Preliminary Program

Fourth SIAM Conference on

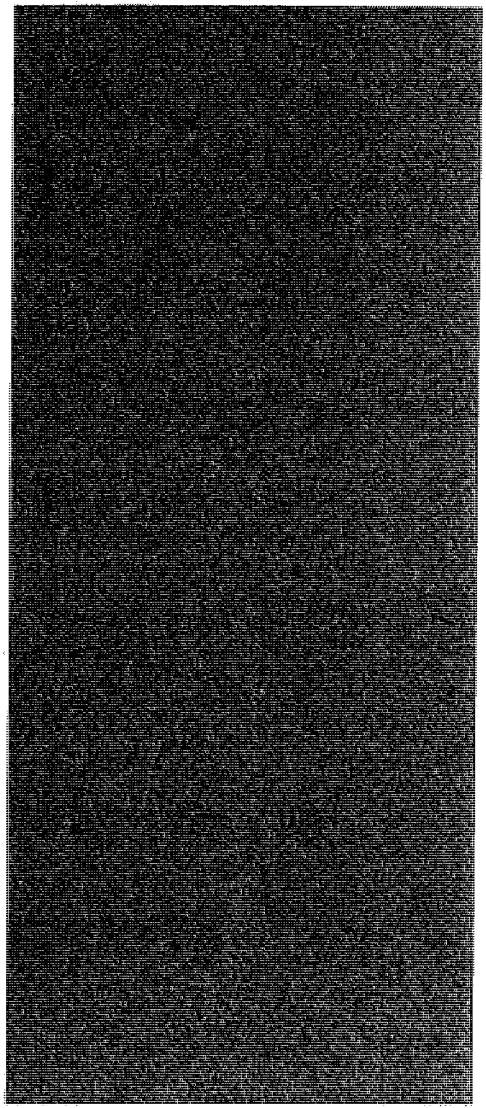
APPLIED LINEAR ALGEBRA

SEPTEMBER 11-14, 1991

Radisson Hotel Metrodome

UNIVERSITY OF MINNESOTA

M•I•N•N•E•A•P•O•L•I•S



- Parallel Matrix Computations
- Direct Methods for Large and Sparse Systems
- Interior Point Methods in Mathematical Programming
- Rational Matrix Functions in Systems Theory
- Core Linear Algebra
- Numerical Methods for Markov Chains
- Signal Processing and Wavelets
- Linear Algebra in Statistics

Sponsored by SIAM Activity Group on Linear Algebra

Contents

Deadline Dates

Hotel Reservations
August 23, 1991

Advance Conference Registration
September 4, 1991

Organizing Committee

Richard A. Brualdi, Chair
University of Wisconsin, Madison

David H. Carlson
San Diego State University

George Cybenko
University of Illinois, Urbana-Champaign

J. Alan George
University of Waterloo, Canada

Gene H. Golub
Stanford University

Roger A. Horn
The Johns Hopkins University

John G. Lewis
Boeing Computer Services

Mitchell B. Luskin
University of Minnesota, Minneapolis

Salvatore D. Morgera
McGill University, Canada

George P.H. Styan
McGill University, Canada

Paul Van Dooren
Philips Research Laboratory, Belgium

Funding Agencies

SIAM is conducting this conference with the partial support of the National Science Foundation and the National Security Agency.

Get-Togethers

SIAM Welcoming Reception
Tuesday, September 10, 1991
7:00 PM - 9:00 PM
Faculty Room
Cash Bar and assorted mini hors d'oeuvres

Banquet
Friday, September 13, 1991
6:30 PM
University Ballroom
Featured Speaker: Alan J. Hoffman,
IBM Thomas J. Watson Research Center

Program Overview

Following are subject classifications for the sessions. The codes in parentheses designate session type and number. The session types are: invited (IP), minisymposium (MS), and contributed (CP).

Numerical and Computational Linear Algebra

Domain Decomposition Methods for Elliptic Problems (MS19, page 10)
Dynamic Condition Estimation (MS13, pages 7&8)
Eigenvalue Problems (CP4, page 5)
Error Analysis and Precision (CP11, page 9)
Iterative Methods for Complex Matrix Problems (MS5, pages 4&5)
Iterative Methods in Linear Algebra (CP19, pages 15-16)
Iterative Methods for Non-hermitian Systems (MS22, page 14)
Lanczos Algorithms for Nonsymmetric Problems (MS9, pages 6&7)
Least Squares Algorithms and Problems (CP3, page 5)
Linear Algebra Models (CP13, page 10)
Matrix Algorithms (CP12, page 9 and CP14, page 11)
Matrix Methods in Dynamic Systems (CP5, page 5)
Matrix Methods in Ordinary Differential Equations and Partial Differential Equations (CP1, page 4)
New Results on Jacobi Methods (MS1, page 3)
Numerical Computation with Toeplitz and Vandermonde Matrices (MS11, page 7)
Parallel Algorithms for Eigenvalue Problems (CP2, page 5)
Parallel Algorithms for Linear Systems (CP16 and CP18, page 15)
Preconditioning and Condition Number (CP7, page 8)
Recent Advances in Solving Eigenvalue Problems (MS15, page 8)
The Design and Analysis of Block Matrix Algorithms (IP1, page 1)

Core Linear Algebra

Basis Free Methods in Linear Algebra (IP7, page 11)
Centrosymmetric Matrices and Their Generalizations (MS25, page 14)
Core Linear Algebra (CP6, page 7)
Determinantal Inequalities and Matrix Completion Problems (MS6, pages 4&5)
Graph-theoretic Spectral Theory (MS14, pages 7&8)
Inequalities and Core Linear Algebra (CP10, pages 7&8)
Matrix Canonical Forms (MS20, pages 10&11)
Matrix Partial Orderings and Generalized Inverses (MS4, pages 3&4)
Numerical Ranges and Numerical Radii (MS7, pages 4&5 and MS21, pages 10 & 11)
Qualitative Aspects of Matrix Theory (MS23, page 14)
Recent Developments on Tournament Matrices (MS16, page 8)
Some Combinatorial Aspects in Matrix Theory (IP8, page 11)

Perturbation Theory

Matrix Perturbation Theory (MS26, page 15)
Spectral Perturbations of Non-Negative Matrices (MS18, pages 10&11)

Matrix Theory in Statistics

Matrix Theory for the Design of Experiments (IP4, page 6)

Matrix Functions, Systems and Control

Applied and Numerical Linear Algebra in Control Theory (MS27, page 15)
Factorization of Matrix Valued Functions with Applications in the Numerical Solution of DAE's and Descriptor Control Problems (MS 8, page 5)
Matrix Functions in Systems and Control (MS2, pages 3&4)
Rational Matrix Functions with Applications to Systems Theory: Interpolation Problems (IP2, page 3)
Systems and Control Theory (CP15, page 14)

Teaching Issues and Pedagogy

Teaching Issues in Linear Algebra (MS3, page 3&4)
Teaching Linear Algebra with Software Tools (MS12, page 7)

Signal Processing

Abstract Algebra and Its Application to Statistical Signal Processing (MS17, page 10)
Multiscale Stochastic Models and Multiscale Statistical Signal Processing (IP2, page 2)
Unitary Hessenberg Matrices (MS24, page 14)

Methods for Sparse Systems

Direct Sparse Methods (MS10, pages 6&7)
Matrix Computations and Sparsity Issues (IP9, page 11)
Sparse Matrix Calculations (CP8, pages 8&9)

Mathematical Programming

Linear Algebra Issues in Interior Methods (IP5, page 9)
Linear Inequalities and Programming (CP10, page 9)

Numerical Methods for Markov Chains

Numerical Methods for Markov Chains (IP3, page 6)

Conference Program

Wednesday Morning, September 11

7:30/University Ballroom Foyer

Registration Desk Opens

8:15/University Ballroom

Welcoming Remarks

Richard A. Brualdi,
University of Wisconsin, Madison

8:30/University Ballroom

IP1 Chair: Gene H. Golub
Stanford University

The Design and Analysis of Block Matrix Algorithms

Block matrix algorithms are rich in matrix-matrix multiplication. In the terminology of LAPACK, this means that most of the floating point operations are performed via level-3 BLA subprograms. This approach has the advantage of high performance and portability for dense problems of numerical linear algebra.

The speaker will survey the status of block algorithms for all the major factorizations. Topics include the delicate art of performance evaluation, GEMM-based BLAS, and the search for a distributed BLAS paradigm. Block ideas in the FFT setting will also be discussed.

Charles Van Loan
Department of Computer Science
Cornell University

9:15/University Ballroom

IP2 Chair: Gene H. Golub
Stanford University

Rational Matrix Functions with Applications to Systems Theory: Interpolation Problems

An important problem in applied mathematics is the determination of rational matrix functions Y(x) from interpolation (local) data. In the context of linear systems theory, such problems are of importance because they can be interpreted as modeling problems (i.e., problems of determining the internal structure of a linear system from external measurements).

