl.*, 65, 225–247 (1985) [MR 86k:15009].

[39] Jia-yu Shao, On the exponent of a primitive digraph, *Linear Algebra Appl.*, 64, 21–31 (1985) [MR 86i:05076].

[40] Jia-yu Shao, On a conjecture about the exponent set of primitive matrices, *Linear Algebra Appl.*, 65, 91–123 (1985) [MR 86k:15013].

[41] Qiao Li and Jia-yu Shao, The index set problem for Boolean (or nonnegative) matrices, *Discrete Math.*, 123, 75–92 (1993) [MR 94k:15010].

[42] Jiong Sheng Li, Yu Cai Lin and Guo Xun Huang, Score vector of Kotzig tournaments, *J. Combinatorial Theory Ser. B*, 42, 328–336 (1987) [MR 88i:05089].

[43] Jiong Sheng Li, Digraphs with degree equivalent induced subdigraphs, *J. Combinatorial Theory Ser. B*, 50, 288–298 (1990) [MR 91m:05094].

Research Papers in Chinese on the Kantorovich and Related Inequalities

GÜLHAN ALPARGU and GEORGE P. H. STYAN, *McGill University, Montréal*

In her recent M.Sc. thesis [1] Gülhan Alpargu has included an extensive bibliography on the Kantorovich and related inequalities. This bibliography of over 170 items includes 16 publications in Chinese. As far as we know, only three of these publications [2], [7] and [13] have been translated into English. Readers who are interested in obtaining copies of [1] (and/or the first draft of a translation into English of [11]) are invited to contact us at McGill: `alpargu@zaphod.math.mcgill.ca` or `mt56@musica.mcgill.ca`.

References

[1] Gülhan Alpargu. The Kantorovich inequality, with some extensions and with some statistical applications. M.Sc. thesis, Dept. of Mathematics and Statistics, McGill University, Montréal (1996). [Includes translations of [2] and [7].]

[2] Yong-Lin Chen. A simpler proof of Kantorovich's inequality and of a generalization of it. *Shuxue de Shijian yu Renshi–Mathematics in Practice and Theory* **1987** (4), 78–79 (1987) [MR 89c:26033]. [Translated into English by Jiabin Zhao: Appendix C of [1].]

[3] Dao-De Gao. Estimation of the deviation between the least squares and the best linear unbiased estimators of the mean vector in a linear model. *Yingyong Gailü Tongji– Chinese Journal of Applied Probability and Statistics* **8** (4), 391–397 (1992) [MR 93m:62150].

[4] Dao-De Gao. A new class of Kantorovich-type inequalities and their applications in statistics. *Xitong Kexue yu Shuxue–Journal of Systems Science and Mathematical Sciences* **13** (4), 331–337 (1993) [MR 94k:62102].

[5] Dao-De Gao. Some extensions of the Kantorovich inequality and their applications in statistics. *Gaoxiao Yingyong Shuxue Xuebao–A Journal of Chinese Universities, Series A (Hangzhou)* **10** (2), 181–188 (1995).

[6] Dao-De Gao and Jing-Long Wang. Efficiency of generalized least square estimates. *Xitong Kexue yu Shuxue–Journal of Systems Science and Mathematical Sciences* **10** (2), 125–130 (1990) [MR 96c:62059].

[7] Chun-Tu Lin. An extension of the Kantorovich inequality and its application to estimating parameters in linear models. *Xitong Kexue yu Shuxue–Journal of Systems Science and Mathematical Sciences* **6** (3), 217–220 (1986) [MR 88a:62176]. [Translated into English by Ming-Yan Venus Chiu: Appendix B of [1].]

[8] Yu-Tong Lou. A generalization of Schweitzer's inequality and Grüss's inequality and their relationship. *Qufu Shifan Daxue Xuebao Ziran Kexue Ban* **17** (4), 24–28 (1991).

[9] En-Wei Shi. An elementary proof of the Kantorovich inequality. *Shuxue de Shijian yu Renshi–Mathematics in Practice and Theory* **1985** (4), 56–61 (1985) [MR 87g:15021].

[10] Jing-Long Wang and Dao-De Gao. Measures of inefficiency for generalized least square estimates of the Euclidean norms of matrices. *Yingyong Gailü Tongji– Chinese Journal of Applied Probability and Statistics* **7** (4), 361–366 (1991) [MR 93m:62160].

[11] Hu Yang. Extensions of the Kantorovich inequality and the error ratio efficiency of the mean square. *Mathematica Applicata Yingyong Shuxue–Chinese Journal of Mathematics and its Applications* **1** (4), 85–90 (1988) [MR 90a:62186]. [First draft available of a translation into English by Xiao-Jie Zhou.]

[12] Hu Yang. The inefficiency of the least squares estimator and its bound. *Applied Mathematics and Mechanics of China* **11** (11), 1087–1093 (1990).

[13] Hu Yang. Two new classes of the generalized Kantorovich inequalities and their applications. *Kexue Tongbao* **35**, 965–967 (1990) [Translated into English: *Chinese Science Bulletin* **36**, 1849–1851 (1991).

[14] Hu Yang. Kantorovich Inequality and its Applications in Statistics. M.Sc. thesis, Dept. of Statistics, Yunnan University, Kunming, 52 pp. (1990).

[15] Hu Yang. Some extensions on the upper bound of Rayleigh quotient. *Journal of Chongqing University* **9**, 16–23 (1990).

[16] Shi-Qiong Zhou. On the weighted mean inequality. *Journal of Changsha Communications Institute: Changsha Jiaotong Xueyuan Xuebao* **7** (3), 52–61 (1991) [MR 95g:26036].

[17] Shi-Qiong Zhou. The inverses of the Hölder inequality and their matrix forms. *Journal of Changsha Communications Institute: Changsha Jiaotong Xueyuan Xuebao* **9**, 10–16 (1993) [MR 95g:26036].

Linear Algebra in Hong Kong

CHI-KWONG LI[1] & NAM-KIU TSING[2]

A few years ago (about 1989), Bob Thompson suggested that we to write an article on the development of linear algebra research in Hong Kong. We deeply regret that we were not able to do this project earlier so that Bob could see the product before he left us. Actually, Bob had given invaluable help and support for the linear algebra group from Hong Kong. In particular, both authors of this article have benefited a great deal from the generosity of Bob in their careers. In any event, we would like to dedicate this article to our very best friend: Bob Thompson.

Also, in the last few years, there have been a lot of linear algebra activities taking place in Hong Kong. If we do not write up the article now, the project might continue to grow and will be too big for us to handle. This is another motivation for us to do it now.

1. Some Background

It can be said that the Mathematics Department of the University of Hong Kong (HKU) is the cradle of linear algebra research in Hong Kong. Founded in 1911, HKU is the oldest university in the territory, and mathematics is one of the core subjects in its curriculum right from the beginning. But research in mathematics really flourished only after 1948, when Professor Yung-Chow Wong, a geometer, was appointed as Chair of Mathematics. The Department of Mathematics also grew from a teaching staff with only two teachers after the second world war to a faculty of well-trained mathematicians who offer a full range of courses to the students.

Linear algebra has always been regarded as an important subject in the mathematics curriculum of HKU. For mathematics students, the first year core courses are analysis (which include elementary mathematical analysis and multivariable calculus) and linear algebra. A set of lecture notes, which later became a textbook, for the linear algebra course was prepared by Dr. K.T. Leung, who treated the material with mathematical vigor and provided ample examples. This early exposure of students to linear algebra may also have some effects on arousing the interest of students on the subject.

In the seventies, the Mathematics Department of HKU was quite well-developed. Research areas for graduate study included geometry, mathematical analysis, differential equations, number theory, linear algebra, combinatorics, topology, and operations research. In any event, most students were encouraged to pursue their graduate study in other countries such as England, USA and Canada, and many of them became successful mathematicians. But still, for various reasons, there were students who had a strong desire to work with certain faculty members in the department, and decided to study in Hong Kong despite the fact that it would be much harder to get a job at the institutions in Hong Kong after graduation. This remains the case even now.

2. The Initiator

Dr. Yik-Hoi Au-Yeung, the initiator of the linear algebra research group in Hong Kong, attended and obtained his first degree from Zhongzhan University in Guangzhou, China, after finishing high school in Hong Kong. Then he spent one and a half years as a graduate student in Fudan University in Shanghai.

In 1962, Dr. Au-Yeung returned to Hong Kong from Shanghai and planned to apply for graduate schools in Australia to study differential equations. The Mathematics Department of HKU was expanding during that period, and its Chairman, Professor Wong, was anxious in recruiting good people. In particular, Dr. Au-Yeung was encouraged to join the department, do his graduate study under Professor Wong, and at the same time do some teaching.

