I M A G E

The Bulletin of the International Linear Algebra Society

Serving the International Linear Algebra Community
Edited by S. J. Leon and R. C. Thompson

Volume 2 Number 1 (Issue 7) JULY 1991

Group Picture Taken at NIU Conference

SECOND NIU CONFERENCE ON LINEAR ALGEBRA, NUMERICAL LINEAR ALGEBRA, AND APPLICATIONS

Report by James R. Weaver

This excellent conference was held on the beautiful Northern Illinois University campus on May 3 through May 5, 1991. The conference meetings and conference banquet (Hans Schneider was the speaker) were all held at the very pleasant Holmes Student Center on the northeastern side of the NIU campus. The conference was sponsored by the IMA (Minneapolis), ILAS, and NIU's Department of Mathematical Sciences, The Graduate School, the College of Liberal Arts and Sciences, and the College of Continuing Education. The organizer and chairman of this conference was Professor Biswa Nath Datta who opened the conference with a welcome which was followed by a remarks from Dr. Jerrold H. Zarr, Dean of the Graduate School, the Provost of Research Dr. Peter Nichols and Dr. William Blair, chairman of the Department of Mathematical Sciences. Professor Hans Schneider served as an advisor for this meeting which had approximately 80 participants from not only the United States, but from Israel, Ireland, Italy, Portugal, and the USSR. The conference was broken up into approximately 36 half hour talks and 32 contributed talks. The purpose of

this conference was to bring together researchers in linear algebra, numerical linear algebra, and those working in various applications areas for an effective exchange of ideas and discussions of recent developments and future directions of research. The goals stated in this purpose were certainly attained with so many excellent talks and discussions taking place throughout the three day period.

The International Linear Algebra Society held its annual business meeting on May 3, 1991 and at this time it was announced that $10,000 had been donated to ILAS for the "Hans Schneider Linear Algebra Prize" and $1,150 had been donated for use in the "Frank Uhlig Educational Fund."

Research papers from this conference will make up a special issue of *Linear Algebra and Its Applications* with Biswa Nath Datta, Roger Horn, and Robert Plemmons serving as the special editors. The submission deadline for this special issue is August 31, 1991 and papers should be submitted to whichever editor you think is the most appropriate.

Thank you Biswa for setting up and conducting such a fine conference.

ILAS NEWS

ILAS ANNUAL REPORT

by Hans Schneider and Danny Hershkowitz

1. The elections of **Bob Thompson** (Vice President) and **Danny Hershkowitz** (Secretary) were completed this past year and they started their second terms of office on March 1, 1991.

2. Elections for the positions of President (nominee **Hans Schneider**), Treasurer (nominee **Jim Weaver**), and board of directors (nominees **Tom Ando** and **Dave Carlson**) will take place this summer (July 1991).

3. The next nominations and elections will take place in 1992. The process is planned to take less time than in the past.

4. An Education Committee has been formed. It consists of **Dave Carlson** (chairman), **Steve Leon** and **Frank Uhlig**. Among the activities of the Education Committee there is a proposal submitted by **Steve Leon** to the NSF. Also, ILAS is supporting three $400 seed grants for proposals involving educational activities. One grant had been awarded and two more are still available. The money for these grants come from the Frank Uhlig Educational Fund.

5. **Dave Carlson** stepped down from the Advisory Committee and accepted an appointment to the Board of Directors.

6. **Roger Horn** has accepted an appointment to the Advisory Committee, to replace **Dave Carlson**.

7. ILAS has established the Hans Schneider Prize in Linear Algebra. **Roger Horn** and **Danny Hershkowitz** have accepted appointments to the Guidelines Committee for the Hans Schneider Prize.

8. There were two ILAS sponsored meetings since the previous report. These were the 6th Haifa Matrix Conference and the Householder Meeting, both held in June 1990.

9. Future ILAS Meetings are:

a.	Lisbon	(Summer 1992)	Organizer: Jose Dias da Silva
b.	Pensacola	(March 1993)	Organizer: Jim Weaver
c.	Colchester	(August 1993)	Organizer: Stephen Barnett
d.	Rotterdam	(Summer 1994)	Organizer: Harm Bart

10. ILAS has established institutional membership (fees are $150). Elsevier Publishing Company is our first institutional member.

ILAS Treasurer's Report March 1, 1990 – Feb. 28, 1991

Report by James R. Weaver

Balance on hand March 1, 1990					864.94
March 1990					
	Income:	Dues	108.00		
		Contributions	48.00	156.00	
	Expenses:	Service Charge (FL. National Bank)	5.00	5.00	151.00
April 1990					
	Income:	Dues	374.00		
		Contrabutions	24.00	398.00	
	Expenses:	Fl. Dept. of State	50.00		
		Supplies	32.55		
		Service Charge (FL. Nat. Bank)	5.00	87.55	310.45
May 1990					
	Income:	Dues	108.00		
		Contributions	12.00	120.00	
	Expenses:	Sec. of State	40.00		
		Service Charge (FL. Nat. Bank)	5.00	45.00	75.00
June 1990					
	Income:	Dues	156.00		
		Contributions	12.00	168.00	
	Expenses:	Exchange Difference	2.46		
		Mailing	122.84		
		Service Charge (FL. Nat. Bank)	4.65	129.95	38.05
July 1990					
	Income:	Dues	336.00		
		BYU Luncheon	15.00		
		Contributions			
		Education	1000.00		
		Regular	45.00	1396.00	
	Expenses:	Sending of *IMAGE*	24.00		
		Service Charge (FL. Nat. Bank)	4.05	28.05	1367.95
August 1990					
	Income:	Dues	264.00		
		Contributions			
		Education	150.00		
		Regular	203.00		
		Interest	5.90	622.90	
	Expenses:	*IMAGE* #5	896.69		
		(Labor – 15.13)			

	(Printing – 303.50) (Postage – 539.84) (Materials – 38.22) Service Charge (First Union)	1.32	898.01	(275.11)
September 1990				
Income:	Dues	328.00		
	Contributions	38.00		
	Interest (First Union)	10.92	376.92	
Expenses:	Check Returned	14.00		
	Service Charge (First Union)	5.00	19.00	357.92
October 1990				
Income:	Interest (First Union)	10.13	10.13	
Expenses:		00.00	00.00	10.13
November 1990				
Income:	Dues			
	Regular	260.00		
	Institutional	150.00		
	Contributions			
	Prize	10,000.00		
	Regular	30.00		
	Interest (First Union)	13.99	10,553.99	
Expenses:		0.00	0.00	10,553.99
December 1990				
Income:	Dues	180.00		
	Interest (First Union)	26.90	206.90	
Expenses:	Mail	124.32		
	CD (First Nat. Bank of SR)	10,000.00		
	Debit (First Union)	12.00	10,136.32	(9,929.42)
January 1991				
Income:	Dues	252.00		
	Interest (First Union)	12.64	264.64	
Expenses:	Deposit Correction	12.00		
	IMAGE #6	386.06	398.06	(133.42)
	(Printing – 146.00)			
	(Env. – 20.25)			
	(Mailing – 219.81)			
February 1991				
Income:	Dues	230.00		
	Contributions	48.00		
	Interest on CD	135.89		
	Interest (First Union)	11.51	425.40	
Expenses:	Exchange Discount	3.79		
	Returned Check	25.00	28.79	396.00
				3,788.09
February 28, 1991				
Account Balance				
	Checking Account	3,788.09		
	Certificate of Deposit	10,000.00		13,788.09
General Fund		2,502.20		
Frank Uhlig Educational Fund		1,150.00		
Hans Schneider Prize		10,135.89		13,788.09