If the value of Y(x) at given points of the complex plane is completely specified, we have the matrix interpolation problem. If, however, only a given linear combination of the rows (columns) of Y(x) is specified, we have the left (right) tangential interpolation problem. A combination of these two yields the bitangential interpolation problem. The main objective is to obtain a parameterization of all solutions to these interpolation problems.

The speaker will present an overview of the current state of these interpolation problems, and will then focus on the recursive structure of the solutions. The main result is that the so-called cascade structure, composed of the cascade (feedback) interconnection of appropriately defined two-ports (i.e., systems having two sets of inputs and two sets of outputs) is the common framework for studying all recursive interpolation problems.

Athanasios C. Antoulas
Department of Electrical and Computer Engineering
Rice University

10:00-10:30/University Ballroom Foyer

Coffee

10:30-12:30/Concurrent Sessions (Minisymposia and Contributed)

MS1/University Ballroom

New Results on Jacobi Methods

Fresh interest on Jacobi methods is mainly due to convenient parallelization as well as to newly discovered accuracy advantages. The speakers in this minisymposium will discuss both aspects of this renewed interest.

Organizers: James Demmel, University of California, Berkeley and Kresimir Veselic, Fernuniversität Hagen, Germany

10:30 One-sided Jacobi for Serial and Parallel Computers
Beresford N. Parlett and *Vince Fernando*, University of California, Berkeley

11:00 Efficient Algorithms for the Hermitian Eigenvalue Decomposition on Parallel Architectures
Andrew Anda and Haesun Park, University of Minnesota, Minneapolis and *V. Hari*, University of Zagreb, Yugoslavia

11:30 On the Convergence of the Jacobi Method for Arbitrary Orderings
Walter Mascarenhas, Universidade Estadual de Campinas, Brazil

12:00 Eigenreducing Symmetric Indefinite Matrices
Kresimir Veselic, Organizer

MS2/Hubert Humphrey Room

Matrix Functions in Systems and Control

The development of the theory of matrix valued functions is driven largely by many applications in linear systems, signal processing and control, and is characterized by mutually enriching cross-fertilization of engineering problems and mathematical methods. In recent years, this research area is being extensively studied by mathematicians and engineers, and has achieved remarkable mathematical depth and a diversity of important applications.

The speakers in this minisymposium will highlight some recent achievements in the theory and applications of matrix valued functions.

Organizer: Leiba Rodman
College of William and Mary

10:30 Minimal Degree Coprime Factorization of Rational Matrix Functions
Joseph A. Ball and J. Kang, Virginia Polytechnic Institute and State University; Leiba Rodman, organizer; and M. Verma, McGill University, Canada

11:00 Sylvester and Lyapunov Equations and Some Interpolation Problems for Rational Matrix Functions
Leonid Lerer, Technion-Israel Institute of Technology, Israel and Leiba Rodman, organizer

11:30 Minimal Rank Extension for Structured Matrices and Partial Realization
Israel Gohberg, Tel-Aviv University, Israel; *M.A. Kaashoek*, Vrije Universiteit, The Netherlands; and Leonid Lerer, Technion-Israel Institute of Technology, Israel

12:00 Minimal Factorizations of Rational Matrix Functions with Symmetries
Daniel Alpay, Ben Gurion University, Israel; Joseph A. Ball, Virginia Polytechnic Institute and State University; Israel Gohberg, Tel-Aviv University, Israel; and *Leiba Rodman*, organizer

Minisymposium 2 continues at 2:00 PM. See page 4 for further information.

MS3/Faculty Room

Teaching Issues in Linear Algebra

Rapidly-growing computing power has magnified and transformed applications of linear algebra. At the same time, overly-abstract first courses, taught without the use of computing and without applications, alienate many good students, and hinder them in mastering the subject.

The speakers in this minisymposium will attack these issues from three directions: curricular reform, insights from learning research for linear algebra instructors, and the use of computing in the classroom.

Organizer: David H. Carlson
San Diego State University

10:30 Teaching and Learning College Mathematics; A Review of Research
Joanna Rossi Becker and Barbara J. Pence, San Jose State University

11:00 On the Development of Mathematical Proof
Guershon Harel, Purdue University, West Lafayette

11:30 Gems of Exposition in Elementary Linear Algebra
Charles R. Johnson, College of William and Mary

12:00 A Proposed Syllabus for a First-Course in Linear Algebra
David H. Carlson, organizer

Minisymposium 3 continues at 2 PM. See page 4 for further information.

MS4/Nolte Room

Matrix Partial Orderings and Generalized Inverses

Partial orders go back to Lowner's partial order which is fundamental in the study of definite matrices. With the introduction of the star and minus orders, many other fields of application were opened up. In particular with the introduction of rank subtractivity, Cochran's theorem and its generalizations made their entrance. Partial orders have found use in quadratic forms of random variables, in electrical networks via the so called "generalized means", in the theory of majorization as well as in discrete optimization. Their study has led to the development of the natural order on any semigroup.

Current research has focused on the construction of partial orders via sets of generalized inverses, the relation between partial orders and the sets of eigenvalues and singular values of matrices, the construction of maximal elements, the uses of partial orders in electrical engineering and on quadratic forms of random variables.

The speakers will present recent developments in network theory, universal construction of generalized inverses, and the construction of new partial orders via sets of g-inverses.

Organizer: Robert E. Hartwig, North Carolina State University

10:30 Extremal Definitions of Generalized Inverses
Michael P. Drazin, Purdue University

11:00 **Partial Orders from Electrical Networks**
William N. Anderson, Fairleigh Dickinson University

11:30 **A Determinantal Formula for the Moore-Penrose Inverse**
Donald W. Robinson, Brigham Young University

12:00 **On the Rank of the Commutator of two Projections and the Degree of Non-orthogonality in Experimental Design**
George P.H. Styan, McGill University, Canada

CP1/Regents Room

Matrix Methods in ODE's and PDE's

Chair: Stephen L. Campbell, North Carolina State University

10:30 **Nonlinear Differential Algebraic Equations and Nonlinear Least Squares**
Stephen L. Campbell, North Carolina State University

10:45 **Orthonormal Eigensystems for Cubic Spline Collocation**
Karin R. Bennett, B. Bialecki and G. Fairweather, University of Kentucky

11:00 **A Domain Decomposition Method for Elliptic Saddle Point Problems**
Torgeir Rusten and Ragnar Winther, University of Oslo, Norway

11:15 **Incremental Unknown Method for Discretized Second Order Linear Elliptic Problems**
Min Chen, Indiana University, Bloomington and Roger Temam, Indiana University, Bloomington and Université Paris-Sud, France

11:30 **Embedded Iterative Solution of Nonlinear PDE's on the Connection Machine**
Graham F. Carey and *Wayne D. Joubert*, University of Texas, Austin

11:45 **Conjugate Gradient Method for Fredholm Integral Equations of the Second Kind**
Jose D. Flores, University of South Dakota

12:00 **Deflated Krylov Subspace Methods for Nearly Singular Linear Systems**
Juan C. Meza, Sandia National Laboratories, Livermore

12:15 **Invariance and Commutativity Properties of Some Classes of Solutions of the Matrix Differential Equation**
Jean-Claude Evard, University of Wyoming

Wednesday Afternoon, September 11

12:30
Lunch

2:00-3:30/Concurrent Sessions (Minisymposia)

MS5/University Ballroom

Iterative Methods for Complex Matrix Problems

Complex matrix problems, especially eigenvalue problems for complex matrices or the solution of linear systems with complex coefficient matrices, arise in important applications. For example, they arise in electromagnetics, underwater acoustics, the numerical solution of Schrodinger's equation, quantum chromodynamices, and in the solution of parabolic partial differential equations using higher order schemes.

The speakers in this minisymposium will present a survey of recent research on iterative methods for large complex eigenvalue problems and the solution of large sparse complex linear systems. Since complex matrix problems frequently exhibit special structures, such as complex symmetry, particular emphasis will be placed on iterative methods which exploit such special structures. In some of the talks, implementation on parallel machines will be addressed.

Organizer: Roland W. Freund
RIACS, NASA Ames Research Center

2:00 **Complex Linear Systems and the Effective Solution of Time-dependent Problems**
Efstratios Gallopoulos, University of Illinois, Urbana

2:30 **A General Preconditioned Capacitance Matrix Method for Boundary Value Problems**
David P. Young, R.G. Melvin, and M.B. Bieterman, Boeing Computer Services; F.T. Johnson, J.E. Bussoletti, and G. SenGupta, Boeing Commercial Airplanes

3:00 **An Implementation of the Look-Ahead Lanczos Algorithm for Non-Hermitian Matrices**
Roland W. Freund, RIACS, NASA Ames Research Center; Martin H. Gutknecht, ETH Zentrum, Switzerland; and *Noel M. Nachtigal*, Massachusetts Institute of Technology

Minisymposium 5 continues at 4:00 PM. See page 5 for further information.