The first research problem that Professor Wong proposed to Dr. Au-Yeung was on eigenvalues of quaternionic matrices. From then on, Dr. Au-Yeung shifted his interest from differential equations to linear algebra. This planted the seeds of future development in linear algebra research in Hong Kong. Dr. Au-Yeung obtained his M.Sc degree in 1966 (thesis title: On the Eigenvalues of Square Quaternion Matrices) and his Ph.D degree in 1970 (thesis title: On Hermitian Functions over Real Numbers, Complex Numbers, or Real Quaternions). He was appointed as assistant lecturer in the department in 1966, and since then has been promoted thrice. He is now a reader in the department.

From the early seventies, Dr. Au-Yeung has been continuously working with a number of graduate students; and maintaining an interest group in linear algebra in the department. For a list of the students of Dr. Au-Yeung, their theses titles, and years of graduation, see Section 5.

[1]Dept. of Mathematics, College of William & Mary, Williamsburg, VA 23187, USA;ckli@cs.wm.edu
[2]Dept. of Mathematics, University of Hong Kong;nktsing@hkuxa.hku.hk

3. The Master and His Apprentices

In the seventies and eighties, there was virtually no support from the Hong Kong government or the university for faculty members to do research and advise graduate students. In those days, working with graduate students simply meant asking for more work and burden. Nevertheless, Dr. Au-Yeung devoted his time and efforts to work with graduate students and to develop the linear algebra group.

Dr. Au-Yeung is very liberal in letting his graduate students choose their research topics, and he does not insist that they to work on his projects and write joint papers with him. On the other hand, in the same manner as his teacher Professor Wong, he demands research work that is of high quality and quantity from his students. This can be seen from the contents of the theses of some of his students (c.f. Section 5):

- Part of the M.Phil. thesis of Fuk-Yum Sing constitutes two journal papers, one of which is on a necessary and sufficient condition for characterizing diagonal elements of matrices with prescribed singular values. This paper was praised highly in the review by Bob Thompson (MR 54:12808), who obtained the same result independently with a different proof just a little earlier.
- Material in the Ph.D. thesis of Bit-Shun Tam constitutes five journal papers. In particular, Tam answered some open problems posed by Hans Schneider and M. Vidyasagar on cones.
- Material in the master thesis of Yiu-Tung Poon constitutes four journal papers. In one of these papers, Poon gave an ingenious elementary proof of the convexity of the c-numerical range, which was previously proved by Roy Westwick using results on Morse theory.

And most of these papers were published or accepted for publication before the theses were completed.

Dr. Au-Yeung's students are usually trained to use various techniques in a clever way to solve linear algebra problems. As a result, in the early stage of their research careers, many of them have been able to use the "low road" approach, cf. "High, low and quantitative roads in linear algebra" by Robert C. Thompson [*Linear Algebra Appl.* 162–164, 23–64 (1992)] to obtain new results or to reprove existing deep linear algebra results. Also, because of their early training, they would be open to different kinds of approaches (high road, low road, analytic, algebraic, geometric, etc.) to linear algebra problems in their research.

To make sure that the work is of sufficient standard and error-free, Dr. Au-Yeung would spend a lot of time to study the papers of his students carefully and give them valuable advice, even when he is not a coauthor of the papers.

Here is a small story that might give some ideas to the readers about Dr. Au-Yeung's attitude towards his graduate students as well as research. In the Spring of 1986, the first author and Tin-Yau Tam were at the final stage of preparing their theses. As usual, everything was in a rush at that point. At that critical moment, Dr. Au-Yeung had to go through an operation of removing his appendix unexpectedly. To avoid delays and to make sure that his students got proper advice in preparing their theses, Dr. Au-Yeung studied the drafts of the theses while he was still in bed in the hospital just after the operation!

To the knowledge of the authors, in the history of HKU there were only two university-wide polls (in 1986 and 1991) for the best teacher. And Dr. Au-Yeung was voted the best teacher in mathematics by the students in both polls.

Dr. Au-Yeung is certainly a highly respected teacher, and he is the key figure in the development of linear algebra research in Hong Kong.

4. Other Active Researchers in Hong Kong

The development of linear algebra in Hong Kong has been enhanced by the return of Dr. Raymond Hon-Fu Chan to Hong Kong in 1986. Raymond got his Ph.D degree on numerical linear algebra at New York University (Courant Institute) in 1985 under Professor O. B. Widlund. He joined the Mathematics Department of HKU in 1986, and from 1993 onwards he has beenis senior lecturer of the Mathematics Department of the Chinese University of Hong Kong. Raymond's research interests include numerical linear algebra, fast iterative solvers for Toeplitz systems, numerical PDE's and other related topics. He won the Leslie Fox Prize (for best research paper in numerical analysis) in 1989, awarded by the Institute of Mathematics and Its Applications, UK. After returning to Hong Kong, he has been actively involved in various linear algebra activities. He now leads another research group, mainly working on numerical linear algebra and iterative methods, in the Chinese University of Hong Kong. For a list of graduate students he produced please see Section 5. Another active researcher in linear algebra is Dr. N.N. Chan of the Statistics Department of the Chinese University of Hong Kong. After spending some years in the USA, the second author rejoined HKU in 1993. He has produced a M.Phil. student.

5. List of Graduates in Linear Algebra

Ph.D. students:

by Dr. Au-Yeung

- Bit-Shun Tam, Some aspects of finite dimensional cones, 1978.
- Nam-Kiu Tsing, A study of generalized numerical ranges, 1983.
- Tin-Yau Tam, A study of induced operators on symmetry classes of tensors, 1986.
- Chi-Kwong Li, Some results on generalized spectral radii, numerical radii, and spectral norms, 1986.
- Che-Man Cheng, Some results on eigenvalues, singular values and orthostochastic matrices, 1991.
- Chi-Fai Chan, Some aspects of generalized numerical ranges and numerical radii associated with positive semi-definite functions, 1993.

by Dr. Raymond Chan

- X. Q. Jin, Circulant preconditioners for Toeplitz matrices and their applications in solving partial differential equations, 1992.
- K. P. Ng, Some fast algorithms in signal and image processing, 1995.
- F. R. Lin, Fast iterative methods for Wiener-Hopf equations, 1995.

M.Phil students:

by Dr. Au-Yeung

- Fuk-Yum Sing, Some properties on the singular values and diagonal elements of a matrix, 1977.
- Yiu-Tung Poon, Some results on generalized numerical ranges, 1980.
- Kam-Chuen Ng, Some properties on doubly-stochastic matrices and the distribution of density on a numerical range, 1982.
- Wai-Yip Man, Some properties of C-numerical ranges and C-numerical radii, 1992.

by Dr. Raymond Chan

- K.P. Ng, Fast iterative methods for solving Toeplitz and Toeplitz-like systems, 1992.
- C.K. Wong, Block Toeplitz type preconditioners for elliptic Problems, 1994.
- W.K. Ching, Construction of preconditioners for queuing networks, 1994.
- H.C. Chan, Iterative methods for solving Toeplitz systems generated by rational functions, 1995.

by Dr. Tsing

- Hon-Kwok Fung, Some linear preserver problems in system theory, 1995.

6. Connections with Linear Algebra Communities Worldwide

Besides producing graduate students, Dr. Au-Yeung and Dr. Raymond Chan are building connections with linear algebra groups in other countries. In particular, Dr. Au-Yeung and his colleagues have organized three mini-conferences on matrix theory in Hong Kong in 1991, 1993 and 1995. Dr. Raymond Chan organized the 1995 Winter School on Iterative Methods in Scientific Computing and Their Applications, and also other conferences and meetings on scientific computing.

There is no doubt that research in linear algebra is becoming more and more active. In particular, the linear algebra communities in various Asian countries are growing rapidly. Under this general trend, the Hong Kong linear algebra group will certainly continue to grow healthily, and will contribute to the linear algebra community worldwide.