THE SECOND ILAS MEETING WILL BE HELD ON AUGUST 3–7, 1992 AT THE UNIVERSITY OF LISBON, PORTUGAL

Report by J. A. Dias Da Silva

The Second Meeting of The International Linear Algebra Society (ILAS) will be held at the University of Lisbon, Portugal, on August 3–7, 1992.

There will be about twelve one-hour invited talks and twenty eight half-hour invited talks. Also, we wish to encourage contributed 15–20 minute talks, subject to the unavoidable limitations of space and time. If you are interested in giving a contributed talk at the conference, please send a title and an abstract, to be received by us no later than May 1, 1992. The title and the abstract should be sent to Professor J. A. Dias Da Silva, at the address given below.

A special issue of Linear Algebra and its Applications will be devoted to the meeting. This issue will contain only papers that meet the publication standards of the journal, and that are approved by normal refereeing procedures. The issue will also contain synopses of the talks of those invited speakers who do not submit a paper to the proceedings. Special editors of this issue are Professors J. A. Da Silva, Chi-Kwong Li and G. N. de Oliveira.

Further information about the conference (when available) will be sent upon request. The organizing Committee of the meeting consists of:

Professor J. A. Dias Da Silva (Chair)
Departamento de Matematica
da Universidade de Lisboa
Rua Ernesto de Vasconcelos, Bloco C1
1700 Lisboa, Portugal
E-mail address: mperdiga@ptearn.BITNET

Professor David H. Carlson
Dept. of Mathematical Sciences
San Diego State University
San Diego, CA 92182-0314, U.S.A.
E-mail address: sdsu!carlson@sdcsvax.ucsd.edu

Professor Daniel Hershkowitz
Mathematics Department
Technion - Israel Institute of Technology
Haifa 32000, Israel
E-mail address: MAR23AA@TECHNION.BITNET

Professor Thomas J. Laffey
Mathematics Department
University College, Belfield,
Dublin, 4, Ireland
E-mail address: TLAFFEY@IRLEARN.BITNET

Professor G.N. de Oliveira
Departamento de Matematica
Universidade de Coimbra
3000 Coimbra, Portugal

Professor Hans Schneider
Mathematics Department
Van Vleck Hall
University of Wisconsin-Madison
Madison, WI 53706, U.S.A.

HANS SCHNEIDER AWARD

by Danny Hershkowitz and Roger Horn

In May 1991, Hans Schneider, the ILAS President, announced the establishment of the Hans Schneider Prize in Linear Algebra.

A Guidelines Committee consisting of Danny Hershkowitz and Roger Horn, has prepared the following preliminary draft of guidelines for the prize. The final version of the guidelines should be available later this summer.

THE HANS SCHNEIDER PRIZE IN LINEAR ALGEBRA

PRELIMINARY DRAFT OF GUIDELINES

The Hans Schneider Prize in Linear Algebra ("the Prize") is awarded by The International Linear Algebra Society for research, contributions, and achievements at the highest level of Linear Algebra. The Prize may be awarded for an outstanding scientific achievement or for lifetime contribution.

AWARD DATE AND PERIOD:

The Prize is awarded every three years at an appropriate ILAS conference, as decided upon by the ILAS Executive Board. In any year in which a Prize is awarded, there may be more than one recipient, within the discretion of the ILAS Executive Board.

ELIGIBILITY:

Aside from specific guidelines developed by the Prize Committee, there shall be no restrictions on who may receive the Prize, including without limitation, restrictions with respect to sex, race, national origin, age, or the time since the recipient took his or her last academic degree.

PROCEDURE:

A Prize Committee shall make specific recommendations to the ILAS Executive Board about the choice of recipients. However, recipients shall actually be chosen by the ILAS Executive Board. The ILAS Executive Board may decide on the preferred nature of the Prize each time it is to be awarded, and instruct the Prize Committee to make its recommendations accordingly.

The Prize Committee shall consist of five members who are appointed by the ILAS President upon the advice of the ILAS Executive Board, and the ILAS President as an ex-officio member. The appointments shall be made at least nine months in advance of the Prize award date. The term of office shall be from the date of appointment until the date of the Prize award.

The committee shall solicit nominations for the Prize from the general membership of ILAS, as well as from other members of the scientific community. The ILAS President shall appoint a replacement for any Prize Committee member who is nominated for the Prize and does not remove his/her name from consideration.

The Prize Committee shall notify the ILAS President of its selection at least three months prior to the award date. The notification must be accompanied by a written justification, as well as a citation that can be used for a certificate and read at award time. The ILAS Executive Board may accept, reject, or change the nomination at least three months prior to the award date.

NOTIFICATION OF AWARD:

The ILAS President shall notify the recipient(s) of the Prize at least two months in advance of the award date. An invitation shall also be extended to the recipient(s) to attend the

award ceremony to receive the Prize and to present a talk.

THE PRIZE PRESENTATION:

The ILAS President shall announce the Prize at the chosen conference and present the Prize to the recipient(s) that are present. The recipient(s) is not required to be present to receive the Prize. An announcement of the Prize recipient(s) shall appear in ILAS' printed and electronic media.

DESCRIPTION OF THE PRIZE:

The Prize consists of a plaque and a certificate containing the citation. The ILAS Executive Board may decide to grant the Prize recipient(s) also a cash award and/or to cover all or some of the expenses of the Prize recipient(s) in attending the award ceremony.

THE PRIZE FUND:

The Prize fund consists of a gift of $10,000.00 given to ILAS by Professor Hans Schneider. Other donors may make gifts to the fund. Such gifts shall be added to the principal. The principal amount of the fund has been invested, and earned interest on the principal is used to fund the Prize.