MS2/Hubert Humphrey Room

Matrix Functions in Systems and Control (continued)

(See page 3, MS2 for description)

Organizer: Leiba Rodman
College of William and Mary

2:00 **Constant Compensators for Squaring-Down and Output-Feedback Stabilization: A Matrix-Factorization Viewpoint**
Viet X. Le, Hughes Aircraft Company and Michael G. Safonov, University of Southern California

2:30 **Title to be announced**
Madan Verma, McGill University, Canada

MS6/Nolte Room

Determinantal Inequalities and Matrix Completion Problems

Given a partial matrix, one for which some of its entries are specified, the question as to whether the remaining entries can be chosen so that the resulting matrix satifies a particular property is called a matrix completion problem. For example, does a partial matrix with positive specified principal minors have a positive definite completion? The study of the completion which maximizes the determinant is related to a maximum entropy spectral analysis and gives rise to a class of determinantal inequalities generalizing the classical Hadamard-Fischer inequalities. The minisymposium will explore a sample of problems from this rapidly developing field.

Organizer: Wayne W. Barrett, Brigham Young University

2:00 **The Positive Definite Completion Problem for Non-Chordal Graphs**
Wayne W. Barrett and Michael Lundquist, Brigham Young University; Charles R. Johnson and Leiba Rodman, College of William and Mary

2:30 **Determinantal Equalities and Inequalities**
Charles R. Johnson and *Mihaly Bakonyi*, College of William and Mary

3:00 **The Band Method for Several Positive Extension Problems of Non-Band Type**
I. Gohberg, Tel Aviv University, Israel; M.A. Kaashoek, Vrije Universiteit; and *Hugo J. Woerdeman*, College of William and Mary

Minisymposium 6 continues at 4:00 PM. See page 5 for further information.

MS7/Regents Room

Numerical Ranges and Numerical Radii (Part 1 of 2)

Let A be a bounded linear operator A on a Hillbert space $\mathcal{H}$ The (classical) numerical range $W(A)$ of A is the set

$$W(A) = \{\langle Ax, x\rangle : x \in \mathcal{H}, \langle x, x\rangle = 1\},$$

and the (classical) numerical radius $r(A)$ of A is the quantity

$$r(A) = \max\{|z| : z \in W(A)\}.$$

The study of these concepts has a long history and there are many generalizations of them that are related and useful to the study of other subjects. The focus of this minisymposium will be on the applications of the theory of numerical ranges and numerical radii 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, and structured singular values.

Organizer: Chi-Kwong Li, College of William and Mary

2:00 **Numerical Ranges and Numerical Radii: Some Research Problems**
Chi-Kwong Li, organizer

2:30 **Matrix-valued Ranges with Applications to C*-convexity Theory**
Douglas R. Farenick, Université de Montreal, Canada

3:00 **Numerical Radii and Block Matrices**
Roy Mathias, College of William and Mary

Minisymposium 7, Part I continues at 4:00 PM. See page 5 for further information.

MS3/Faculty Room

Teaching Issues in Linear Algebra (continued)

(See page 3, MS3 for description)

Organizer: David H. Carlson, San Diego State University

2:00 **Without Compromise: An Effective Format for a CAI-aided Course in Linear Algebra**
Homer Bechtell, University of New Hampshire

2:30 **The Row-Echelon Decomposition of a Matrix**
Robert M. Corless, David J. Jeffrey and Morton A.H. Nerenberg, University of Western Ontario, Canada

3:00 **A Calculator-Enhanced Course in Linear Algebra**
Donald R. LaTorre, Clemson University

3:30-4:00/University Ballroom Foyer
Coffee

4:00-6:00/Concurrent Sessions

MS5/University Ballroom

Iterative Methods for Complex Matrix Problems (continued)

(See page 4, MS5 for description)

Organizer: Roland W. Freund, RIACS, NASA Ames Research Center

4:00 **The QMR Method for Complex Non-Hermitian and Complex Symmetric Linear Systems**
Roland W. Freund, organizer

4:30 **Conjugate Gradient Methods Applied to Electromagnetic Scattering Problems**
Robert D. Ferraro, Jet Propulsion Laboratory

5:00 **A Parallel Iteration Method and the Convection-diffusion Equation**
John de Pillis, University of California, Riverside

MS8/Hubert Humphrey Room

Factorization of Matrix Valued Functions with Applications in the Numerical Solution of DAE's and Descriptor Control Problems

Factorizations of constant matrices like the Schur decomposition, singular value decomposition or the QR-decomposition are well-studied and good numerical methods are available. These factorizations are important tools for computing eigenvalues, nullspace, condition number, the rank of a matrix etc. They are therefore useful for numerical methods in many different fields of application. In this minisymposium recent developments in the generalization of these methods to matrix valued functions are discussed and applications in different areas are given.

Organizers: Angelika Bunse-Gerstner, Universität Bremen, Germany and Volker Mehrmann, Universität Bielefeld, Germany

4:00 **A Review of Basic Eigenvalue Perturbation Theory for Matrix-Valued Functions of One or More Variables, and Implications for Applications**
Michael L. Overton, Courant Institute of Mathematical Sciences, New York University

4:30 **Analytic Properties of Singular Values and Vectors**
Bart De Moor, Katholieke Universiteit Leuven, Belgium

5:00 **Numerical Computation of an Analytic Singular Value Decomposition of a Matrix Valued Function — Part I**
Angelika Bunse-Gerstner, co-organizer; Ralph Byers, University of Kansas; Volker Mehrmann, co-organizer; and Nancy K. Nichols, University of Reading, United Kingdom

5:30 **Numerical Computation of an Analytic Singular Value Decomposition of a Matrix Valued Function — Part II**
Angelika Bunse-Gerstner, co-organizer; *Ralph Byers*, University of Kansas; Volker Mehrmann, co-organizer; and Nancy K. Nichols, University of Reading, United Kingdom

MS6/Nolte Room

Determinantal Inequalities and Matrix Completion Problems (continued)

(See page 4, MS6 for description)

Organizer: Wayne W. Barrett, Brigham Young University

4:00 **Completing a Matrix with a Partially Prescribed Inverse**
Michael E. Lundquist, Brigham Young University

4:30 **Completion of Partial Upper Triangular Matrices**
Tamir Shalom, Columbia University

MS7/Regents Room

Numerical Ranges and Numerical Radii (Part 1 of 2 continued)

(See page 4, MS7 for description)

Organizer: Chi-Kwong Li, College of William and Mary

4:00 **The Dual Norm of Numerical Radius and Applications**
Kazuyoshi Okubo, Hokkaido University of Education, Japan

4:30 **The Convexity of a Generalized Numerical Range**
Yiu-Tung Poon, Iowa State University

MS4/Faculty Room

Matrix Partial Orderings and Generalized Inverses (continued)

(See page 4, MS4 for description)

Organizer: Robert E. Hartwig, North Carolina State University

4:00 **Partial Orders Induced by Generalized Inverses**
Sujit Mitra, Indian Statistical Institute, India

4:30 **On Partial Orderings of Matrices**
Hans J. Werner, University of Bonn, Germany

CP2/Presidents Room

Parallel Algorithms for Eigenvalue Problems

Chair: Anne Greenbaum, Courant Institute of Mathematical Sciences, New York University

4:00 **A Parallel Algorithm for the Nonsymmetric Eigenvalue Problem**
Jack J. Dongarra and Majed Sidani, University of Tennessee, Knoxville

4:15 **On Parallel Methods for Generalized Symmetric Eigenvalue Problems**
Christopher Beattie and *Calvin J. Ribbens*, Virginia Polytechnic Institute and State University

4:30 **Parallel Solution of the Symmetric Generalized Eigenvalue Problem**
Ricardo D. Pantazis, Duke University and Daniel B. Szyld, Temple University

4:45 **Parallel Householder Tridiagonalization on a Hypercube Using the Torus Wrap Mapping**
Bruce Hendrickson, Sandia National Laboratories, Albuquerque

5:00 **A Fast Parallel Jacobi Algorithm for the SVD of Complex Matrices**
Nariankadu D. Hemkumar and Joseph R. Cavallaro, Rice University

5:15 **An Efficient Parallel Homotopy Algorithm for Eigenvalue Problems of Symmetric Tridiagonal Matrices**
Kuiyuan Li, Tien-Yien Li and *Zhonggang Zeng*, Michigan State University

5:30 **Practical Improvement of the Divide-and-conquer Eigenvalue Algorithms**
Dario Bini, Università di Pisa, Italy and *Victor Pan*, Lehman College, City University of New York, Bronx

5:45 **Parallel Bisection on Vector and SIMD Architectures**
John M. Conroy and Louis J. Podrazik, Institute for Defense Analyses

5:00-6:00/Concurrent Sessions

CP3/Regents Room

Least Squares Algorithms and Problems

Chair: Ilse C.F. Ipsen, Yale University

5:00 **Component-Wise Perturbation Theory for Linear Systems and Least Squares Problems**
Shivkumar Chandrasekaran and *Ilse C.F. Ipsen*, Yale University

5:15 **On Parameter Convergence in Probability for the Method of Recursive Least Squares Algorithms**
Jianwei Miao, New York State Department of Health

5:30 **An Efficient Total Least Squares Algorithm Based on the Rank- Revealing URV Decomposition**
Sabine Van Huffel, Katholieke Universiteit Leuven, Belgium and Hongyuan Zha, Stanford University

5:45 **A Fast QR Decomposition Based RLS Algorithm for Toeplitz Matrices**
Xiadong Luo and *Sanzheng Qiao*, McMaster University, Canada

CP4/Faculty Room

Eigenvalue Problems

Chair: Alan Edelman, University of California, Berkeley

5:00 **Analyzing Failures in Algorithms Using Singularity Theory**
James W. Demmel and *Alan Edelman*, University of California, Berkeley

5:15 **Monotonic, Quadratic Convergence in Computing the Spectral Radius of Nonnegative, Irreducible Matrices**
Dennis Phillips, Davis Hibbard Mayer Norton & Phillips, Inc.