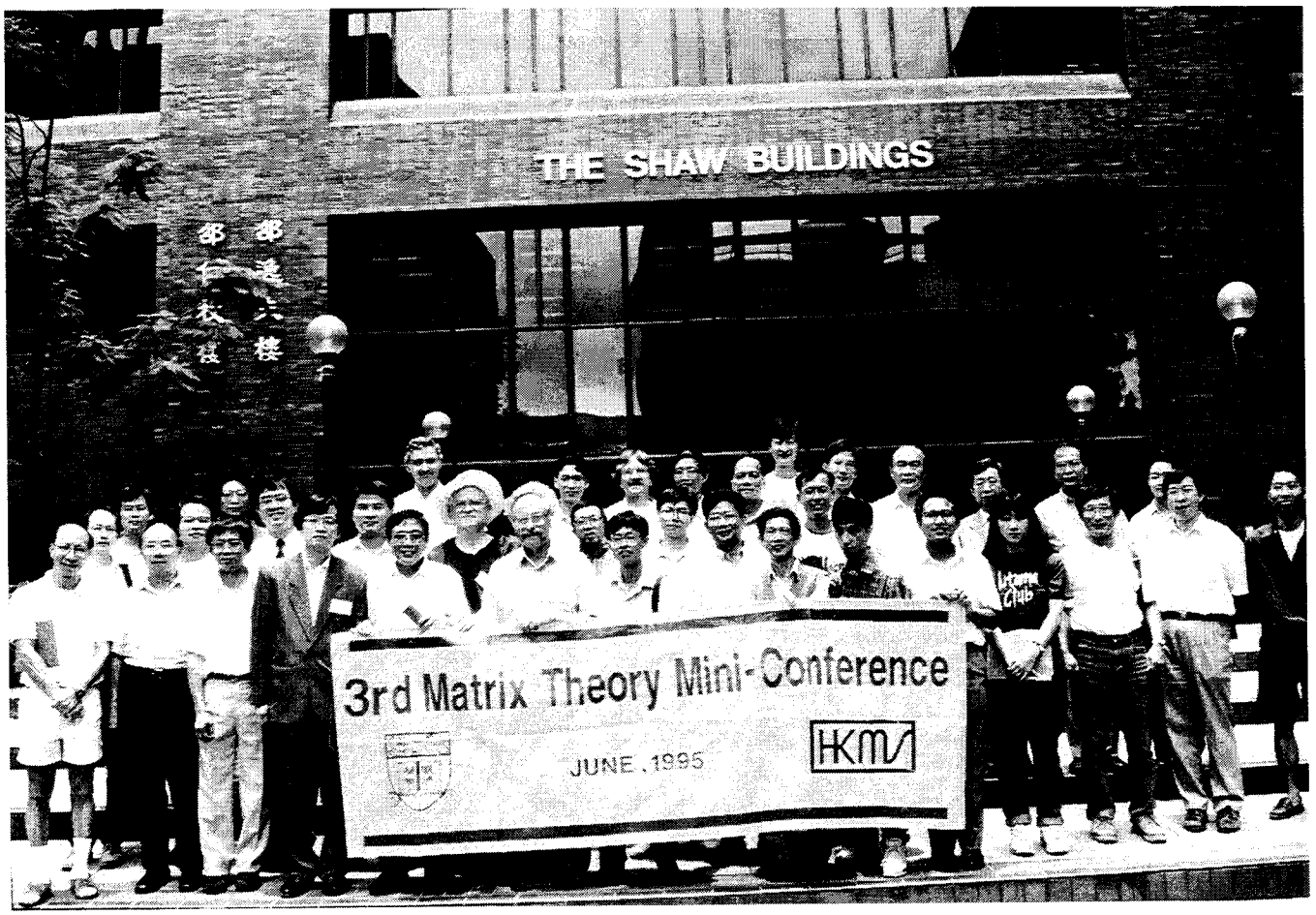
Reports on Linear Algebra Events Attended

3rd Matrix Theory Mini-Conference: Hong Kong: June 29–30, 1995

Report by Nam-Kiu Tsing

The Third Matrix Theory Mini-Conference was held at The University of Hong Kong on June 29–30, 1995. This conference was organized by K. Y. Chan, Y. H. Au-Yeung and N. K. Tsing, and was jointly sponsored by the Mathematics Department of The University of Hong Kong and the Hong Kong Mathematics Society. The aim of this conference was to provide a forum, in particular for local mathematicians, to discuss problems in pure and applied matrix theory. More than forty-five participants from local universities, and from the United States, Japan, China, Taiwan, and Macau attended the conference.

There were four invited talks: Richard A. Brualdi (University of Wisconsin–Madison): Spectral radius of matrices of zeros and ones; Hans Schneider (University of Wisconsin–Madison): Some old-and-new results on inverse M-matrices; Bit-Shun Tam (Tamkang University): Spectrum inclusion regions and invertibility of matrices; and Frank Uhlig (Auburn University): Inverse eigenvalue problems with applications to mechanical systems. Adding to these invited talks were 18 contributed talks on various areas of matrix theory given by: Y. H. Au-Yeung, N. N. Chan, J. C. Chen, Che-Man Cheng, Wai-Shun Cheung, Jie Fang, Hon-Kwok Fung, Charles R. Johnson, Chi-Kwong Li, Luoluo Li, Wen Li, Bolian Liu, Michael K. Ng, K. Okubo, Yiu-Tung Poon, Tin-Yau Tam, N-K Tsing, and Mou-Cheng Zhang.



Utah State University Mini-Conference: Combinatorial Matrix Theory

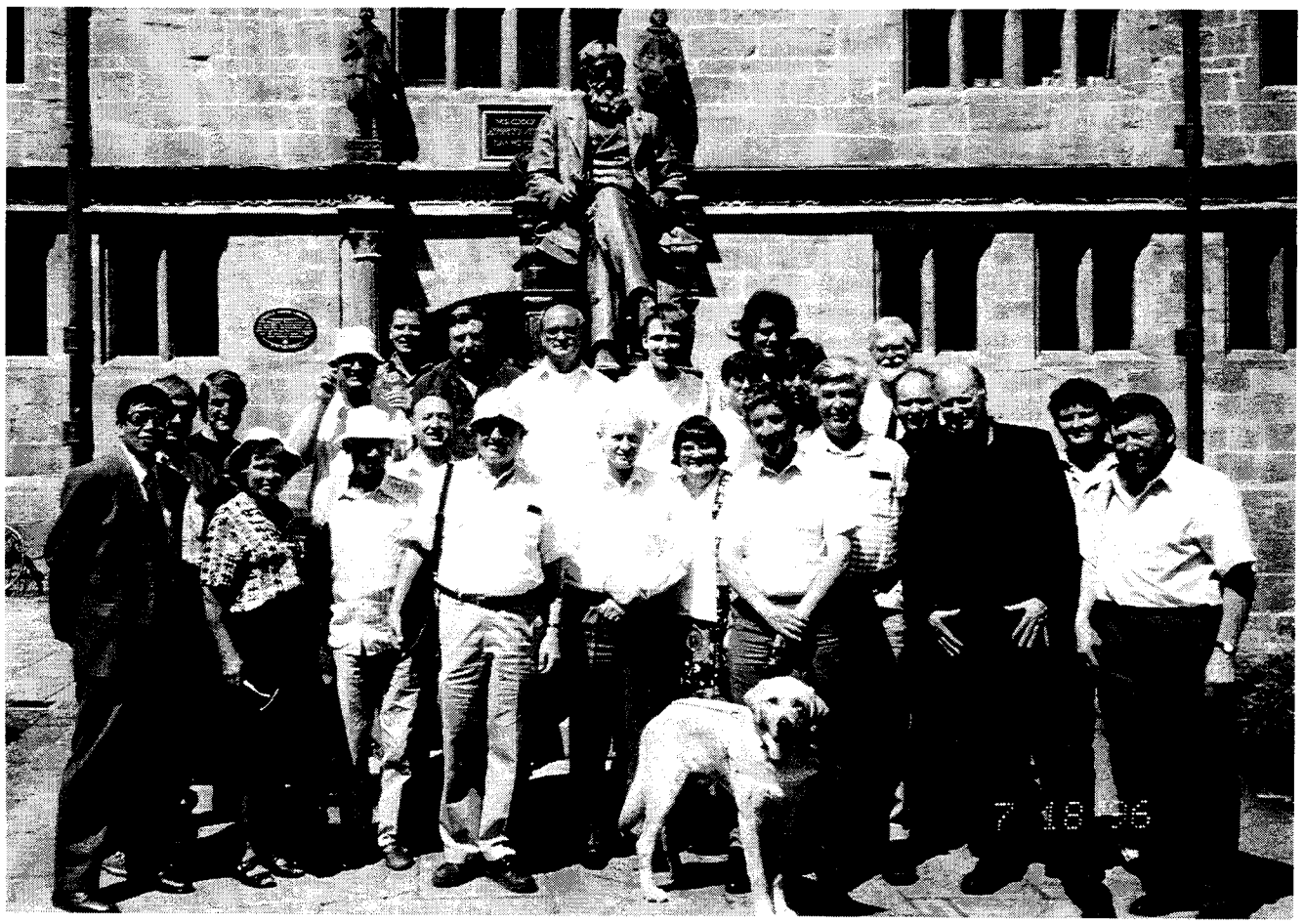
Logan, Utah: May 24–25, 1996—Report by LeRoy B. Beasley

An annual event at the Department of Mathematics and Statistics at Utah State University (USU) is the USU Mini-Conference sponsored by the College of Science and the Vice President for Research at USU. This year the topic was "Combinatorial Matrix Theory" and was organized by LeRoy B. Beasley. This was the third Mini-Conference at USU with a topic in the area of linear algebra, the previous ones being in 1983 and 1987. This year there were 25 participants from the U.S. and Canada. There were five one-hour lectures and five half-hour lectures. The one-hour lectures were presented by David Gregory, Steve Kirkland, John Maybee, Sylvia Monson, and Bryan Shader. The half-hour lectures were presented by Tracy Hall (student at Brigham-Young University), Daniel Nakano, Mohammad Othman Omran (student at Brigham-Young University), Don Robinson and Cindy Wyels. An informal problem session followed the formal lectures. Following the conference, eight of the participants remained at USU for 3 to 5 days for an informal research workshop.