For further information about the award contact:

Danny Hershkowitz (MAR23AA@TECHNION.BITNET) or
Roger Horn (RHORN@JHUVMS.BITNET)

EIGHTH ISSUE OF *IMAGE* PLANNED FOR JANUARY 1992

IMAGE is edited by S. J. Leon and R. C. Thompson. The Production Editor is Ann Cox. News items for the eighth issue should be sent no later than December 7, 1991 to:

Steven J. Leon
Dept. of Mathematics
Southeastern Massachusetts University
North Dartmouth, MA 02747
E-mail: SLEON@SEMASSU.BITNET or SLEON@SEMASSU.EDU
FAX: (508) 999-8901

All news of interest to the Linear Algebra community is welcome including: news of conferences, journals and books, upcoming events, and activities of members. E-mail appears to be the fastest and most efficient way to submit news items.

Future issues of *IMAGE* will contain feature articles on linear algebra activities in other countries. These articles should be no more than three pages in length. If you're a member of ILAS then *IMAGE* is your publication. It needs your support. Please keep us informed about the linear algebra activities in your country.

ILAS-NET

The International Linear Algebra Society also maintains an electronic news service *ILAS-NET* edited by Danny Hershkowitz. If you want to submit news items or to have your name added to the *ILAS-NET* distribution list, send a message to Danny at:

MAR23AA@TECHNION.BITNET

ILAS MEETING ANNOUNCEMENTS

Twice a year the International Linear Algebra Society (ILAS) sends out dues notices. At that time ILAS can also send an announcement or a call for papers of an ILAS MEETING or an ILAS SPONSORED MEETING. The deadlines for submission of these announcements are June 20 and December 1 of each year. Information should be sent to:

James R. Weaver
Department of Mathematics and Statistics
The University of West Florida
11000 University of West Florida
Pensacola, Florida 32514-5751, USA
E-Mail: JWEAVER@UWF.BITNET

ILAS EDUCATIONAL SEED GRANTS

by Dave Carlson and Frank Uhlig

The International Linear Algebra Society (ILAS) announces its intention to award two Seed Grants of $400 each for the 1991–92 year for proposals to improve the teaching of (primarily undergraduate) linear algebra. The purpose of these awards is to encourage work in this area by providing funding to assist individuals in preparing grant proposals and thereby to indicate to granting agencies the support of the linear algebra community for these proposals.

PROCEDURES: To apply for a 1991–1992 ILAS Seed Grant, an individual should submit to:

Professor Frank Uhlig
Mathematics Department
120 Math Annex
Auburn University
Auburn, AL 36849–5307
phones: office 205–844–3641, FAX 205–844–5900, home 205–887–8302
e-mail: FUHLIG@AUDUCVAX.BITNET

a brief (2–5 pages) outline of the grant proposal under preparation, including

1. activities proposed for support in the overall proposal
2. activities proposed for support by the ILAS Seed Grant
3. site(s) of the proposed activities
4. vita of principal investigator(s), including linear algebra teaching experience
5. expected granting agency and program
6. approximate budget

Any individual(s) from any country with experience in teaching linear algebra may apply, whether ILAS member or not. We encourage applications from outside the U.S.

The selection of the awardees will be made by the ILAS President upon the recommendation of the ILAS Education Committee. The deadline for applications for the first 1991–1992 ILAS Seed Grant will be July 1, 1991; this award will be announced by August 1, 1991. The deadline for the second award will be January 1, 1992; this award will be announced February 1, 1992.

Each awardee is asked to send to Professor Uhlig a copy of the grant proposal for which they have received an ILAS Seed Grant. ILAS may use these grant proposals in preparing lists of possible educational activities in linear algebra.

OTHER INFORMATION: Individuals wishing more information about possible grant activites and procedures before applying for an ILAS Seed Grant may contact Professor Uhlig or either of the other members of the ILAS Education Committee:

Professor Dave Carlson
Mathematical Sciences Department
San Diego State University
San Diego, CA 92182-0314
phones: office 619-594-6670, FAX 619-594-6746, home 619-488-2864
email: carlson@math.sdsu.edu

Professor Steve Leon
Mathematics Department
Southeastern Massachusetts University
North Dartmouth, MA 02747
phones: office 508-999-8320, FAX 508-999-8901, home 508-992-5757
e-mail: SLEON@SEMASSU.BITNET or SLEON@SEMASSU.EDU

The U.S. programs which seem most appropriate are

1. NSF Undergraduate Curriculum Development in Mathematics: Calculus. This program is headed by John S. (Spud) Bradley; its next deadline will be early October. (By "calculus" read "calculus and the first two years". This is the program through which the Williamsburg Workshop was funded. It is envisioned that, possibly as part of a broader effort, this program will continue for a long time.)

2. FIPSE (The Fund for the Improvement of Postsecondary Education, in the U.S. Department of Education). This program's next deadline is October 16. FIPSE funds both undergraduate and graduate proposals in a broad set of areas; it "indicates general problems...and invites applicants to address these problems imaginatively".

3. NSF Faculty Enhancement. This program is headed by William Haver; its next deadline will be in April 1992. Please note that NSF cannot award grants to non-American instituitions, although non-American scientists may receive NSF funds under grant to U.S. institutions.

BOARD OF REVIEWERS APPOINTED FOR *IMAGE*

The book review editor for *IMAGE* is **Steven J. Leon**. He has appointed the following individuals to serve on the Board of Reviewers: **Zhaojun Bai**, University of Kentucky, **A. Ben-Israel**, Rutgers University, **Avi Berman**, Technion - Israel Institute of Technology, **Rajendra Bhatia**, Indian Statistical Institute, **Amit Bhaya**, Federal University of Rio de Janeiro, Brazil, **Pieter de Groen**, Vrije Universiteit Brussel, Belgium, **Renato Deleone**, University of Wisconsin, **Bart De Moor**, ESAT - K.U. Leuven, Belgium, **Murli Gupta**, George Washington University, **Melvin Henriksen**, Harvey Mudd College, **Charlie Johnson**, College of William and Mary, **Irving Katz**, George Washington Univ., **Arnold Krauter**, Montanuniversitat Leoben, Austria, **Roy Mathias**, College of William and Mary, **Jorma Merikoski**, University of Tampere, Finland, **Leiba Rodman**, College of William and Mary, **Jeff Stuart**, Univ. of Southern Mississippi, **Daniel B. Szyld**, Temple Univeristy, **Marc Teboulle**, University of Maryland, Baltimore County Campus, **Frank Uhlig**, Auburn University, **David Wood**, University of Delaware, **Pei Yuan Wu**, National Chiao Tung University, Taiwan