5:30 **Numerical Methods for Inverse Singular Value Problems**
Moody T. Chu, North Carolina State University

5:45 **The Inverse Generalized Eigenvalue Problem**
Qingxiang Yin, Yale University

CP5/Nolte Room

Matrix Methods in Dynamic Systems

Chair: Bryan L. Shader, University of Wyoming

5:00 **Some Matrix Formulations for Damped MDOF Dynamic Systems**
M. Tong, Z. Liang and G.C. Lee, State University of New York, Buffalo

5:15 **On Complex Modes of Linear Dynamic Systems**
Z. Liang and M. Tong, State University of New York, Buffalo

5:30 **Matrix Functions in Second-Order Linear Damped Systems**
Julio Cesar Ruiz Claeyssen, Universidade Federal do Rio Grande Sul, Brazil

5:45 **A New Measure for the Robustness of a System Matrix**
Chia-Chi Tsui, City University of New York, College of Staten Island

CONFERENCE PROGRAM

4:00-6:00/University Ballroom Foyer

Poster Session

Pole Assignment by Output Feedback with Multiple Poles and Prescribed Jordan Form
Ji-cheng Chen, Zhongshan University, People's Republic of China

On Generalized Symmetric Matrix and Generalized Positive Definite Matrix
Chunhai Yu, Jinzhou Teacher's College, People's Republic of China

Improving the Symmetric QR Algorithm by Accelerating the Computation of Eigenvectors
Humberto Madrid, Universidad Autonoma de Coahuila, Mexico

An Integer System of Linear Equation Solver: An Aid for Teaching Linear Algebra
Daniel Gomez-Garcia and *Humberto Madrid*, Universidad Autonoma de Coahuila, Mexico

Roundoff Error in Markov Chain Methods
R. Bruce Mattingly, Youngstown State University

New Algorithms to Robustify the Kalman Filter for High Precision Navigation
Burkhard Schaffrin, Ohio State University

Solving p-Cyclic Problems by the GSII and GSII-SI Methods
Newton R. Santos, Universidade Federal de Minas Gerais, Brazil

Thursday Morning, September 12

8:00/University Ballroom Foyer

Registration Desk Opens

8:30/University Ballroom

IP3 Chair: Paul van Dooren, Philips Research Laboratory, Belgium

Numerical Methods for Markov Chains

Discrete Markov Chains arise in many applications, where the principle numerical problem is to calculate the steady state; i.e., the left eigenvector of the transition matrix corresponding to the eigenvalue one. The problem is unusual in that the eigenvalue in question is known and the problem can therefore be reduced to that of solving a homogeneous linear system. A consequence of this fact is that a wide variety of techniques from numerical linear algebra can be applied to the problem. This talk presents a systematic survey of these techniques and their interrelations.

G.W. Stewart
Computer Science Department
University of Maryland, College Park

9:15/University Ballroom

IP4 Chair: Paul van Dooren, Philips Research Laboratory, Belgium

Matrix Theory for the Design of Experiments

Information matrices in experimental design models are defined as the minimum of a set of matrices, where the minimum is understood relative to the Loewner ordering. Attainment of the minimum is secured by the Gauss-Markov theorem. Information matrices are a special instance of shorted operators, and this relation produces an easy formula for the rank of any given information matrix.

It is also of interest to study the information matrix mapping, which maps a given nonnegative definite matrix into an information matrix. This mapping is matrix upper semicontinuous on the closed cone of nonnegative definite matrices. However it fails to be continuous. Thus information matrices provide a fascinating instance where matrix algebra meets matrix calculus.

The speaker will provide an overview of recent work in this area and describeits application to polynomial regression models. As a side result novel proofs for some classical properties of the Chebyshev polynomials are provided.

Friedrich Pukelsheim
Institute for Mathematics
University of Augsburg, Germany

10:00-10:30/University Ballroom Foyer

Coffee

10:30-12:30/Concurrent Sessions (Minisymposia and Contributed)

MS9/Hubert Humphrey Room

Lanczos Algorithms for Nonsymmetric Problems

The nonsymmetric Lanczos biorthogonalization method can be used to compute eigenvalues of large sparse nonhermitian matrices or to solve large sparse nonhermitian linear systems. It has the attractive feature of a three-term recurrence, while competing iterative solvers based on orthogonalization (e.g., the generalized conjugate gradient and conjugate residual methods) employ much longer recurrences. However, the Lanczos process is susceptible to possible breakdowns and potential instabilities. Recent work has concentrated on a better understanding of the inherent theoretical and numerical problems and aims at overcoming them. Connections to related areas (system theory, error correction, fast Hankel solvers) are also discussed.

Organizer: Martin H. Gutknecht, ETH-Zentrum, Switzerland

10:30 **Linear System Theory Can Illuminate the Lanczos Algorithm**
Beresford N. Parlett, University of California, Berkeley

11:00 **Lanczos Type Methods for Nonsymmetric Linear Systems — Overview**
Martin H. Gutknecht, organizer

11:30 **Lanczos Algorithms for Solving Nonsymmetric Linear Systems of Equations**
Jane K. Cullum, IBM Thomas J. Watson Research Center

12:00 **The Nonsymmetric Lanczos Algorithm and Quasi-Minimal Residual Polynomials**
Roland W. Freund, RIACS, NASA Ames Research Center and Noel M. Nachtigal, Massachusetts Institute of Technology

Minisymposium 9 continues at 2:00 PM. See page 7 for further information.

MS10/University Ballroom

Direct Sparse Methods

The need to solve large sparse matrix problems arises in many important practical applications, such as structural analysis, linear programming, and computational fluid dynamics. Sparse matrix research encompasses research from fields such as numerical linear algebra, graph theory, computer architectures and mathematical software. And, with the advent of vector and parallel supercomputers, the practical use of such advanced machines for direct sparse solutions has posed new and challenging problems in large scale scientific computing.

The speakers in this minisymposium will discuss direct methods for the solution of sparse linear systems. Particular attention will be given to the exploitation of the current generation of supercomputers in sparse solutions.

Organizer: Joseph W.H. Liu, York University, Canada

10:30 **Some Recent Developments in Multifrontal Methods**
Iain S. Duff, Rutherford Appleton Laboratory, United Kingdom

11:00 **Exploiting Structural Symmetry in a Sparse Partial Pivoting Code**
Stanley C. Eisenstat, Yale University

11:30 **Dynamic Programming on a Shared-Memory Multiprocessor**
Phil Edmonds, Eleanor Chu and *J. Alan George*, University of Waterloo, Canada

12:00 **Parallel Preordering for Sparse Factorization**
John Gilbert, Xerox Palo Alto Research Center

MS11/Faculty Room

Numerical Computation with Toeplitz and Vandermonde Matrices

Numerical linear algebra problems involving Toeplitz and Vandermonde matrices arise in a wide variety of application areas. Algorithms which use the special form of these matrices have been developed for the solution of linear equations, and in the case of Toeplitz matrices, for eigenvalue computation as well. We are still a long way from a full understanding of these algorithms. Issues such as numerical stability, backward errors analysis, and relative efficiencies of the various algorithms remain to be resolved.

The speakers in this minisymposium will highlight the current state of the art algorithms for linear system and eigenvalue computation involving Toeplitz and Vandermonde matrices and provide some insight into our understanding of these algorithms.

Organizer: James M. Varah, University of British Columbia, Canada

10:30 **Inversion of Toeplitz Matrices**
Tamir Shalom, Columbia University

11:00 **Stability of Fast Vandermonde System Solvers**
Nicholas J. Higham, University of Manchester, United Kingdom

11:30 **Spectral Properties of Real Symmetric Toeplitz Matrices**
William F. Trench, Trinity University

12:00 **Backward Error Estimates for Toeplitz and Vandermonde Systems**
James M. Varah, organizer

MS12/Nolte Room

Teaching Linear Algebra with Software Tools

Linear algebra is a cornerstone of applied mathematics. Thus it is incumbent upon the mathematical community to develop high quality instructional sequences for linear algebra. Recent software packages give us opportunities for aiding in this process. This minisymposium will present a sample of current instructional uses for a variety of software packages for linear algebra courses at various levels. Speakers have been asked to discuss specific course areas where software is heavily used and give an overview of the instructional strategies used. It is hoped that the talks will foster an exchange of ideas and provide a basis for discussions.