5th International Workshop on Matrix Methods for Statistics

Shrewsbury, England: July 18–19, 1996—Report by George P. H. Styan

The 5th International Workshop on Matrix Methods for Statistics was held at The Gateway Education and Arts Centre in Shrewsbury, Shropshire, England, on Thursday–Friday, July 18–19, 1996. The Organising Committee comprised Richard William Farebrother (Victoria University of Manchester, UK; Chair), Simo Puntanen (University of Tampere, Finland), George P. H. Styan (McGill University, Montreal, Canada), and Hans Joachim Werner (University of Bonn, Germany). Sheila Farebrother (Royal Shrewsbury Hospital) served as Administrative Assistant and Hans Jessen (Victoria University of Manchester) as Editorial Assistant. The participants were: Philip V. Bertrand (University of Birmingham, UK), John S. Chipman (University of Minnesota, Minneapolis, USA), Tom Downs (University of Texas, Houston, USA), Luis Firinguetti (University of Santiago, Chile), John C. Gower (Open University, Milton Keynes, UK), Patrick J. F. Groenen



(University of Leiden, Netherlands), Michael Harrison (Trinity College Dublin, Ireland), Jan Hauke (Adam Mickiewicz University, Poznań, Poland), Berthold Heiligers (Universität Magdeburg, Germany), Erin M. Hodgess (University of Houston-Downtown, USA), Eric Iksoon Im (University of Hawaii, USA), George G. Joseph (Victoria University of Manchester, UK), Augustyn Markiewicz (Agricultural University of Poznań, Poland), Heinz Neudecker (University of Amsterdam, Netherlands), Anthony O'Hagan (University of Nottingham, UK), D. Stephen G. Pollock (Queen Mary and Westfield College London, UK), Peter Šemrl (University of Maribor, Slovenia), George P. H. Styan (McGill University, Montreal, Canada), H. Taeger (Universität Dortmund, Germany), Götz Trenkler (Universität Dortmund, Germany), Sven-Oliver Troschke (Universität Dortmund, Germany), Bart J. van Os (University of Leiden, Netherlands), Song-Gui Wang (Beijing Polytechnic University, China), and Hans Joachim Werner (University of Bonn, Germany). The Welcome Reception was held in the Clive House Museum with the Mayor of Shrewsbury welcoming the participants; a delicious Workshop Dinner was served at the Rowton Castle Hotel on the Thursday followed by a most interesting evening visit to the Wroxeter 'Roman' Vineyard on the Friday—we can definitely recommend the Madeleine Superior! Many thanks go to Sheila Farebrother, without whose enormous help this Workshop would not have been possible. Photograph by Eric Iksoon Im.

Selected Forthcoming Linear Algebra Events

AMS Regional Meeting: Four Sessions on Matrix Theory

Chattanooga, Tennessee: October 11–12, 1996

The AMS Regional Meeting at Chattanooga, Tennessee, October 11–12, 1996, will feature four Sessions on Matrix Theory organized by Jason Li, Ron Smith, and Frank Uhlig. The Invited Speakers are: Session I, Matrix Completions (Friday am): C. R. Johnson, M. Bakonyi, W. Barrett, L. Rodman; Session II, Numerical Linear Algebra (Friday pm): R. Mathias, N. Nachtigal, G. Poole, M. Berry, I. Ipsen, B. Plemmons; Session III, General Linear Algebra and Matrix Theory (Saturday am): T.-Y. Tam, C.-K. Li, T. Markham, T. Pate, F. Zhang; Session IV, Graph Theoretical/Sign Patterned Matrix Theory (Saturday pm): R. Brualdi, F. Hall, P. Gibson, P. Nylen, D. Stanford, C. Eschenbach, J. Weaver There will be other special sessions (see AMS *Notices*), contributed paper sessions, and a special session on Reform in Undergraduate Mathematics Education. Details are available via the AMS web page: `http://www.ams.org` and from the organizers of the special Sessions on Matrix Theory: Jason Li, `matzli@gsusgi2.gsu.edu`; Ron Smith & Shu-An Hu, `rsmith@utc.utcvm.edu` & Frank Uhlig, `uhligfd@mail.auburn.edu`.

Mark Krein International Conference on Operator Theory & Applications

Odessa, Ukraine: August 20–23, 1997

We announce our intention to conduct the commemorative conference on operator theory and applications timed to coincide with the 90th birthday anniversary of one of the distinguished Reformers of Analysis Professor Mark Krein. The conference will be held in Odessa, Ukraine, where the great mathematician's productive period took place. The dates are likely August 20–23, 1997. The aim of the conference is to bring together experts interested in Operator Theory, Function Theory and their applications to Mechanics, Physics, Systems and Control. The main themes of the conference will be recent advances in Operator Theory and Applications and classes of problems related to Mark Krein's creative legacy. At this time funding for the conference is being studied, and we hope that a modest amount of support for some participants will be available. If you are interested in participating or in receiving further announcements, please contact one of the local organisers: Vadim Adamyan, Damir Arov, Genady Popov, Lev Sakhnovich, Institute of Mathematics, University of Odessa, ul. Petra Velikogo 2, 270100 Odessa, Ukraine; `1.krein@imem.odessa.ua`, `2.krein@dtp.odessa.ua`; FAX (380) 482-238200.

International Calendar of Events in Linear Algebra & Related Topics

1996

August 6–9: Sapporo, Japan. 3rd Workshop on Numerical Ranges & Numerical Radii. The Sapporo Guest House. [T Ando, Faculty of Economics, Hokusei Gakuen University, Atsubetsu-ku, Sapporo 004] *See Image 14:42.*

August 12–16: Jilin, China. 2nd China Matrix Theory Conference. Chinese Mathematical Society & Jilin Normal College. [Bit-Shun Tam, Dept of Mathematics, Tamkang University, Tamsui 25137, Taiwan; BSM01@HPAP.TKU.EDU.TW, FAX (886-2) 620-9916] *See Image 15:16.*

August 14–17: Chemnitz, Germany. International Linear Algebra Society (ILAS) Conference. [VL Mehrmann, Fakultät für Mathematik, Technische Universität Chemnitz-Zwickau, PSF 964, D-09009 Chemnitz; FAX (49-371) 531-2657, MEHRMANN@MATHEMATIK.TU-CHEMNITZ.DE, http://www.tu-chemnitz.de/ilas/] *See Image 16:12.*

August 21–24: Leuven, Belgium. 2nd International Workshop on Total Least Squares and Errors-in-Variables Modeling. [Ida Tassens, Dept. of Electrical Engineering, ESAT/SISTA, Katholieke Universiteit Leuven, Kardinaal Mercierlaan 94, B-3001 Leuven-Heverlee; ida.tassens@esat.kuleuven.ac.be, FAX (32-16) 32.19.86] *See Image 16:12.*

August 26–29: Beijing, China. 3rd Gauss Symposium. [WA Rodrigues Jr., Division of Math & Theoretical Physics, Institutum Gaussianum, IMECC-UNICAMP, CP 6065, 13081-970 Campinas SP; WALROD@IME.UNICAMP.BR]

October 9–11: Cœur d'Alene, Idaho. 2nd SIAM Conference on Sparse Matrices. Cœur d'Alene Resort. [SIAM, 3600 University City Science Center, Philadelphia, PA 19104-2688; http://www.siam.org, MEETINGS@SIAM.ORG, FAX (1-215) 386-7999] *See Image 16:13.*

October 11–12: Chattanooga, Tennessee. Four Sessions on Matrix Theory at the AMS Regional Meeting. [Jason Li, matzli@gsusgi2.gsu.edu; http://www.ams.org] *See Image 17:19.*

November 2: Northridge, California. 10th Southern California Matrix Theory Meeting. [Michael G. Neubauer, Dept. of Mathematics, California State University, Northridge, CA 91330; michael.neubauer@csun.edu, FAX (1-818) 677-3634]