SPECIAL SESSION ON NUMERICAL LINEAR ALGEBRA AT AMS MEETING IN PHILADELPHIA, OCTOBER 12–13, 1991

by Daniel B. Szyld

There will be a Special Session on Numerical Linear Algebra at the American Mathematical Society (AMS) meeting 868, in Philadelphia, October 12–13, 1991. Listed below are the speakers and the title of their presentations. Abstracts of these talks will appear in the *Abstracts of the AMS* before the conference. Further information, including hotel and travel directions, will appear in the Notices of the AMS later on this summer. You can also contact the session organizer:
Daniel B. Szyld, Dept. of Mathematics, Temple University 038-16, Philadelphia, PA 19122-2585, e-mail : *szyld@euclid.math.temple.edu*

Jesse L. Barlow, *Error Analysis of Update Methods for the Symmetric Eigenvalue Problem*

Ralph Byers, *Numerical Computation of an Analytic Singular Value Decomposition of a Matrix Valued Function*

Howard Elman, *Parallel Implementation of the hp-version of the Finite Element Method on a Shared-Memory Architecture*

Anne Greenbaum, *Laplace's Equation and the Dirichlet-Neumann Map in Multiply Connected Domains*

Linda Kaufman, *Modifying the Shougen-Shuqin algorithm for the banded Symmetric Generalized Matrix Eigenvalue Problem*

Ivo Marek, *Convergent Iterative Methods to Find Stationary Distribution of Markov Processes*

Carl D. Meyer, *A Direct Method For Solving Unstructured Sparse Linear Systems*

Michael Neumann, *Asynchronous Parallel Iterations for Nonlinear Systems*

Michael Overton, *On the Convex Hull of Projection Matrices*

Ricardo Pantazis, *Parallel Solution of Generalized Band Eigenvalue Problems by Sectioning*

Mordukh Primak, *A Projection Cutting Plane Algorithm for Convex Programming Problems*

Lothar Reichel, *A New Implementation of the GMRES Method*

G. W. Stewart, *Updatable, Rank-Revealing Decompositions*

William Stewart, *Some Convergence Properties of Markov Chains*

Gilbert Strang, *Joint Stability of Two Matrices and their Joint Spectral Radius*

L. N. Trefethen, *Eigenvalues and Pseudo-eigenvalues of Nonsymmetric Random Matrices*

Olof B. Widlund, *Some Recent Results on Schwarz Type Domain Decomposition Algorithms*

MINISYMPOSIA AT THE SIAM CONFERENCE ON APPLIED LINEAR ALGEBRA, MINNEAPOLIS, SEPTEMBER 11–14

A number of minisymposia are planned for the SIAM Conference on Applied Linear Algebra to be held in Minneapolis, Minnesota, September 11–14, 1991. If you are interested in giving a presentation at any of the following minisymposia please contact the organizer to see if they are still accepting papers. For information on other activities at this conference contact Richard Brualdi, Department of Mathematics, University of Wisconsin, Madison, WI 53706, e-mail: brualdi@vanvleck.math.wisc.edu

Minisymposium on Numerical Ranges and Numerical Radii

Report by C. K. Li

As indicated by the title, this minisymposium will focus on the different generalizations of the numerical range and numerical radius. Of particular interest are the applications of the theory to the study of other topics such as linear operators, matrix inequalities, unitary similarity invariant norms, induced operators on symmetry class of tensors, simultaneous diagonalization of Hermitian forms, structured singular values, etc.

For those who are interested in presenting a paper at the minisymposium please contact:

Dr. Chi-Kwong Li
Department of Mathematics
The College of William and Mary
Williamsburg, VA 23185 USA

(No support funds are anticipated for minisymposia participants.)

Minisymposium on Partial Orders and Generalized Inverses

Report by R. E. Hartwig

As indicated by the title, this minisymposium will focus on the various partial orders that come up in pure and applied matrix theory, and their possible interaction with generalized inverses. Of particular interest are the applications of matrix partial orders to other disciplines such as statistics and optimization.

For those who are interested in presenting a paper at the minisymposium, please contact:

Dr. Robert E. Hartwig
Mathematics Department
NC State University
Raleigh NC 27695-8205
e-mail: REH @ NCSUMATH.bitnet
tel: 919-737-2385

Minisymposium on Abstract Algebra and Its Application to Statistical Signal Processing

Report by Salvatore D. Morgera

The aim of this minisymposium is to strengthen the bridge between certain elements of abstract algebra and statistical signal processing, thereby raising the mathematical abstraction of statistical signal processing a notch and rendering the available tools and concepts both simpler and more powerful. The scope is intentionally broad; I expect the minisymposium to address topics ranging from problems in statistical inference, linear and nonlinear systems theory, and optimal filtering theory, to geometrically constrained matching problems arising in computer vision and robotics, as well as topics to be suggested as a result of this announcement.

Those that are interested in presenting a paper at this minisymposium should contact:

Dr. Salvatore D. Morgera
McGill University
Department of Electrical Engineering
Information Networks and Systems Laboratory
3480 University Street
Montreal H3A 2A7 Quebec, CANADA
TEL: (514)398-7137, FAX: (514)398-4470
E-MAIL: sal@brahms.insl.mcgill.ca or morgera@larry.mcrcim.mcgill.ca

It is suggested that E-MAIL or FAX be used to avoid unneccessary delay. Although no support funds are available for Minisymposium participants, our laboratory would consider it a pleasure to invite participants to deliver seminars at McGill, which should help to defray some of the travel cost.

Minisymposium on Centrosymmetric Matrices and their Generalizations

Report by James Weaver

The purpose of this minisymposium is to report on a number of advances in the basic structure, spectral theory, decomposition, and applications of centrosymmetric matrices and their generalizations.

For those who are interested in presenting a paper at the minisymposium please contact:

Dr. James R. Weaver
Dept. of Math/Stat
University of West Florida
11000 University Parkway
Pensacola, FL 32514, USA
email: jweaver@uwf.bitnet

or

Dr. Jeffrey L. Stuart
Dept. of Mathematics
University of Southern Mississippi
Hattiesburg, Mississippi 39406, USA
email: stuart@usmcp6.bitnet

(No support funds are anticipated for minisymposia participants.)