The speakers in this minisymposium will provide a forum for experiences in using software as an aid in linear algebra instruction. With a variety of quality software packages available, it is important to disseminate information about their use in linear algebra and hear first hand from those actively involved in their use.

Organizer: David R. Hill, Temple University

10:30 **Using MAPLE in Freshman Linear Algebra Teaching**
John W. Auer, Brock University, Canada

11:00 **Teaching Linear Algebra with Instructional Tools and Experiments in MATLAB**
David R. Hill and *David E. Zitarelli*, Temple University

11:30 **Using Mathematics in Linear Algebra**
A.D. Andrew and *T.D. Morley*, Georgia Institute of Technology

12:00 **MATLAB and the Numerical Range**
Roger Lautzenheizer, Rose-Hulman Institute of Technology

CP6/Regents Room

Core Linear Algebra 1

Chair: Bart De Moor, Katholieke Universiteit Leuven, Belgium

10:30 **Generalizations of the Singular Value and QR Decomposition**
Bart De Moor, Katholieke Universiteit Leuven, Belgium

10:45 **A Theory of Types for Minors**
Mark Kauderer, University of Texas, San Antonio

11:00 **Matrix Approach to the Quadratic Equation**
Mark Kauderer, University of Texas, San Antonio

11:15 **Graph-theroetic Interpretation of the Resolvent of a Square Matrix**
Kurt J. Reinschke, Hochschüle für Bauwesen Cottbus, Germany

11:30 **Partially Zero Jordan Chains**
Jeffrey L. Stuart, University of Southern Mississippi

11:45 **Collatz-Wierlandt Numbers in General Partially Ordered Spaces**
Ivo Marek, Charles University, Czechoslovakia

12:00 **Sparse Integer Matrices in Topology**
Mark W. McConnell, Oklahoma State University

12:15 **Idempotence for Sign Pattern Matrices**
Carolyn Eschenbach, University of South Carolina

Thursday Afternoon, September 12

12:30
Lunch

2:00-3:30/Concurrent Sessions (Minisymposia)

MS9/Hubert Humphrey Room

Lanczos Algorithms for Nonsymmetric Problems (continued)

(See page 6, MS9 for description)

Organizer: Martin H. Gutknecht, ETH-Zentrum, Switzerland

2:00 **Error Correction via the Lanczos Process**
Daniel L. Boley, University of Minnesota, Minneapolis; Richard P. Brent, Australian National University, Australia; Gene H. Golub, Stanford University; and Franklin T. Luk, Cornell University

2:30 **Experience with a Fast Stable Sylvester Solver**
Stan Cabay and *Ron Meleshko*, University of Alberta, Canada

MS13/University Ballroom

Dynamic Condition Estimation

The process of estimating matrix condition numbers in a dynamic situation is important in many areas of numerical linear algebra. For instance it is useful to track the condition number of the computed factor **R** of a matrix **A** in **QR** factorization schemes. An incremental scheme for estimating the conditioning as **R** is computed is important. On the other hand, one often needs to track the condition of low rank modifications to a symmetric positive definite matrix **A** over time, as **R** is updated or downdated. In this case adaptive condition estimation is important.

In this minisymposium, the speakers will describe recent work in designing fast and robust dynamic condition estimation schemes. These schemes include incremental condition estimation by Bischof, adaptive condition estimation for symmetric rank-one modifications by Pierce and Plemmons, adaptive condition estimation for rank-one updates of QR factorizations by Shroff and Bischof, general adaptive condition estimation using Lanczos methods by Ferng, Golub and Plemmons, and rank revealing QR factorizations and some applications by Chan and Hansen.

Organizer: Robert J. Plemmons, Wake Forest University

2:00 **Incremental Condition Estimation**
Christian H. Bischof, Argonne National Laboratory

2:30 **Adaptive Lanczos Methods for Recursive Condition Estimation**
Gene H. Golub, Stanford University; William Ferng, North Carolina State University; and Robert J. Plemmons, organizer

3:00 **Fast Adaptive Condition Estimation**
Daniel J. Pierce, Boeing Computer Services and Robert J. Plemmons, organizer

Minisymposium 13 continues at 4:00 PM. See page 8 for further information.

MS14/Faculty Room

Graph-theoretic Spectral Theory

Graph theoretic spectral matrix theory concerns the relationship of various spectral properties of matrices (such as their eigenvalues, eigenvectors, ranks, and indices) with their graph theoretic properties (such as their patterns). In recent years the emphasis has been on nonnegative matrices or M-matrices, and this is now being broadened to general matrices. Other topics of current interest concerning M-matrices are splittings and special types of nonnegative bases for the generalized nullspace.

Organizers: Daniel Hershkowitz, Technion-Israel Institute of Technology, Israel and Hans Schneider, University of Wisconsin, Madison

2:00 **Combinatorial Eigenvalues of Matrices**
John S. Maybee, University of Colorado, Boulder; D. Dale Olesky, *Michael J. Tsatsomeros*, and P. van den Driessche, University of Victoria, Canada

2:30 **Principal Components of Minus M-Matrices**
Michael Neumann, University of Connecticut, Storrs; and Hans Schneider, University of Wisconsin, Madison

3:00 **Graph-dependent and Graph-independent Spectral Properties**
Daniel B. Szyld, Temple University and Ivo Marek, University Karlovy, Czechoslovakia

Minisympsium 14 continues at 4:00 PM. See page 8 for further information.

CONFERENCE PROGRAM

MS15/Nolte Room

Recent Advances in Solving Eigenvalue Problems

EISPAC implements very stable methods for small dense eigenvalue problems. These are eigenvalue problems that are not easily handled by EISPAC or by LAPACK. The speakers in this session will present methods for solving such problems. They will discuss methods for solving the banded generalized eigenvalue problem, which arises often in methods for solving partial differential equations, the tridiagonal nonsymmetric problem, very large problems that are not amenable to the techniques in EISPAC or LAPACK, and nonsymmetric problem where one knows that the eigenvalues are real. These methods take advantage of some property for the problem to produce an algorithm which is more efficient than those appearing in the common packages.

Organizer: Linda Kaufman, AT&T Bell Laboratories

2:00 **Modifying the Shougen-Shuqin Algorithm for the Banded Symmetric Generalized Matrix Eigenvalue Problem**
Linda Kaufman, organizer

2:30 **Calculating the Eigenvalues and Eigenvectors for a General Matrix Reduced to Tridiagonal Form**
George A. Geist, Oak Ridge National Laboratory; Jack Dongarra, University of Tennessee, Knoxville and Oak Ridge National Laboratory; and Charles H. Romine, Oak Ridge National Laboratory

3:00 **Parallel Solution of the Generalized Eigenproblem Using Lanczos' Method**
Mark Jones, Argonne National Laboratory

Minisymposium 15 continues at 4:00 PM. See next column for further information.

MS16/Regents Room

Recent Developments on Tournament Matrices

Tournament matrices are the adjacency matrices of round robin tournaments. They are 0-1 matrices $A = [a_{ij}]$ with $a_{ii} = 0$, $i = 1 \ldots, n$ and $a_{ij} = 1$ if and only if $a_{ji} = 0$. These matrices and close relatives of them occur also in some other applications such as paired comparisons, tournament codes and game theory.

Tournament matrices has been a very active field of research over the past few years. The purpose of the minisymposium is to provide an overview of recent developments in research and applications. The speakers will survey the current directions of research and mention many of the open problems.

Organizer: John S. Maybee, University of Colorado, Boulder

2:00 **Eigenspaces of Tournament Matrices**
Bryan Shader, University of Wyoming

2:30 **Algebraic Multiplicity of the Eigenvalues of a Tournament Matrix**
Dominique de Caen, David A. Gregory, Stephen J. Kirkland and *Norman J. Pullman*, Queen's University, Canada and John S. Maybee, University of Colorado, Boulder

3:00 **Tournament Matrices, Score Vectors and Eigenvalues**
Steve Kirkland, Queen's University, Canada

Minisymposium 16 continues at 4:00 PM. See next column for further information.