1997

June 6–8: Winnipeg, Manitoba. International Linear Algebra Society (ILAS) Symposium: Fast Algorithms for Control, Signals and Image Processing. [Robert J Plemmons, Computer Science Dept., Box 7388, Wake Forest University, Winston-Salem, NC 27109; plemmons@mthcsc.wfu.edu] *See Image 16:13.*

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.*

1998

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

June 3–6: Madison, Wisconsin. International Linear Algebra Society (ILAS) Conference. [Richard A Brualdi, Dept of Mathematics, Univ of Wisconsin, Van Vleck Hall, 480 Lincoln Drive, Madison, WI 53706-1388; FAX (1-608) 262-1402, BRUALDI@MATH.WISC.EDU]

1999

July 19–22: Barcelona, Spain. International Linear Algebra Society (ILAS) Conference. [Richard A Brualdi, Dept of Mathematics, Univ of Wisconsin, Van Vleck Hall, 480 Lincoln Drive, Madison, WI 53706-1388; FAX (1-608) 262-1402, BRUALDI@MATH.WISC.EDU]

2002

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.*

New and Forthcoming Publications in Linear Algebra

High Performance Algorithms for Structured Linear Systems edited by Peter Arbenz, Marcin Paprzycki and Ahmed Sameh

First Call For Papers

A volume in the series "Advances in the Theory of Computation and Computational Mathematics" (published by ABLEX, Norwood, New Jersey). In recent years, knowledge about the high performance solution of structured linear systems has grown rapidly. By structured linear systems we mean large sparse systems assembled from relatively small dense or sparse blocks. Examples of such systems abound in many applications; they can be bidiagonal, tridiagonal, banded, block tridiagonal, almost block diagonal, or arrowhead systems. Our understanding of high performance computing is rather broad and includes vector, RISC as well as parallel architectures. Parallel computers considered can be those of shared or distributed memory architectures, or cluster-based that combine characteristics of both. The volume has three goals. First, it is to summarize the state of the art in the area of high performance solution of structured linear systems. Second, it is supposed to indicate what research directions are perceived as the most important ones for the future. The third and final goal is to provide a collection of algorithms and ideas that may enhance future algorithm development in this area.

In the volume, we hope to cover direct as well as iterative methods. We also hope that a wide spectrum of high performance architectures will be reviewed. It needs to be pointed out that even though we are primarily interested in parallel algorithms for the solution of structured linear systems, high performance algorithms for a single-processor system (each node of a multiprocessor system) are crucial for realizing high performance on parallel platforms. Thus, we will also accept papers with emphasis on single-processor performance (as related to parallel algorithms). It is our goal to present the results in a more unified way than merely assembling papers into a collection. This means, among other things, that the authors of accepted papers may be requested to present their experiments on equivalent linear systems and/or using similar performance metrics. The volume is expected to be published in early 1997. To contribute, please send 6 hard copies of the paper (or preferably, submit your paper electronically—prepared in plain LaTeX or PostScript) by August 31, 1996 to one of the volume editors: Peter Arbenz, Inst. of Computer Science, ETH–Zürich, CH-8092 Zürich, Switzerland, arbenz@inf.ethz.ch; Marcin Paprzycki, Dept. of Mathematics & Computer Science, University of Texas at Permian Basin, Odessa, TX 79762, USA, paprzycki_m@utpb.edu; Ahmed Sameh, Dept. of Computer Science, University of Minnesota, Minneapolis, MN 55455, USA , sameh@cs.umn.edu.

Åke Björck: *Numerical Methods for Least Squares Problems*

Numerical Methods for Least Squares Problems by Åke Björck, SIAM, Philadelphia, 408 pp., ISBN 0-89871-360-9 (P), List US $47.50; SIAM Member Price US$38.00.

Today applications of least squares arise in a great number of scientific areas, such as statistics, geodesics, signal processing and control. This monograph aims at covering the full spectrum of relevant problems and methods in least squares. It collects recent research results and treats methods for solving very large and sparse problems with both direct and iterative methods. It covers updating of solutions and factorizations as well as methods for generalized and constrained least squares problems. The 860 references provide a comprehensive survey of the available literature on the subject. The book should be useful for mathematicians working in numerical linear algebra, computational scientists and engineers, statisticians, and electrical engineers. *Contents:* 1: Mathematical and Statistical Properties, 2: Basic Numerical Methods, 3: Modified Least Squares Problems, 4: Generalized Least Squares Problems, 5: Constrained Least Squares Problems, 6: Direct Methods for Sparse Problems, 7: Iterative Methods, 8: Least Squares Problems with Special Bases, 9: Nonlinear Least Squares Problems.

ATLAST Computer Exercises for Linear Algebra edited by Steven J. Leon, Eugene Herman, and Richard Faulkenberry

ATLAST Computer Exercises for Linear Algebra edited by Steven J. Leon, Eugene Herman, and Richard Faulkenberry, Prentice Hall, in press (expected in August 1996).

The ATLAST collection of computer exercises represents the best creative efforts of the more than 350 faculty members who participated in the thirteen ATLAST workshops offered between 1992 and 1995. Workshop participants designed computer exercises and projects suitable for use in undergraduate linear algebra courses. From the entire ATLAST database of materials, the editors have selected a comprehensive set of exercises covering all aspects of the first course in linear algebra. Each chapter is divided into two sections. The first section consists of shorter exercises and the second section consists of longer projects. The computer exercises are all based on MATLAB. A unique feature of MATLAB is that it is the only major mathematical software package that is based almost entirely on matrices.

A collection of MATLAB routines (M-files) has been developed to accompany this book. Many of these routines are designed to give visual illustrations of important linear algebra concepts such as coordinate systems, linear transformations, and eigenvalues. Other M-files illustrate visual applications such as using linear transformations for computer animations or using matrix factorizations for digital imaging. Still other M-files can be used to generate special structured matrices. Students are then challenged to discover properties of the special matrices. The entire collection of ATLAST M-files can be obtained either from the ATLAST Web page: `http://tango.mth.umassd.edu/ATLAST/ATLAST.html` or by anonymous ftp from `ftp.cis.umassd.edu` (directory: `pub/atlast`) These files are required for many of the exercises and projects in the book. The collection of files will be updated and expanded a few times a year; so check the web page or ftp site periodically for the latest versions.

Of the sixty M-files currently in the collection some of the more interesting files to preview are: 1. TRANSFOR: a utility for visualizing linear transformations. 2. COGAME: a utility for visualizing linear combinations and coordinate systems in the plane 3. Eigshow-a utility for visualizing eigenvalues and eigenvectors of 2×2 matrices. 4. PYR: a utility for studying rotations in three space by examining the pitch, yaw, and roll of an airplane. 5. SVDSHOW: a utility for visualizing the singular value decomposition of a 2×2 matrix. The ATLAST book has computer lab projects for each of these utilities. The book will be published as an inexpensive paperback manual that can be used in conjunction with any of the standard linear algebra textbooks. Unlike other manuals of computer exercises, this collection is a massive collaboration representing a wide variety of views. Publication is scheduled early in August 1996, so it is possible to preview the book and order it for this coming fall.

Shuangzhe Liu: *Contributions to Matrix Calculus and Applications in Econometrics*

Contributions to Matrix Calculus and Applications in Econometrics by Shuangzhe Liu, Tinbergen Institute Research Series, 106. Thesis Publishers, Amsterdam, 1995, xii + 121 pp., ISBN 90-5170-356-2 (P).

Econometrics is heavily dependent on mathematics, statistics and computer science in addition to economic theory. Matrix calculus is a very powerful mathematical tool. In this book, which is the author's PhD thesis, matrix methods and advanced techniques are studied, and new matrix results obtained. Some of these results are applied to selected topics in statistics and econometrics. Mainly Cauchy-Schwarz and Kantorovich-type matrix (trace) inequalities, Hadamard products of matrices and vectors presenting algebraic and statistical properties, the Moore-Penrose inverse and matrix-partitioning methods are involved

Chapter 1 is an introduction. In Chapter 2 the first two sections are devoted to the Cauchy-Schwarz and Kantorovich-type matrix (trace) inequalities and several applications. The third section is a collection of basic Kantorovich-type inequalities. Chapter 3 concentrates on Hadamard products of matrices and vectors presenting algebraic and statistical properties, and applications to a heteroskedastic linear regression model and its estimation. In Chapter 4 the first section derives the probability density of the Moore-Penrose inverse of a random matrix with given distribution. The second presents an estimator of the variance matrix for a multivariate normal distribution. Matrix-partitioning methods are used to study optimal allocations for experiments with mixtures in Chapter 5.