CALENDAR OF COMING CONFERENCES

August 19–23, 1991, Conference on Structured Matrix Theory, Georgia State University, Atlanta, Georgia
Information: Prof. Carolyn Eschenbach, Department of Mathematics and Computer Science, Georgia State University, Atlanta, GA 30303–3083 (See article in *IMAGE* #6)

1991–92 Applied Linear Algebra Year, IMA, University of Minnesota
Emphasis: Fall Quarter: Discrete Matrix Analysis, Winter Quarter: Matrix computations, Spring Quarter: Signal Processing, Systems and Control
Information: R.A. Brualdi, Dept. of Math., Univ. of Wisconsin, Madison, WI 53706, e-mail: brualdi@vanvleck.math.wisc.edu (See article in *IMAGE* #5)

September 11–14, 1991, SIAM Conference on Applied Linear Algebra, Minneapolis, Minnesota
Information: R.A. Brualdi, Dept. of Math., Univ. of Wisconsin, Madison, WI 53706, e-mail: brualdi@vanvleck.math.wisc.edu (See article in *IMAGE* #5)

October 14–18, 1991, IMA Workshop on Sparse Matrix Computations: Graph Theory Issues and Algorithms, University of Minnesota

November 11–15, 1991, IMA Workshop on Combinatorial and Graph-Theoretic, Problems in Linear Algebra, University of Minnesota

January 13–17, 1992, IMA Workshop on Linear Algebra, Markov Chains, and Queuing Models, University of Minnesota

February 24 – March 1, 1992, IMA Workshop on Iterative Methods for for Sparse and Structured Problems, University of Minnesota

April 6–10, 1992, IMA Workshop on Linear Algebra for Signal Processing, University of Minnesota

June 1–5, 1992, IMA Workshop on Linear Algebra for Control Theory, University of Minnesota

August 3–7, 1992, ILAS Conference, Lisbon University, Portugal
Information: See article in this issue of *IMAGE*

March 1993, ILAS Conference, University of West Florida, Pensacola, Florida
Information: See future issues of *IMAGE*

June 1993, Special Month in Linear Algebra, Technion-Israel Institute of Technology, Haifa; Eighth Haifa Matrix Theory Conference, Technion-Israel Institute of Technology, Haifa
Information: A. Berman, e-mail: MAR64AA@TECHNION.BITNET or D. Hershkowitz (MAR23AA@TECHNION.BITNET)

June 1993, 12th Householder Symposium on Numerical Linear Algebra, Lake Arrowhead, California
Information: Gene Golub, Computer Science Dept., Stanford University or Tony Chan, Mathematics Department, UCLA

August 1993, ILAS Conference, University of Essex, Colchester, England
Information: See future issues of *IMAGE*

December 13–17, 1993 International Cornelius Lanczos Centenary Conference, North Carolina State University, Raleigh, North Carolina
Information: R. J. Plemmons, North Carolina State University, Raleigh, NC 27695–8205

Summer 1994, ILAS Conference, Erasmus University, Rotterdam
Information: See future issues of *IMAGE*

REPORTS ON CONFERENCES ATTENDED

THE SEVENTH HAIFA MATRIX THEORY CONFERENCE

Report by Daniel Hershkowitz

The Seventh Haifa Matrix Theory Conference was held on June 3-6, 1991, at the Technion - Israel Institute of Technology, Haifa, Israel. It was the seventh in a series of conferences in Linear Algebra which take place every year in Haifa. The program consisted of three one hour talks and thirty seven half hour talks, all in plenary sessions, covering a wide range of topics in theoretical and applied linear algebra. The participants came from Australia, Canada, Israel, Italy, United States and Germany.

The social activities included a reception as well as a banquet, followed by a lecture of Professor Bertram Mond, Dean of the School of Mathematics and Information Sciences, La Trobe University, Australia, who participated in the conference. There was also a half day tour of Haifa.

The organizing committee of the conference consisted of A. Berman and D. Hershkowitz as co-chairmen, and of M. Goldberg, L. Lerer, R. Loewy and A. Zaks. The conference was sponsored by the Israel Mathematical Union and the International Linear Algebra Society (ILAS). The Eighth Haifa Matrix Theory Conference is planned for June 1993, as a conclusion of a special month in Linear Algebra, organized by the Institute for Advanced Studies in Mathematics at the Technion.

AMS–MAA JOINT MATHEMATICS MEETINGS, SAN FRANCISCO

Report by Steven J. Leon

The AMS–MAA Joint Meetings were held in San Francisco, January 16–19, 1991. The major activities of interest to the linear algebra community were an MAA minicourse on the use of software in teaching linear algebra, a panel discussion on undergraduate linear algebra curriculum, and a session of contributed linear algebra papers. Unfortunately, the session of contributed papers was scheduled at the same time as the panel discussion.

The MAA minicourse was conducted by Eugene Herman and Charles Jepsen, both from Grinnell College, Iowa. Part A of the course was held from 8:00 – 10:00 am on Wednesday, January 16 and Part B was held at the same time the following day. Participants in the minicourse learned to use the linear algebra software package *MAX* which was developed by Eugene Herman and is distributed by Brook/Cole Publishers. The minicourse included an introduction to some of the matrix factorizations used in numerical linear algebra and a discussion of how to incorporate computing exercises into linear algebra courses. Altogether there were 31 participants. In general the presenters received a favorable and enthusiastic response from the audience.

The panel discussion on undergraduate linear algebra curriculum was held Thursday evening, January 17 from 7:00 – 10:00 pm. Actually the program was divided into four parts. First a panel consisting of Duane Porter (moderator), University of Wyoming, David Lay, University of Maryland, Richard Brualdi, University of Wisconsin, Charles Johnson, College of William and Mary, and James Bunch, University of California, San Diego presented the findings of the NSF sponsored Linear Algebra Curriculum Study Group that had been

organized a year earlier. A series of five recommendations were presented based upon the findings of the Study Group. These recommendations were:

1. The syllabus and presentation of the first course in linear algebra must respond to the needs of client disciplines.

2. Math departments should seriously consider making their first course in linear algebra a matrix-oriented course. For many departments this may be a shift in focus rather than a significant change in content.

3. A core syllabus was presented for a matrix-oriented first course in linear algebra. (This core syllabus elicited a considerable amount of discussion and debate from the audiance.)

4. At least one "second course" in matrix theory/linear algebra should be a high priority for every mathematics curriculum.

5. Faculty should consider the needs and interests of students as learners.

6. Faculty should be encouraged to utilize technology in the first linear algebra course.

Next a panel of mathematicians working in applied fields discussed how they used linear algebra in their work and which specific topics they considered to be important. The panel consisted of Alan C. Tucker (moderator), Associate Chair, Department of Applied Mathematics and Statistics, SUNY – Stony Brook, Rosemary E. Chang, Silicon Graphics Computers Systems, Charles Desoer, Dept. of Electrical Engineering and Computer Sciences, University of California, Berkeley, Robert Schreiber, Research Institute for Advanced Computer Science, (RIACS).

The third part of the evening program consisted of discussions by Jane Day, San Jose State University, on pedagogy and Dave Carlson, San Diego State University, on "gems of linear algebra". The program concluded with a MATLAB demonstration by Steve Peirce, San Diego State University.

The linear algebra contributed papers session consisted of ten 15 minute presentations given by Jeongook Kang, Virginia Polytechnic Institute, Chul Kim, University of South Dakota, Boris Reichstein, Catholic University of America, William P. Wardlaw, United States Naval Academy, Zhongshan Li, North Carolina State University, E. A. Schreiner, Western Michigan Univ., Keith Bourque, University of Southwestern Louisiana, Shu-An Hu, University of Connecticut, Wasin So, University of California, Santa Barbara, and Dale Woods, Central State University.