3:30-4:00/University Ballroom Foyer

Coffee

4:00-6:00/Concurrent Sessions (Minisymposia and Contributed)

MS13/University Ballroom

Dynamic Condition Estimation (continued)

(See page 7, MS13 for description)

Organizer: Robert J. Plemmons, Wake Forest University

4:00 **Adaptive Condition Estimation for Rank-One Updates of QR Factorizations**
Gautam M. Shroff, California Institute of Technology

4:30 **Rank Revealing QR Factorizations and Some Applications**
Tony F. Chan, University of California, Los Angeles and Per Christian Hansen, Technical University of Denmark, Denmark

MS14/Faculty Room

Graph-theoretic Spectral Theory (continued)

(See page 7, MS14 for description)

Organizers: Daniel Hershkowitz, Technion-Israel Institute of Technology, Israel and Hans Schneider, University of Wisconsin, Madison

4:00 **Splittings and Graph Compatibility**
Joseph P. Kavanagh, Southern Connecticut State University

4:30 **Spectral Properties of a Matrix of Redheffer**
Wayne Barrett, Brigham Young University; Tyler J. Jarvis, Princeton University; and David A. Cardon, Stanford University

MS15/Nolte Room

Recent Advances in Solving Eigenvalue Problems (continued)

See previous column, MS15 for description)

Organizer: Linda Kaufman, AT&T Bell Laboratories

4:00 **On a Parallelizable Eigensolver for Real Diagonalizable Matrices with Real Eigenvalues**
Anna Tsao and Steven Lederman, Supercomputing Research Center, Bowie, Maryland

4:30 **Compute the Dominant Invariant Subspace of a Nonsymmetric Matrix**
Zhaojun Bai, University of Kentucky and G.W. Stewart, University of Maryland, College Park

MS16/Regents Room

Recent Developments on Tournament Matrices (continued)

(See previous column, MS16 for description)

Organizer: John S. Maybee, University of Colorado, Boulder

4:00 **A Problem on p-ranks of Regular Tournament Matrices**
Dominique de Caen, Queen's University, Canada

4:30 **On Tournament Codes**
J. Richard Lundgren, University of Colorado, Denver

CP7/Presidents Room

Preconditioning and Condition Number

Chair: Bart De Moor, Katholieke Universiteit Leuven, Belgium

4:00 **Backward Error and Condition of Structured Linear Systems**
Desmond J. Higham, University of Dundee, United Kingdom and *Nicholas J. Higham*, University of Manchester, United Kingdom

4:15 **Preconditioners for Toeplitz-Block Matrices**
Tony Chan, University of California, Los Angeles and *Julia Olkin*, SRI International

4:30 **Ordering Methods for Preconditioned Conjugate Gradient Methods Applied to Unsymmetric Problems**
E.F. D'Azevedo, Oak Ridge National Laboratory; P.A. Forsyth and *Wei-Pai Tang*, University of Waterloo, Canada

4:45 **Preconditioned Iterative Methods for Systems Arising in Circuit Simulation**
William D. McQuain, *Calvin J. Ribbens* and Layne T. Watson, Virginia Polytechnic Institute and State University and Robert C. Melville, AT&T Bell Laboratories

5:00 **One Step Methods for the Estimation of the Condition Number of Matrices**
German Gonzalez, CINVESTAV, Mexico

5:15 **Multilevel Preconditioners and Their Performance on Connection Machine**
X.Z. Guo and H. Elman, University of Maryland, College Park

5:30 **The Interface Probing Technique in Domain Decomposition**
Tony F. Chan and Tarek P. Mathew, University of California, Los Angeles

5:45 **Circulant Preconditioners Constructed from Kernels**
Raymond Honfu Chan and Man-Chung Yeung, University of Hong Kong, Hong Kong

CP8/Hubert Humphrey Room

Sparse Matrix Calculations

Chair: Alex Pothen, Pennsylvania State University

4:00 **On Parallel Solution of Sparse Triangular Systems**
Alex Pothen, Pennsylvania State University

4:15 **A Compact Column-Oriented Data Structure for Sparse Cholesky Factors**
Alex Pothen and *Chunguang Sun*, Pennsylvania State University

4:30 **Parallel Sparse Cholesky Decomposition on a Square Mesh of Transputers**
L. Daniel J.C. Loyens, Koninklijke/Shell-Laboratorium, The Netherlands

4:45 **Parallel Level Set Red-Black Preconditionings for General Sparse Linear Systems**
Sangback Ma and Youcef Saad, University of Minnesota, Minneapolis

5:00 **A New Class of Algorithms for Reducing the Height of an Elimination Tree**
Fredrik Manne, University of Bergen, Norway

5:15 **Improving the Elimination Tree for LU-Decomposition with Partial Pivoting**
Trond-Henning Olesen, University of Bergen, Norway

5:30 **Computing the Leading Eigenpairs of Large Sparse Unsymmetric Matrices**
Miloud Sadkane, CERFACS, France

5:45 **Nested Epsilon Decompositions for Large Sparse Systems:Direct Methods Approach**
Lubomir Bakule, Czechoslovakia Academy of Sciences, Czechoslovakia

5:00-6:00/Concurrent Sessions (Contributed)

CP9/Faculty Room

Core Linear Algebra 2

Chair: Peter Gibson, University of Alabama, Huntsville

5:00 **Stochastic and Perron Complements in Nonnegative Matrices**
Peter M. Gibson, University of Alabama, Huntsville

5:15 **Eventually Nonnegative Representation of Matrices**
Boris G. Zaslavsky, Agrophysical Research Institute, USSR

5:30 **Factorizations of Block Toeplitz and Hankel Matrices and the Moment Problems**
Miron Tismenetsky, IBM Haifa Scientific Center, Israel

5:45 **A Sufficient Condition for Solvability of a Class of Operator Equations**
Mohammad R. Khadivi, Jackson State University

CP10/NolteRoom

Linear Inequalities and Programming

Chair: Ralph Byers, University of Kansas

5:00 **Dynamical Systems that Solve Optimizaiton Problems on a Polyhedra**
L. Faybusovich, Harvard University

5:15 **Implementation of a Primal Potential Reduction Algorithm for Linear Programming**
Marielba Rojas L. and Marianela Lentini G., Universidad Simon Bolivar, Venezuela

5:30 **An Improvement on Quadratic Programming for Optimal Traffic Flow Disposition**
Jinfu Sun, Chongqing University, People's Republic of China

5:45 **Determination and Correction of an Inconsistent System of Linear Inequalities**
Yi-Yong Nie, Academia Sinica, People's Republic of China

CP11/Regents Room

Error Analysis and Precision

Chair: LeRoy Beasley, Utah State University

5:00 **Error Analysis of Update Methods for the Symmetric EigenvalueProblem**
Jesse L. Barlow, Pennsylvania State University

5:15 **Error Analysis of Certain Algorithms in Linear Algebra**
Daniela Calvetti, Stevens Institute of Technology

5:30 **Decreasing the Precision of Linear Algebra Computations by Using Compact Multigrid and Backward Interval Analysis**
Victor Pan, Lehman College, City University of New York, Bronx and John Reif, Duke University

5:45 **Algebraic Coarsening of Extrapolation Methods**
Robert W. Leland, Sandia National Laboratories, Albuquerque

CP12/University Ballroom

Matrix Algorithms

Chair: Steven F. Ashby, Lawrence Livermore National Laboratory

5:00 **Conjugate Gradient Methods for Complex Linear Systems**
Steven F. Ashby, Lawrence Livermore National Laboratory and Paul E. Saylor, University of Illnois, Urbana

5:15 **Optimal Restarting of Generalized Conjugate Gradient Methods for Nonsymmetric Linear Systems**
Wayne D. Joubert and Graham F. Carey, University of Texas, Austin

5:30 **Lanczos Algorithm for the Quadratic Eigenvalue Problem**
C. *Rajakumar* and C. Rogers, Swanson Analysis Systems, Inc.

5:45 **Eigenvalue Solver for Toeplitz Matrices**
George W. Grossman, Central Michigan University

Friday Morning, September 13

8:00/University Ballroom Foyer

Registration Desk Opens

8:30/University Ballroom

IP5 Chair: George Cybenko, University of Illinois, Urbana-Champaign

Linear Algebra Issues in Interior Methods

The development of Karmarkar's linear programming method in 1984 and subsequent determination of its relationship to barrier methods have encouraged research on interior methods for linear, quadratic and nonlinear programming. Interior methods include all constraints at every iteration, and hence identify the active set only implicitly. A contrast between active-set techniques (such as the simplex method) and interior methods is often the tradeoff between many "cheap" iterations and a few expensive iterations.

Interior methods typically involve symmetric equations, both positive definite and indefinite, and linear least-squares problems. The linear systems frequently display inherent ill-conditioning, with singularity in the limit, so that standard techniques may be used only with safeguards. This talk will survey linear algebraic aspects of interior methods, including popular techniques and some unresolved issues.

Margaret H. Wright
AT&T Bell Laboratories
Murray Hill

9:15/University Ballroom

IP6 Chair: George Cybenko, University of Illinois, Urbana-Champaign

Multiscale Stochastic Models and Multiscale Statistical Signal Processing

In this presentation, the speaker will describe the results of a research effort aimed at developing a probabilistic theory for multiresolution stochastic models that can provide the foundation for optimal multiscale statistical signal processing algorithms. Wavelet transforms and multiscale signal representations lead naturally to the study of stochastic processes indexed by nodes on lattices and trees.

The speaker will introduce several classes of dynamic models for multiscale processes in which the direction of recursion is in scale. This leads to a new theory of optimal estimation in which the fusion of data at different resolutions is naturally accommodated and to a theory of multiscale autoregressive modeling, with associated generalizations of the celebrated Levinson algorithm.

The speaker will demonstrate that it is possible to construct surprisingly accurate and simple multiscale approximate models for a wide variety of processes, allowing one to use estimation procedures that not only can accept multiresolution sensor data but are in fact far faster and more highly parallelizable than such well-known procedures as the Kalman filter.