More Books on Linear Algebra and Related Topics: 1995–1996

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 have been published in 1995 or in 1996; this list augments and updates the lists published in *Image* 14:23–26; 15:8–9; 16:20–21. References to reviews in *Mathematical Reviews* [MR] are given in square brackets; (P) denotes paperback and (H) hard cover.

Allenby, R. B. J. T. (1995). *Linear Algebra*. Modular Mathematics Series, Edward Arnold, xii + 227 pp., ISBN 0-340-61044-1 (P).

Brualdi, Richard A., and Shader, Bryan (1995). *Matrices of Sign-solvable Linear Systems*. Cambridge Tracts in Mathematics, no. 116, Cambridge University Press, xii + 298 pp., ISBN 0-521-48296-8 (H).

Das Gupta, S.; Ghosh, J. K.; Mitra, S. K.; Mukhopadhyay, A. C.; Prakasa Rao, B. L. S.; Rao, P. S. S. N. V. P.; Rao, S. B.; and Sarma, Y. R. , eds. (1995). *Selected Papers of C. R. Rao: Volume 3*. New Age International (P) Limited, New Delhi, ISBN 81-224-0774-9, and Wiley, New York, ISBN 0-470-22093-7, x + 437 pp. [Two more volumes expected.]

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

Gohberg, Israel; Kaashoek, Marinus, and van Schagen, Frederik (1995). *Partially Specified Matrices and Operators: Classification, Completion, Applications*. Operator Theory Advances and Applications 79, Birkhäuser, xi + 333 pp., ISBN 3-7643-5259-0 (H).

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

Härdle, W.; Klinke, S.; and Turlach, B. A. (1995). *XploRe: An Interactive Statistical Computing Environment*. Springer-Verlag, xvi + 387 pp., ISBN 0-387-94429-X.

John, J. A., and Williams, E. R. (1995). *Cyclic and Computer Generated Designs*. Second Edition, Monographs on Statistics and Applied Probability 38, Chapman & Hall, xii + 255 pp., ISBN 0-412-57580-9 (H).

Kelley, C. T. (1995). *Iterative Methods for Linear and Nonlinear Equations*. With separately available software. Frontiers in Applied Mathematics 16, SIAM, iv + 165 pp., ISBN 0-89871-352-8 [MR 96d:65002].

Lawson, Terry (1996). *Linear Algebra*. Wiley, xvi + 408 pp., ISBN 0-471-30897-8 (H). [*Student Solutions Manual*, ISBN 0-471-14954-3.]

Leon, Steven J.; Herman, Eugene, and Faulkenberry, Richard, eds. (1996). *ATLAST Computer Exercises for Linear Algebra*. PrenticeHall, in press. *See Image 17:22.*

Naniewicz, Z., and Panagiotopoulos, P. D. (1995). *Mathematical Theory of Hemivariational Inequalities and Applications*. Monographs and Textbooks in Pure and Applied Mathematics, 188, Marcel Dekker, xviii + 267 pp., ISBN 0-8247-9330-7 (H) [MR 96d:47067].

Neter, John; Kutner, Michael H.; Nachtsheim, Christopher J.; and Wasserman, William (1996a). *Applied Linear Regression Models*. Third Edition, Richard D. Irwin, xv + 720 pp. + disk, ISBN 0-256-08601-X.

Neter, John; Kutner, Michael H.; Nachtsheim, Christopher J.; and Wasserman, William (1996b). *Applied Linear Statistical Models*. Fourth Edition, Richard D. Irwin, xv + 1408 pp. + disk, ISBN 0-256-11736-5.

Sharma, Subhash (1996). *Applied Multivariate Techniques*. Wiley, xviii + 493 pp. + disk, ISBN 0-471-31064-6.

Stapleton, James H. (1995). *Linear Statistical Models*. Wiley, xiii + 449 pp., ISBN 0-471-57150-4 (H).

Szidarovszky, Ferenc, and Bahill, A. Terry (1996). *Linear Systems Theory*. CRC Press, xvii + 425 pp., ISBN 0-8493-8013-8.

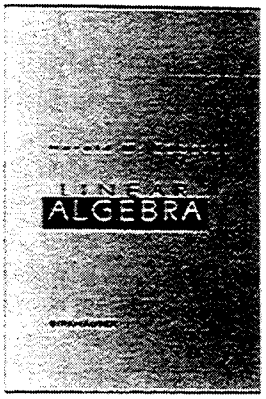
Trapp, Heinz W. (1995). *Einführung in die Algebra: Vektorrechnung, algebraische Grundbegriffe, lineare Algebra*. Universitätsverlag Rasch, Osnabruck, viii + 356 pp., ISBN 3-930595-23-0.

Wicks, John R. (1996). *Linear Algebra: An Interactive Laboratory Approach With Mathematica®*. Addison-Wesley, xxii + 384 pp., ISBN 0-201-82642-9 (P).

Williams, Gareth (1996). *Linear Algebra With Application*. Third Edition, Wm. C. Brown, xix + 556 pp., ISBN 0-697-26849-7.

LINEAR ALGEBRA

Harold M. Edwards, *New York University*



In this undergraduate textbook, Harold Edwards proposes a radically new and thoroughly algorithmic approach to linear algebra. Originally inspired by the constructive philosophy of mathematics championed in the 19th century by Leopold Kronecker, the approach is well suited to students in the computer-dominated late 20th century. Each proof is an algorithm described in English that can be translated into the computer language the class is using and put to work solving problems and generating new examples, making the study of linear algebra a truly interactive experience.

From a review of one of the author's previous books—

"This is the way mathematics should be presented, with an excitement and liveliness that show why we are interested in the subject."

CONTENTS: Preface • Matrix Multiplication • Equivalence of Matrices–Reduction to Diagonal Form • Matrix Division • Determinants • Testing for Equivalence • Matrices with Rational Number Entries • The Method of Least Squares • Matrices with Polynomial Entries • Similarity of Matrices • The Spectral Theorem • Appendix: Linear Programming • Answers to Exercises • Index

1995 184 pp. Hardcover $36.50
ISBN 0-8176-3731-1

TEXTBOOK ADOPTION POLICY—

To request an examination copy, please send your request on departmental letterhead and include the name of your course and current text, estimated class size, and the adoption decision date. Send adoption examination requests to: Birkhäuser, Marketing Dept. Y999, 675 Massachusetts Ave., Cambridge, MA 02139-3309.

Three Easy Ways to Order!

- **CALL:** Toll-Free 1-800-777-4643. In NJ please call 201-348-4033 or FAX 617-876-1272. Your reference number is Y999.
- **WRITE:** Birkhäuser, Marketing Dept. Y999, 675 Massachusetts Ave., Cambridge, MA 02139; E-mail: orders@birkhauser.com
- **VISIT:** Your local technical bookstore or urge your librarian to order for your department.

Remember, your 30-day return privilege is always guaranteed!

Prices are valid in North America only and are subject to change without notice. For price and ordering information outside North America, please contact Birkhäuser Verlag AG, P.O. Box 133, Klosterberg 23, CH-4010, Basel, Switzerland. Fax 41 61 271 7666.

VISIT OUT NEW WEB SITE!
http://www.birkhauser.com

Birkhäuser
Boston • Basel • Berlin

LINEAR ALGEBRA and Its Applications

A Periodic Service for our Readers

UPDATE

In December 1995, Elsevier Science will launch electronic services for **Linear Algebra and Its Applications (LAA)**, complete with current awareness and full text features. The home page will be at:

http://www.elsevier.com/locate/linearalgebra

Two Levels of Access

There will be two levels of access: Current awareness files and full text features. The current awareness will be available to anyone with WWW access. Full text features will be available to researchers at subscribing institutions.

Universally Accessible Current Awareness Features

All researchers with WWW access will be able to access current awareness files as follows:

Tables of Contents of **LAA** issues published complete with lists of authors, titles, and bibliographic citation data arranged by issue/volume. Each article entry will be linked to its abstract.

Forthcoming Articles — Including lists of bibliographic data such as title, author, or acceptance date for papers in production. Article titles will be listed alphabetically in one file and linked to their abstracts.

Abstracts — To be available via links in the Table of Contents and the list of forthcoming articles.

Past and Forthcoming Special Issues — Will be listed along with their tables of contents. Each entry in the file will be linked to its appropriate abstract.

Subscription-Linked Full-Text Features

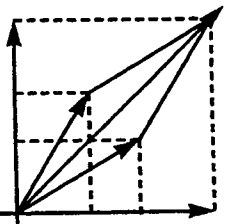
If your domain address matches that of an institution subscribing to **LAA**, you'll be able to access:

Accepted **LAA** articles in LaTeX — Full-text, pre-copyedited preprints will be available for papers submitted in LaTeX. The article files will be linked to their abstracts and will be deleted from the server upon publication. Preprints will consist of full-text versions of pre-copyedited compuscripts submitted in LaTeX.