HONG KONG MATRIX THEORY MINI-CONFERENCE

Report by Y. H. Au-Yueng

The Hong Kong Matrix Theory Mini-Conference was held on June 7–8, 1991 at the University of Hong Kong with Yik-Hoi Au-Yeung and Raymond H. Chan as organizers. The mini-conference was sponsored by the University of Hong Kong and the Hong Kong Mathematical Society.

There were 37 registered participants from China, Hong Kong, Macau, Portugal and U.S.A. Among the 17 speakers, the invited speakers were Ji-Cheng Chen, Charles R. Johnson and Graciano de Oliveira.

JOURNAL NEWS

LINEAR ALGEBRA AND ITS APPLICATIONS (LAA)

Special Issues in Progress

Title:	Iterations in Linear Algebra and in Applications Dedicated to G. H. Golub, R. S. Varga, and D. M. Young
Special Editors:	Owe Axelsson, John de Pillis, Michael Neumann, Wilhelm Niethammer, Robert J. Plemmons
To Appear:	LAA Vol. 154/155, August/September 1991
Title:	Algebraic Linear Algebra
Special Editors:	R. M. Guralnick, W. H. Gustafson, L. S. Levy
To Appear:	LAA Vol. 157, October 15, 1991
Title:	Proceedings of Auburn 1990 Conference
Special Editors:	Frank Uhlig, David Carlson
Full Announcement:	See *IMAGE* #3
Submission Deadline:	September 30, 1990
Title:	Proc. of the Sixth Haifa Conference on Matrix Theory
Special Editors:	A. Berman, M. Goldberg, D. Hershkowitz
Submission deadline:	October 1, 1990
Title:	Proc. of the International Workshop on Linear Models, Experimental Designs, and Related Matrix Theory
Special Editors:	J. K. Baksalary and G. Styan
Submission Deadline:	October 31, 1990
Title:	Proc. of the Second NIU Conference on Linear Algebra, Numerical Linear Algebra and Applications
Special Editors:	Biswa Datta and Robert Plemmons
Submission Deadline:	July 31, 1991
Title:	Numerical Linear Algebra in Control, Signals and Systems
Special Editors:	Gregory Ammar, Volker Mehrmann, Nancy K. Nichols, and Paul Van Dooren
Submission Deadline:	July 31, 1992

JOURNAL OF NUMERICAL LINEAR ALGEBRA WITH APPLICATIONS

MANAGING EDITOR: Owe Axelsson, Faculty of Mathematics and Informatics, University of Nijmegen, NL-6525 ED Nijmegen, The Netherlands.

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that include (but are not limited to): Conjugate Gradients like and other iterative methods, Preconditioning Methods, Direct Solution Methods, Numerical Methods for Eigenproblems, Newton-like methods for Nonlinear Equations, Parallel and Vectorizable Algorithms in Numerical Linear Algebra, Applications of Methods of Numerical Linear Algebra in Science, Engineering and Economics.

The Journal emphasizes mathematical rigour in presenting new methods in Numerical Linear Algebra including their analysis and applications. Where it turns out to be difficult to give full mathematical rigour to the presentation, well- chosen numerical test problems can suffice to demonstrate the usefulness of the presented method, if these are accompanied by a discussion and heuristic explanations. The journal also emphasizes analysis of the computational and communication complexity of algorithms in Numerical Linear Algebra when implemented in different computer architectures.

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BOOK REVIEWS

Matrix Perturbation Theory, by G. W. Stewart and Ji-guang Sun, Academic Press, 1990

Review by Roy Mathias, College of William and Mary

The authors announce:

Deriving perturbation bounds is like cutting a diamond. Tap a problem in just the right way and it decomposes into one or two informative expressions. Smash it with a hammer and it shatters in ugly uninformative expressions. One of the purposes of this book is to introduce the reader to the art of deriving perturbation bounds.

They have succeded admirably in this respect. Throughout, the authors have tried to present the ideas and proof techniques as clearly as possible.

In order that the book be self-contained the first two chapters are devoted to preliminaries. The first deals with eigenvectors, projections, angles between subspaces and the QR, CS and singular value decompositions. The second deals with norms (general norms and especially unitarily invariant norms on M_n, which are used a lot in the rest of the book) and metrics on subspaces on C^n. It is nice that the CS decomposition and angles between subspaces, which are usually not covered in linear algebra texts, are discussed here.

In the third chapter the authors consider linear systems and least squares problems. First they consider the sensitivity of the linear system $Ax = b$ when A and b are subjected to perturbations. Next they introduce the notion of 'acute perturbations' and give error bounds for the pseudo-inverse under acute and non-acute perturbations. The last topic in

the chapter is the least squares problem itself. This is the only chapter where component-wise bounds (rather that norm bounds) are considered.

Chapter 4 deals with eigenvalues and most of the results are fairly well-known. It starts with the general theorems of Bauer, Fike, Henrici and Gerschgorin, then moves on to bounds for normal and Hermitian matrices and then finally perturbation bounds for the eigenvalues of Hermitian matrices subjected to arbitrary perturbations. As noted by the authors the monograph [1] is an essential supplement to this chapter.

In Chapter 5 the authors consider the perturbation of invariant subspaces. The basic approach to the perturbation of invariant subspaces of general matrices is to reduce the problem to the solution of a particular nonlinear matrix equation. The Davis-Kahan theory is introduced to deal with Hermitian matrices and invariant subspace problems associated with the singular value decomposition. This is a particularly well written chapter.

Chapter 6 is devoted to the generalized eigenvalue problem (both eigenvalues and invariant subspaces). There is a preliminary discussion of the difficulties associated with the generalized eigenvalue problem and the need for the chordal metric and then results like those in the previous chapter.

Naturally there are a few topics that have been omitted - in particular one might have hoped for more component-wise bounds and some perturbation theory for functions of matrices (e.g., e^A, $A^{1/2}$).

The main text contains the the most important results and proofs that are not too complicated - the generalizations and the more complicated proofs are in the exercises (or are omitted). This makes the book easier to read than it would otherwise have been. The reader never gets bogged down in details, except possibly in the chapter on the generalized eigenvalue problem. There are numerous historical notes at the end of each section - often pointing out that X's Theorem is actually due to Y.

This would be a very good text for an advanced course on matrix perturbation theory. It would also be a good reference for a researcher as it collects the most important results in the subject in one place, presents proofs in a unified manner, gives a few new results, and points out a some open problems. This book was a pleasure to review.

References

[1] R. Bhatia. *Perturbation Bounds for Matrix Eigenvalues.* Pitman Research Notes in Mathematics 162. Longman Scientific and Technical, New York, 1987.