Alan S. Willsky
Laboratory for Information and Decision Systems , Massachusetts Institute of Technology

CONFERENCE PROGRAM

10:00-10:30/University Ballroom Foyer
Coffee

10:30-1:00/Concurrent Sessions (Minisymposia and Contributed)

MS17/University Ballroom
Abstract Algebra and Its Application to Statistical Signal Processing

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 minisymposium will cover the following topics: the algebra of subspaces from a lattice- theoretic point-of-view, the numerical computation of invariant subspaces, covariance models characterized by specialized algebras, e.g., Jordan, von Neumann, and Clifford algebras, and harmonic analysis over finite noncommutative and Abelian groups and construction of "best" group approximating models.

Applications of these, and related, topics to statistical inference, optimal filtering theory, data compression, error-correcting codes, and matching problems arising in computer vision will be stressed.

Organizer: Salvatore D. Morgera
McGill University, Canada

10:30 **Geometrically Constrained Pattern Matching Techniques**
Salvatore D. Morgera, organizer

11:00 **Multivariate Interpolation and Ideals of Projective Points**
M.G. Marinari, Università di Genova, Italy; H.M. Moeller, Fernuniversität Hagen, Germany; and T. Mora, Università di Genova, Italy

11:30 **Subspace Rotation Using Modified Householder Transforms and Projection Matrices**
V. Ch. Venkaiah and A. Paulraj, Bharat Electronics, India

12:00 **Almost-Commutative Matrices Over Finite Fields**
Edmond D. Dixon, Tennessee Technological University

12:30 **Parallel Homotopy Algorithm for Symmetric Large Sparse Eigenproblems**
Liang Jiao Huang and Tien-Yien Li, Michigan State University

MS18/Hubert Humphrey Room
Spectral Perturbations of Non-Negative Matrices

The minisymposium will incorporate presentations of papers on spectral properties of perturbed matrices. Applications will include stochastic matrices and non-negative matrices.

There is a group of investigators who have been studing spectral properties of perturbed matrices. As such problems have broad and important applications we expect wide participation.

Organizers: Uriel G. Rothblum, Rutgers University and Hans Schneider, University of Wisconsin, Madison

10:30 **On the Perturbation of the Spectral Radius of a Matrix with Multiple Eigenvalues**
Michael L. Overton, Courant Institute of Mathematical Sciences, New York University

11:00 **Applying Spectral Radii and Resolvent Approximations to Locate the Spectrum of a Matrix**
Dennis Phillips, Davis Hibbard Mayer Norton & Phillips, Inc.

11:30 **Solving a System of Linear Equations with Small Coefficient Perturbation**
Ying Huang, Philips Laboratories

12:00 **Fractional Power Series Expansions of the Spectral Radius of Perturbed Nonnegative Matrices**
Uriel G. Rothblum, organizer

Minisymposium 18 continues at 4:00 PM. See page 11 for further information.

MS19/Faculty Room
Domain Decomposition Methods for Elliptic Problems

The study of domain decomposition methods for elliptic problems has become a very active area of numerical analysis research in recent years. These algorithms appear to offer the best promise for the parallel solution of the often very large linear and nonlinear algebraic systems of equations that must be solved when continuum mechanical problems are discretized by finite element, finite difference, or spectral methods. This minisymposium will attempt to assess the current state of development. Discussions of actual performance of such algorithms on state of the art parallel computers will be included.

Organizer: Olof Widlund, Courant Institute of Mathematical Sciences, New York University

10:30 **The Boundary Probing Technique in Domain Decomposition**
Tony F.C. Chan and Tarek P. Mathew, University of California, Los Angeles

11:00 **Issues in Parallel Domain Decomposition Algorithms**
William D. Gropp, Argonne National Laboratory

11:30 **Parallel Solution of Elliptic PDEs Using Iterative Substructuring**
Barry F. Smith, Argonne National Laboratory

12:00 **Recent Developments of Domain Decomposition Algorithms of Schwarz Type**
Olof B. Widlund, organizer

MS20/Nolte Room
Matrix Canonical Forms

A standard problem in matrix theory is to determine whether two given matrices lie in the same equivalence class with respect to a given equivalence relation. Some examples are similarity, unitary similarity, orthogonal similarity, unitary congruence, unitary equivalence, and consimilarity. One approach to this problem is to seek a "simple" set of representatives of prescribed form, one from each equivalence class, and try to reduce each given matrix to one of them. Such a set of representatives is a canonical form.

The speakers in this minisymposium will discuss new canonical forms, new approaches to calculating and interpreting known canonical forms, and the use of canonical forms to solve new problems.

Organizer: Roger A. Horn, Johns Hopkins University

10:30 **Canonical Forms for Unitary Similarity**
Helene Shapiro, Swarthmore College

11:00 **A Canonical Form Under $\emptyset$-Equivalence**
Yoopyo Hong, Northern Illinois University

11:30 **Nilpotent Block Triangular Matrices**
Erik A. Schreiner, Western Michigan University

12:00 **Contragradient and Hermitian Congruence**
Charles R. Johnson and *Ilya Spitkovsky*, College of William and Mary

Minisymposium 20 continues at 4:00 PM. See page 11 for further information.

MS21/Regents Room
Numerical Ranges and Numerical Radii (Part 2 of 2)

(See page4, MS7 for description)

Organizer: Chi-Kwong Li, College of William and Mary

10:30 **On the Permanental Congruence Numerical Range**
Tin-Yau Tam, Auburn University and Tian-Gang Lei, Beining Institute of Chemical Technology, People's Republic of China

11:00 **Some Observations on Generalized Numerical Ranges**
N. Bebiano, Universidade de Coimbra, Portugal

11:30 **Joint Numerical Ranges: Applications to Positive Definite Matrix Sets**
David P. Stanford, College of William and Mary

12:00 **Multiform Numerical Range in Robust Control**
M.K.H. Fan, Georgia Institute of Technology and Andre L. Tits, University of Maryland, College Park

CP13/Presidents Room
Linear Algebra Models

Chair: Jesse L. Barlow, Pennsylvania State University

10:30 **Error Bounds and Condition Estimates for the Computation of Null Vectors with Applications to Markov Chains**
Jesse L. Barlow, Pennsylvania State University

10:45 **On the Sensitivity of the Solution of Nearly Uncoupled Markov Chains**
G. Zhang, University of Maryland, College Park

11:00 **Tail Coefficients for Moving-Averages**
Allan J. MacLeod, Paisley College, Scotland

11:15 **Microcomputer-Based Adaptive Controller of Blood Pressure**
Jianwei Miao, New York State Department of Health

11:30 **A Fuzzy Linear Regression Method to System Modeling**
Li-Min Jia, Xi-Di Zhang, and Yi-Juin Zhang, China Academy of Railway Sciences, People's Republic of China

11:45 **Parallel Matrix Algebra Approach to Physical Space-time, Kline-Gordon Equation and the Unified Field Theory**
P.D. Narang, Agra University, India

12:00 **The Numerical Solution of $J_0(z) - i\,J_1(z) = 0$**
Yasuhiko Ikebe, Issei Fujishiro and Yasushi Kikuchi, University of Tsukuba, Japan

12:15 **On Predator-Prey Systems with Unchanging Source**
Fude Cheng, Hubei Normal Institute, People's Republic of China

Friday Afternoon, September 13

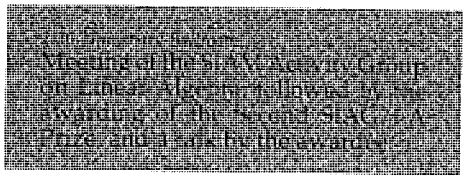
12:30
Lunch

2:00/University Ballroom
IP7 Chair: David H. Carlson, San Diego State University
Basis Free Methods in Linear Algebra

The use of matrices in the solution of a linear algebra problem implies, whether or not explicitly stated, a choice of basis. The thesis of this presentation is that basis-free methods can be helpful in some problems in linear algebra.

The speaker will present several examples to illustrate the usefulness of basis-free methods. One of these is perhaps the oldest nontrivial result in linear algebra--the Jordan canonical form. A proof will be outlined which uses the dual of a vector space. Another example is a recent theorem confirming a conjecture of Choudhury and Horn concerning an algebraic variant of the important polar decomposition of a matrix.