New services will be added to the **LAA** home page in the months ahead, possibly including a cumulative index and access to supplementary data.

Elsevier Science Inc. **655 Avenue of the Americas** **New York, NY 10010 • (212) 989-5800**

Matrix Algebra *Using MINImal MATlab*



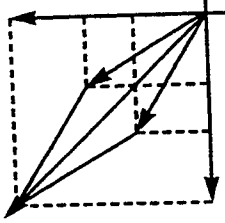
Joel W. Robbin

Robbin has created the ultimate student-friendly book on the subject of matrix algebra. This undergraduate text aims to teach mathematical literacy by providing a careful treatment of set theoretic notions and elementary mathematical proofs. It gives a complete handling of the fundamental normal form theorems of matrix algebra. Use of the computer is fully integrated into Robbin's approach; not only does the book describe the basic algorithms in the computer language MATlab and provide unique computer exercises, it also includes as a part of the complete whole an accompanying diskette and tutorial manual. This text takes the teaching of matrix algebra to the heights of modern instructional techniques and would be the essential foundation to any course on the subject.

Contents

1995
Hardcover, 566 pages
with 3.5" PC disk included
1-56881-024-5
$59.95

Ask about our 25% Examination Copy Discount.



A K Peters, Ltd *Publisher of Science & Technology*

289 Linden Street, Wellesley, MA 02181
617.235.2210, fax 617.235.2404, email akpeters@tiac.net

New Titles in Applied Mathematics from SIAM

Society for Industrial and Applied Mathematics

Linear Differential Operators

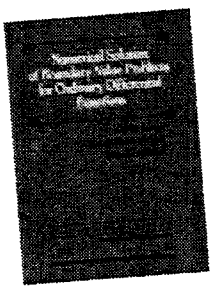
Cornelius Lanczos

Classics in Applied Mathematics 18

Don't let the title fool you! If you are interested in numerical analysis, applied mathematics, or the solution procedures for differential equations, you will find this book useful. Because of Lanczos' unique style of describing mathematical facts in nonmathematical language, *Linear Differential Operators* also will be helpful to nonmathematicians interested in applying the methods and techniques described.

Originally published in 1961, this Classics edition continues to be appealing because it describes a large number of techniques still useful today. Although the primary focus is on the analytical theory, concrete cases are cited to forge the link between theory and practice. Considerable manipulative skill in the practice of differential equations is to be developed by solving the 350 problems in the text. The problems are intended as stimulating corollaries linking theory with application and providing the reader with the foundation for tackling more difficult problems.

Available June 1996 / xviii + 564 pages / Softcover / ISBN 0-89871-370-6
List Price $49.50 / SIAM Member Price $39.60 / ***Order Code CL18***



Numerical Solution of Boundary Value Problems for Ordinary Differential Equations

Uri M. Ascher
Robert M. M. Mattheij
Robert D. Russell

Classics in Applied Mathematics 13

This book is the most comprehensive, up-to-date account of the popular numerical methods for solving boundary value problems in ordinary differential equations. It aims at a thorough understanding of the field by giving an in-depth analysis of the numerical methods by using decoupling principles. Numerous exercises and real-world examples are used throughout to demonstrate the methods and the theory. Although first published in 1988, this republication remains the most comprehensive theoretical coverage of the subject matter, not available elsewhere in one volume.

1995 / xxvi + 595 pages / Softcover / ISBN 0-89871-354-4
List Price $39.50 / SIAM Member Price $31.60 / ***Order Code CL13***

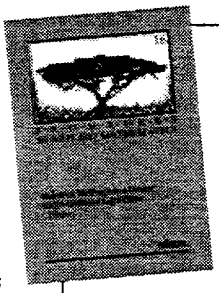
Numerical Solution of Initial-Value Problems in Differential-Algebraic Equations

K.E. Brenan
S.L. Campbell
L.R. Petzold

Classics in Applied Mathematics 14

This book describes some of the places where differential-algebraic equations (DAEs) occur. The basic mathematical theory for these equations is developed and numerical methods are presented and analyzed.

1996 / x + 256 pages / Softcover
ISBN 0-89871-353-6
List Price $29.50
SIAM Member Price $23.60
Order Code CL14



Iterative Methods for Linear and Nonlinear Equations

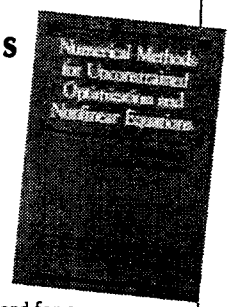
C. T. Kelley

Frontiers in Applied Mathematics 16

Linear and nonlinear systems of equations are the basis for many, if not most, of the models of phenomena in science and engineering, and their efficient numerical solution is critical to progress in these areas. This is the first book to be published on nonlinear equations since the mid-1980s. Although it stresses recent developments in this area, such as Newton–Krylov methods, considerable material on linear equations has been incorporated. This book focuses on a small number of methods and treats them in depth.

The author provides a complete analysis of the conjugate gradient and generalized minimum residual iterations as well as recent advances including Newton–Krylov methods, incorporation of inexactness and noise into the analysis, new proofs and implementations of Broyden's method, and globalization of inexact Newton methods.

1995 / xiii + 165 pages/ Softcover/ ISBN 0-89871-352-8
List Price $32.50 / SIAM Member Price $26.00 / ***Order Code FR16***



Numerical Methods for Unconstrained Optimization and Nonlinear Equations

J. E. Dennis, Jr.
Robert B. Schnabel

Classics in Applied Mathematics 16

This book has become the standard for a complete, state-of-the-art description of the methods for unconstrained optimization and systems of nonlinear equations. Originally published in 1983, it provides information needed to understand both the theory and the practice of these methods and provides pseudocode for the problems. The algorithms covered are all based on Newton's method or "quasi-Newton" methods, and the heart of the book is the material on computational methods for multidimensional unconstrained optimization and nonlinear equation problems. The republication of this book by SIAM is driven by a continuing demand for specific and sound advice on how to solve real problems.

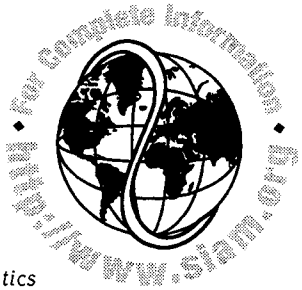
1996 / xvi + 378 pages / Softcover / ISBN 0-89871-364-1
List Price $34.50 / SIAM Member Price $27.60 / ***Order Code CL16***

TO ORDER CALL 1-800-447-SIAM.

Use your credit card (AMEX, MasterCard, and VISA): Call toll free in USA: 800-447-SIAM; Outside USA call: 215-382-9800; Fax: 215-386-7999; E-mail: service@siam.org

Or send check or money order to:
SIAM, Dept. BKIL96, P.O. Box 7260, Philadelphia, PA 19101-7260

Shipping and Handling:
USA: Add $2.75 for first book and $.50 for each additional book. Canada: Add $4.50 for first book and $1.50 for each additional book. Outside USA/Canada: Add $4.50 per book.
All overseas delivery is via airmail.



siam®
Science and Industry Advance with Mathematics

Image Problem Corner

We present solutions to 3 of the 4 problems appearing in our previous Problem Corner [*Image* 16:32 (Winter 1996)] and 3 new problems. We invite readers to submit solutions, as well as new problems, for publication in *Image*. Please send material to George Styan, Joint Editor: *Image*, preferably in LaTeX and by e-mail to `styan@math.mcgill.ca`.

Problem 16-1 [*Image*, 16:32 (Winter 1996)]: **A Determinantal Inequality.**
Proposed by FUZHEN ZHANG, *Nova Southeastern University, Fort Lauderdale, Florida, USA.*

Show that for any square complex matrices X and Y of the same size

$$|\det(X+Y)|^2 \le \det(I+XX^*)\det(I+Y^*Y),$$

where * means conjugate transpose.

Solution by R. B. BAPAT, *Indian Statistical Institute–Delhi Centre, New Delhi, India.*

Let

$$A = \begin{pmatrix} I & X \\ Y^* & I \end{pmatrix}.$$

Then

$$B = AA^* = \begin{pmatrix} I & X \\ Y^* & I \end{pmatrix}\begin{pmatrix} I & Y \\ X^* & I \end{pmatrix} = \begin{pmatrix} I+XX^* & X+Y \\ (X+Y)^* & I+Y^*Y \end{pmatrix}.$$

is positive semidefinite. Hence

$$C = \begin{pmatrix} \det(I+XX^*) & \det(X+Y) \\ \det(X+Y)^* & \det(I+Y^*Y) \end{pmatrix},$$

being a principal submatrix of the nth compound of B, is positive semidefinite. Thus $\det(C) \ge 0$ which gives the desired inequality.