Applications of Matrix Theory, edited by M. J. C. Gover and S. Barnett, Clarendon Press, Oxford 1989, 324+xiii pages

Review by Charles R. Johnson, College of William and Mary

This volume is a collection of refereed papers associated with most of the talks presented at a conference held in Bradford, England in July 1988 with partial support from the British IMA. The focus of the meeting was upon the variety of ways in which matrix theory is applied, and the editors note that this was the first general meeting on matrix theory held in Britain.

The papers of the nine invited speakers (N. Higham, C. Johnson, T. Laffey, D. Limebeer, M. Powell, J. Reid, R. Bailey, J. (Alan) George, and R. Thompson) alone give a good indication of the breadth and depth of "applications of matrix theory". They cover applications in numerical analysis, economics, algebra, control, optimization, statistics, computing, and inequalities. The talks of Bailey and George appear only by abstract (and the talk of Thompson is not included), presumably because they appear elsewhere. In addition there are 18 contributed papers that fit the theme well with further applications in the same areas

and by adding approximation theory, operations research, partial differential equations, and zero location. Many of the papers are quite nice and could provide useful examples and general knowledge in pedagogical and other situations. At least one of the papers represents a fruitful collaboration begun at the meeting (between P. Graves-Morris and this reviewer) and continuing into the present. Another provided the stimulus for much simpler and more general results that suggested a line of inquiry that also continues. This reviewer feels that such occurrences are among the many intellectual benefits of the breadth of the applied importance of matrix theory.

The organizers are to be thanked for hosting a valuable meeting that met important objectives and for providing a nice volume that illustrates some of the power and ubiquity of matrix theory. In their introduction they note the formation of ILAS as one of the symptoms of the research vitality of the field!

Iterative Methods for Large Linear Systems, edited by David Kincaid and Linda Hayes, Academic Press, 1990

Review by Murli Gupti, George Washington University

In October 1988, a conference on Iterative Methods for Large Linear systems was held at the University of Texas at Austin in honour of David Young's 65th birthday. This book contains 17 papers from the conference with the objective of providing "an overview of the state of the art in the use of iterative methods for solving sparse linear systems". It covers a wide spectrum of research topics such as search for optimum parameters, use of hierarchical basis preconditioners, and development of algorithms for vector and parallel computers.

The first two chapters, written by Loyce Adams and Owe Axelsson, deal with multilevel hierarchical basis preconditioners. Next, Garrett Birkhoff and Robert Lynch provide a historical perspective on the use of ELLPACK and ITPACK as research tools for solving elliptic problems. Paul Concus and Paul Saylor describe a conjugate gradient method with circulant preconditioning for solving symmetric positive definite Toeplitz matrices. Louis Ehrlich describes a local relaxation scheme, referred to as Ad-Hoc SOR, for solving nine-point and block difference schemes for certain elliptic equations. Howard Elman and Gene Golub describe block iterative methods for linear systems resulting from two-cyclic discretization of the two- dimensional convection diffusion equations.

In Chapter 7, Gene Golub and John de Pillis consider a two-parameter SOR method where the parameters are obtained using singular value decomposition of a partitioned iteration matrix using red/black ordering. Louis Hageman describes an IQE method for solving the incompressible Navier-Stokes equations discretized using the marker and cell (MAC) method. Robert Lynch describes the Hodie method for automatically computing coefficients of 9-point approximations of second order linear elliptic equations so as to incorporate general linear boundary conditions. Wayne Joubert and Thomas Manteuffel survey polynomial methods for solving nonsymmetric linear systems including Krylov projection methods.

In Chapter 11, David Harrar and James Ortega consider the solution of three-dimensional generalized Poisson equations using SSOR preconditioned conjugate gradient method on vector computers. Dan Marinescu and John Rice present a multilevel asynchronous iteration for partial differential equations using domain decomposition and provide a technique for effectively embedding the multiple levels in a hypercube. Paul Saylor presents an adaptive algorithm for obtaining optimum parameters of Richardson's method for nonsymmetric linear systems. Xiezhang Li and Richard Varga develop a functional equation for the eigenvalues of unsymmetric SOR (USSOR) iteration matrix; this result generalizes and unifies "all" of the recent research on SSOR and USSOR methods applied to a block p-cyclic matrix.

In Chapter 15, Eugene Wachspress solves the ADI minimax problem using the theory of elliptic functions and obtains near optimum parameters for realistic complex spectral regions. Maksymilian Dryja and Olof Widlund describe domain decomposition algorithms for large linear systems corresponding to discrete elliptic problems. In the last chapter entitled "The

Search for Omega", David Young and Tsun-Zee Mai survey the entire spectrum of iterative algorithms and review procedures for choosing iteration parameters. The discussion includes analytic, spectral and adaptive procedures for symmetric as well as nonsymmetric systems.

The book is well designed and contains a list of all 47 papers presented at the conference. An appreciation of Professor David Young also lists the titles of M.S. and Ph.D. theses supervised by him in 30 years.

Introduction to Numerical Linear Algebra and Optimisation. by Philippe G. Ciarlet (with the assistance of Bernadette Miara and Jean-Marie Thomas for the exercises; translated by A. Buttigieg), Cambridge University Press, Cambridge, UK, 1989, xiv + 436 pp. $ 79.50, cloth, ISBN 0-521-32788-1; $ 29.95, paper,.ISBN 0-521-33984-7. A volume in Cambridge Texts in Applied Mathematics.

Review by Zhaojun Bai, University of Kentucky

The book is an admirable attempt to provide "a thorough description, and a rigorous mathematical analysis, of some of the most commonly used methods in Numerical Linear Algebra and Optimisation". It covers a wealth of material from these two exceedingly interactive fields. As the author says, the book is directed to advanced undergraduate and beginning graduate students in pure and applied mathematics, mechanics, and engineering, and also to practicing engineers, physicists, biologists, economists, etc., wishing to acquire a basic knowledge of, or implement, the basic numerical methods.

The first part (215 pages) of the book is concerned with numerical linear algebra. After an introductory Chapter 1, recalling some basic results relating to vectors, matrices and norms, Chapter 2 states the fundamental problems of the numerical linear algebra as solving linear systems of equations and computing the eigenproblem of a matrix, and discusses the concept of the conditioning of these problems. Chapter 3 contains a review of various approximate methods to solve partial differential equations arising in physics that eventually lead to the solution of a linear system or of a matrix eigenvalue problem. The standard direct and iterative methods for solving linear systems of equations are presented in Chapters 4 and 5. Chapter 6 discusses the popular Jacobi and Givens-Householder methods for the symmetric eigenvalue problem and QR algorithm for the nonsymmetric eigenvalue problem.

The second part (195 pages) of the book is devoted to optimisation. It starts by reviewing the basic results of differential calculus, and showing their applications to the characterization (necessary and sufficient conditions) of an optimal point of a function, and then introducing the relaxation, gradient, conjugate gradient and penalty methods for unconstrained and constrained optimisation problems. Chapter 9 covers the general nonlinear programming with the Kuhn-Tucker conditions, duality, and a section on Uzawa's method for constrained convex programming. Finally, Chapter 10 deals with linear programming.

The book is accompanied by a separate issue of exercises of varying degree of difficulty. Many of the exercises contain notable results.

There are also a bibliography (with comments), a fairly detailed and well-explained description of the main notation used, and an index.

No doubt the author has done an excellent job in the rigorous mathematical analysis of the numerical methods. The level of difficulty increases throughout the book. It is a challenge to students. The constant use of terminologies such as Banach, Hilbert and topological spaces in the second half of the book will undoubtedly incur difficulties for the less advanced mathematics majors and the practicing engineers and physicists, etc, although, in principle, it is possible for the reader to specialize the analysis to finite dimensions.

The reviewer is surprised that the author omits the family of quasi-Newton methods which have in some areas dominated the research and practice of solving many optimisation problems.

On the practical side of this book, in my opinion, the author is a little less successful. There is much less detail to guide the reader who wishes to know more about the implemen-

tation of the algorithms. For example, a lot of important details have been omitted in the double shift QR algorithm for solving the nonsymmetric eigenvalue problem. The author appears to have ignored referring to some important sources of software packages such as LINPACK, EISPACK and libraries of mathematical software such as those of NAG (Numerical Algorithms Group) and IMSL (International Mathematical and Statistical Libraries).

On the whole the book is certainly a valuable and welcome addition to the literature. It is a joy to read for those who have a solid background in mathematics. For whose who do not feel comfortable with mathematics, it is a chance to learn, if you are prepared to exert yourself.

Topics in Matrix Analysis by Roger A. Horn and Charles R. Johnson, Cambridge University Press,1991

Review by David H. Wood, University of Delaware

There are three reasons why Horn and Johnson's new book *Topics in Matrix Analysis* and its predecessor *Matrix Analysis* are indispensable. First, the authors cover their topics in depth. Second, they cover nonstandard topics. Third, they organize their material in the style of a textbook. Compared to an encyclopedia, they are more selective and more detailed; compared to exhaustive treatises, they are less selective and less detailed. Horn and Johnson establish a middle ground where they come much more than half way in meeting the reader who wants to *do something* with linear algebra.

To get a overview of the selection of topics covered in *Topics in Matrix Analysis*, we recall what was covered in the first half of their earlier book, *Matrix Analysis*: Review and miscellanea, Eigenvalues, eigenvectors, and similarity, Unitary equivalence and normal matrices, and Canonical forms. These chapter headings give a misleadingly bland impression of the material. An example of the depth of presentation is that Shur's theorem "Every square matrix A is unitarily equivalent to a triangular matrix whose diagonal entries are the eigenvalues of A in a prescribed order," is followed by about two dozen applications and insights (including exposing common false "proofs" of the Cayley-Hamilton theorem), and that's not even counting the illustrative problems at the end of the chapter!

The rest of their previous book consists of chapters that cover obviously useful topics familiar to all of us. However, the main impression you get from reading this book is that there is a lot more to know about these subjects than you realized. The remaining chapters in the earlier book are: Hermitian and symmetric matrices, Norms for vectors and matrices, Location and perturbation of eigenvalues, Positive definite matrices, and Nonnegative matrices.

In the preface to their new book Horn and Johnson deadpan, "This volume ... includes development of further topics that support applications of matrix theory." Yeah, I would say so, too. The chapter headings do not form your standard list of topics: The field of values, Stable matrices and inertia, Singular value inequalities, Matrix equations and the Kronecker product, The Hadamard product, and Matrices and functions. Now you *know* that these topics are not standard and are often treated as disreputable relatives in the literature. Yet this volume is loaded with evidence that these topics have their own special beauty and application areas. In fact, just reading the introduction and motivation sections of each chapter exposes many powerful techniques that are not well known. The topics chosen are covered in depth (for example, M matrices are characterized by a list of eighteen equivalent conditions) but not exhaustively (reference is given to still more conditions and proofs).

Horn and Johnson write in textbook style although their topics are certainly too special to produce significant royalties from sales to university students. However, all of us are students, in a sense, and we benefit greatly from traditional textbook presentation. For example, their two books have a few hundred definitions and a few thousand exercises and problems. By way of contrast, I am thinking of another two volume work which I am convinced contains material that would be of great use to me. In these other volumes the ratio is reversed:

about two hundred exercises are combined with about two thousand definitions that I would have to digest to know what aspects would be useful to me. In this case, I guess, ignorance is bliss. Or if not bliss, at least preferable to the alternative. In Horn and Johnson's books the exercises are easy examples and facts forming an integral part of the text, but with the proofs left to the reader. Naturally, some of their problems develop alternate derivations or extensions of results from the chapter in which they occur. It is a special treasure to find problems presenting key results from a wide range of research papers in a uniform context and notation. The problems are augmented by hints for their solution.

Although we may be placed in the role of students, we do not want to be forced to study things that we do not have to know. The authors carefully maintain an independence of topics, using cross references as needed. Nowadays computers help to generate superb indices that we take for granted; the present index need only to be compared to those of many classic books to realize how important this improvement is. Horn and Johnson also provide a welcome index of notation that gives *definitions* as well as page numbers. The index of notation often refers to the earlier *Matrix Analysis*, but the main index does not. It would be an advantage to have a combined index for both volumes.

Aside from the usual greedy cries for more, more, more, I have another criticism. I like to see problems sequenced and annotated to bring out the *themes* being developed. The model I have in mind is the book that most people refer to facetiously as "*Functional Analysis in the Plane*" or correctly as *Finite-Dimensional Linear Analysis: A Systematic Presentation in Problem Form* by I. M. Glazman and Ju. I. Ljubič (MIT Press, 1974).

I have to add that *Topics in Matrix Analysis* has ugly typesetting. This seems surprising since the quite attractive earlier volume *Matrix Analysis* is from the same publisher. In the new volume, the font seems to have a minimum line width that leads to an ungraceful heaviness in such symbols as $(), \{\}, \oplus, \otimes$, and $\|$. This is compounded by truly clumsy summation and product symbols bearing indices in a font that does not match the font of other indices.

The books *Topics in Matrix Analysis* and the earlier *Matrix Analysis* are sure to become the standard references for the topics they treat. Indeed, when I encounter something unfamiliar in linear algebra the first question I ask is, "Is it in Horn and Johnson?"

References

[1] R. A. Horn and C. R. Johnson, *Matrix Analysis*, Cambridge University Press, 1985, reprinted with corrections 1987

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