Excellent solutions were also received from Louis Kates (University of Waterloo), Chi-Kwong Li (College of William & Mary), David London (Technion–Haifa), Roy Mathias (College of William & Mary), Ingram Olkin (Stanford University), and from the proposer.

Problem 16-2 [*Image*, 16:32 (Winter 1996)]: **A Hadamard Product Inequality.**
Proposed by FUZHEN ZHANG, *Nova Southeastern University, Fort Lauderdale, Florida, USA.*

Let A be an $n \times n$ complex matrix and let U be an $n \times n$ unitary matrix. Denote the Hadamard product of A and U by $A \circ U = (a_{ij}u_{ij})$ and the largest singular value by $\sigma_{\max}$. Then show that

$$\min_U \sigma_{\max}(A \circ U) \le \frac{1}{\sqrt{n}}\left(\sum_{i,j=1}^{n} |a_{ij}|^2\right)^{\frac{1}{2}}.$$

Solution No.1 by CHI-KWONG LI, *College of William and Mary, Williamsburg, Virginia, USA*

Let $U = n^{-1/2}(w^{ij})$, where w is the nth root of unity. Then U is unitary and for $B = A \circ U$, we have

$$\sigma_{\max}(B)^2 \le \mathrm{tr}(BB^*) = (\sum |a_{ij}|^2)/n.$$

The result follows.

Solution No. 2 by JORMA KAARLO MERIKOSKI & ARI VIRTANEN, *University of Tampere, Tampere, Finland.*

Let $\alpha_1 \geq \cdots \geq \alpha_{n^2}$ be the ordered absolute values of the elements of A. It is easy to see that there is a permutation $\pi \in S_n$ such that $\alpha_1, \ldots, \alpha_{n-1}$ do not belong to $\{|a_{1,\pi(1)}|, \ldots, |a_{n,\pi(n)}|\}$. Therefore

$$\min_{\pi} \max\{|a_{1,\pi(1)}|, \ldots, |a_{n,\pi(n)}|\} \leq \alpha_n.$$

Let P_π be the permutation matrix corresponding to π. Since

$$\sigma_{\max}(A \circ P_\pi) = \max\{|a_{1,\pi(1)}|, \ldots, |a_{n,\pi(n)}|\},$$

the assertion follows easily. So it is enough to let U go through the permutation matrices.

Excellent solutions were also received from David London (Technion–Haifa), Kazuyoshi Okubo (Hokkaido University of Education), and from the proposer.

Problem 16-4 [*Image*, 16:32 (Winter 1996)]: **Algebraic Reverse of a Convex Matrix Inequality.**
Proposed by SHUANGZHE LIU, *University of Amsterdam, Amsterdam, The Netherlands*

Let A and B be two positive definite matrices with eigenvalues contained in the interval $[m, M]$, where $M \geq m > 0$. Let $0 \leq \lambda \leq 1$. Prove that

$$\lambda A^2 + (1-\lambda)B^2 - [\lambda A + (1-\lambda)B]^2 \leq \tfrac{1}{4}(M-m)^2 I.$$

Note that this inequality is a "reverse" of the following convex matrix inequality:

$$0 \leq \lambda A^2 + (1-\lambda)B^2 - [\lambda A + (1-\lambda)B]^2.$$

Solution No. 1 by LOUIS KATES, SERGE KRUK & HENRY WOLKOWICZ, *University of Waterloo, Waterloo, Ontario, Canada.*

Let $C \succeq D$ denote the Loewner partial order on the space of $n \times n$ symmetric matrices, i.e. it denotes $C - D$ is positive semidefinite. First, matrix multiplication yields

$$\lambda A^2 + (1-\lambda)B^2 - (\lambda A + (1-\lambda)B)^2 = \lambda(1-\lambda)(A-B)^2.$$

But $(m-M)I \preceq A - B \preceq (M-m)I$ so that $(A-B)^2 \preceq (M-m)^2 I$. Therefore,

$$\lambda(1-\lambda)(A-B)^2 \preceq \lambda(1-\lambda)(M-m)^2 I \preceq \tfrac{1}{4}(M-m)^2 I.$$

This proves the reverse convex inequality.

Solution No. 2 by INGRAM OLKIN, *Stanford University, Stanford, California, USA.*
Clearly

$$\alpha A^2 + (1-\alpha)B^2 - (\alpha A + (1-\alpha)B)^2 = \alpha(1-\alpha)(A-B)^2 \leq \tfrac{1}{4}(A-B)^2; \quad 0 \leq \alpha \leq 1,$$

while the maximum eigenvalue

$$\lambda_1(A-B) = \max_{x^*x=1} x^*(A-B)x \leq \max_{x^*x=1} x^*Ax + \max_{x^*x=1} x^*(-B)x = M - m.$$

Thus $(A-B)^2 \leq (M-m)^2 I$ and the desired inequality follows.

Excellent solutions were also received from William N. Anderson, Jr. (Baxter Healthcare, Irvine, CA), R. B. Bapat (Indian Statistical Institute–Delhi Centre), Jürgen Groß (Universität Dortmund), Chi-Kwong Li (College of William & Mary), Heinz Neudecker (University of Amsterdam), and from the proposer.

New Problems

Problem 17-1: On the sum of the largest two entries in a matrix. No: $A=\begin{bmatrix}8&1\\0&7\end{bmatrix}$

Proposed by R. B. BAPAT, *Indian Statistical Institute–Delhi Centre, New Delhi, India.*

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

Problem 17-2: On a characterization associated with the matrix arithmetic and geometric means.

Proposed by JÜRGEN GROß, GÖTZ TRENKLER & SVEN-OLIVER TROSCHKE, *Universität Dortmund, Dortmund, Germany.*

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

$$\tfrac{1}{2}(\mathbf{A}+\mathbf{A}^*) = (\mathbf{A}\mathbf{A}^*)^{1/2}?$$

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

Problem 17-3: When does $\mathbf{A}\mathbf{A}^* = \mathbf{B}\mathbf{B}^*$?

Proposed by JÜRGEN GROß, *Universität Dortmund, Dortmund, Germany.*

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

Alexander Craig Aitken: A Biographical Note

Richard William Farebrother, *Victoria University of Manchester*

Alexander Craig Aitken, the author of *Determinants and Matrices* (1939) and the joint author (with Herbert Western Turnbull) of *An Introduction to the Theory of Canonical Matrices* (1932), was born in Dunedin, New Zealand, on 1 April 1895. He was educated at the University of Otago, Dunedin, New Zealand, where he was awarded the degree of M.A. in 1919, having spent the years 1915–1918 as an infantryman in ANZAC. After four years as a school teacher in Otago, he resumed his formal education at the University of Edinburgh, Edinburgh, Scotland, where he was awarded the degree of D.Sc. in 1925 in place of the anticipated Ph.D. He joined the teaching staff of the University of Edinburgh, rising to the rank of Reader. On the retirement of Sir Edmund Whittaker in 1946 Aitken was elected to the vacant chair of mathematics, a post he held until his own retirement in 1965. Aitken died in Edinburgh on 3 November 1967.

References

A. C. Aitken, *Determinants and Matrices*, Oliver and Boyd, Edinburgh (1939) & Greenwood Press, London (1983).

A. C. Aitken, *To Catch the Spirit*, University of Otago Press, Dunedin (1995).

M. S. Bartlett, Aitken's work on statistics, *Biographical Memoirs of Fellows of the Royal Society*, 14, 8–14 (1968).

C. Elliott and R. W. Farebrother, Subject index on obituary notices 1838–1993, *Journal of the Royal Statistical Society (Series A: Statistics in Society)*, 157, 165–171 (1994).

D. G. Kendall, A. C. Aitken's contributions to statistics, *Proc. Edinburgh Mathematical Society (Series 2)*, 16, 156–158 (1968).

W. W. Ledermann, A. C. Aitken's work in pure mathematics, *Proc. Edinburgh Mathematical Society (Series 2)*, 16, 162–166 (1968).

J. C. P. Miller, A. C. Aitken's work in numerical methods, *Proc. Edinburgh Mathematical Society (Series 2)*, 16, 158–162 (1968).

G. J. Tee, Two New Zealand mathematicians, *First Australian Conference on the History of Mathematics*, Monash University, 182–199 (1980).

H. W. Turnbull & A. C. Aitken, *An Introduction to the Theory of Canonical Matrices*, Blackie, London (1932) & Dover, New York, 1961.

J. M. Whittaker, Alexander Craig Aitken, 1895–1967, *Biographical Memoirs of Fellows of the Royal Society*, 14, 1–8 (1968).