Irving Kaplansky
Mathematical Sciences Research Institute
University of California, Berkeley



3:30-4:00/University Ballroom Foyer
Coffee

4:00-5:15/Concurrent Sessions (Minisymposia and Contributed)

MS18/Hubert Humphrey Room
Spectral Perturbations of Non-Negative Matrices (continued)

(See page 10, MS18 for description)

Organizers: Uriel G. Rothblum, Rutgers University and Hans Schneider, University of Wisconsin, Madison

4:00 **Taylor Expansions of Eigenvalues of Perturbed Matrices withApplications to Spectral Radii of Nonnegative Matrices**
Moshe Haviv, Hebrew University of Jerusalem, Israel

4:30 **Approximations of the Spectral Radius, Corresponding Eigenvector and Second Largest Modulus of an Eigenvalue for Square Nonnegative Irreducible Matrices**
Orna Gross, Technion-Israel Institute of Technonogy, Israel

MS20/Nolte Room
Matrix Canonical Forms (continued)

(See page 10, MS20 for description)

Organizer: Roger A. Horn, Johns Hopkins University

4:00 **Factorizations of Certain Polynomials Involving Jordan Blocks**
Thomas J. Laffey, University College Dublin, Ireland

4:30 **Canonical Forms and Inequalities**
Robert C. Thompson, University of California, Santa Barbara and Barbara A. Li Santi, Mills College, Oakland

MS21/Regents Room
Numerical Ranges and Numerical Radii (Part 2 of 2 continued)

(See page 4, MS7 for description)

Organizer: Chi-Kwong Li, College of William and Mary

4:00 **The Numerical Range and the Resolvent**
Lloyd N. Trefethen, Cornell University

4:30 **Numerical Ranges for Partial Matrices**
Charles R. Johnson and Michael Lundquist, College of William and Mary

CP14/Faculty Room
Matrix Algorithms 2

Chair: Paul van Dooren, Philips Research Laboratory, Belgium

4:00 **About Block Shifts and Block QR Steps**
Paul Van Dooren, Philips Research Laboratory, Belgium

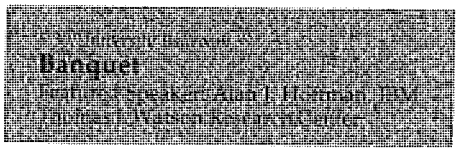
4:15 **Implementing the Bunch-Kaufman Algorithm**
Linda Kaufman, AT&T Bell Laboratories

4:30 **The Generalized Cyclic Reduction Algorithm for Solving Pentadiagonal Linear Systems**
Pierluigi Amodio, Università di Bari, Italy

4:45 **On the Cubic Convergence of a Quasi-Cyclic Paardekooper Method**
Vjeran Hari, University of Zagreb, Yugoslavia and Noah H. Rhee, University of Missouri, Kansas City

5:00 **Rank-revealing QR Factorizations and the Singular Value Decomposition**
Y.P. Hong and C.-T. *Pan*, Northern Illinois University

5:15 **Inverse Spectrum Problems for Block-Jacobi Matrices**
Benren Zhu, Shandong University, People's Republic of China and University of Toronto, Canada



Saturday Morning, September 14

8:00/University Ballroom Foyer
Registration Desk Opens

8:30/University Ballroom
IP8 Chair: John G. Lewis, Boeing Computer Services
Some Combinatorial Aspects in Matrix Theory

The speaker will discuss several topics related to classes of special matrices, with emphasis on the purely combinatorial structure of the entries of the matrix (the placement of the zeros and nonzeros within the matrix) or the sign pattern structure of the entries (the placement of the positive elements, negative elements, and zeros within the matrix). Applications to geometry and to graph theory will be presented.

Miroslav Fiedler
Czechoslovakia Academy of Sciences, Prague

9:15/University Ballroom
IP9 Chair: John G. Lewis, Boeing Computer Services
Numerical Stability of Direct Methods for Sparse Augmented Systems

In many contexts it is required to solve sparse symmetric indefinite linear system of the form

$$\begin{pmatrix} B & A \\ A^T & 0 \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} b \\ c \end{pmatrix}.$$

This problem includes, for example, when $B = I$ as special cases both the least squares problem $\min_y(\|Ay - b\|_2 + 2c^T y)$ and the problem of minimal distance solution of an underdetermined systems, $\min_x \|b - x\|_2$, where $A^T x = c$.

In direct methods based on a sparse QR factorization of A it is often uneconomical to store and access the matrix Q. Then the solution is computed from the seminormal equations using R only. Some limitations of accuracy for this methods is illustrated, and it is shown how an accurate solution can often be retrieved by a simple correction step.

Another much used method is based on computing a sparse LDL^T factorization of the augmented system matrix using 1 x 1 and 2 x 2 pivots. Through an error analysis an optimal scaling parameter for the factorization is derived. In practice the pivoting strategy has to be a compromise between stability and sparsity, and then this method is not in general backward stable. It is discussed how the accuracy of the computed solution can be restored by iterative refinement.

Åke Björck
Department of Mathematics
Linköping University, Sweden

10:00-10:30/University Ballroom Foyer
Coffee

CONFERENCE PROGRAM

10:30-1:00/Concurrent Sessions (Minisymposia and Contributed)

MS22/University Ballroom

Iterative Methods for Non-Hermitian Systems

Attempts to iteratively solve large sparse linear systems $Au = b$ (often induced as discretization of differential equations) have produced many well-known techniques for the frequently-occurring case when matrix A is symmetric positive definite. Iterative methods such as Successive Overrelaxation (SOR), Conjugate Gradient (CG) and Lanczos Methods have proved to be very successful in this regard. But problems arise where more general systems need to be solved.

Both stationary and non-stationary methods (like SOR and CG) have been extended to the case when A is not symmetric positive definite (as, for example, when A models a differential equation with irregular boundary.) Early attempts to extend conjugate-gradient and Lanczos methods to the non-positive definite case were often met with problems related to stability and accuracy.

The speakers will present an overview of some results which contain extensions of stationary and non-stationary iterative methods to the wider class of systems $Ax = b$ where A need not be symmetric positive-definite.

Organizer: John E. de Pillis, University of California, Riverside

10:30 A Matrix Analysis of Conjugate Gradient Algorithms
Steve Ashby, Lawrence Livermore Laboratory

11:00 A Dual Strategy Incomplete Factorization Preconditioner for General Sparse Matrices
Youcef Saad, University of Minnesota, Minneapolis

11:30 Iterative Solution Methods and Stiff Initial Value Problems
Paul Saylor, University of Illinois, Urbana

12:00 Krylov Subspace Methods for Iterative Solution of Large Sylvester Equations
D. Hu and *Lothar Reichel*, University of Kentucky

Minisymposium 22 continues at 2:00 PM. See column three for further information.

MS23/Hubert Humphrey Room

Qualitative Aspects of Matrix Theory

Qualitative matrix analysis deals with the analysis of matrix theoretic properties based only upon either the signs (+, -, 0) or the zero/nonzero pattern of matrix entries. A signed or unsigned directed graph is associated with such a pattern. This association leads to interplay between graph theory, combinatorics and matrix theory. Important qualitative problems addressed in this way include sign solvability, sign nonsingularity, sign controllability, qualitative stability, sparse matrix analysis and their generalizations.

The speakers in this minisymposium will provide an overview of research in qualitative matrix analysis and discuss open problems and applications.

Organizers: D. Dale Olesky and P. van den Driessche, University of Victoria, Canada

10:30 Some Problems of Qualitative Matrix Theory
Charles R. Johnson, College of William and Mary

11:00 On Inverses of *L*-matrices
John S. Maybee, University of Colorado, Boulder

11:30 Sign Controllability of a Nonnegative Matrix and a Positive Vector
Charles R. Johnson, College of William and Mary; Volker Mehrmann, Universitat Bielefeld, Germany; and *D. Dale Olesky*, organizer

12:00 *L*-matrices
Richard A. Brualdi and Keith L. Chavey, University of Wisconsin, Madison and Bryan L. Shader, University of Wyoming

12:30 Class of Optimization Problems for Symmetric Matrices with Given Zero Entries
Miroslav Fiedler, Czechoslovakia Academy of Sciences, Prague, Czechoslovakia

MS24/Faculty Room

Unitary Hessenberg Matrices

Unitary Hessenberg matrices are closely related to the study of orthogonal on the unit circle, and have many properties that are analogous with properties of symmetric tridiagonal matrices. Unitary Hessenberg matrices arise naturally in scattering theory and signal processing. For example, the eigenproblem for unitary Hessenberg matrices arises in several frequency estimation procedures, while the solution of the inverse eigenproblem can be used to design efficient and reliable algorithms for discrete least-squares approximation by trigonometric polynomials for arbitrarily sampled data. This session will focus on new algorithmic procedures for unitary Hessenberg matrices and the theoretical underpinnings of these algorithms.

Organizer: Gregory S. Ammar, Northern Illinois University

10:30 Schur Flows
William B. Gragg, Naval Postgraduate School

11:00 On the Construction of Szego Polynomials
Carl Jagels and Lothar Reichel, University of Kentucky

11:30 A Sturm Sequence for Unitary Hessenberg Matrices
Chunyang He and Angelika Bunse Gertsner, Universitat Bielefeld, Germany

12:00 Frequency Estimation and the Orghogonal Eigenproblem
Gregory S. Ammar, organizer

MS25/Regents Room

Centrosymmetric Matrices and Their Generalizations

Centrosymmetric matrices and their generalizations occur naturally in problems involving Markov chains, scientific and engineering applications, and the discretization of certain partial differential equations.

The structure of these matrices is often obtained by studying certain permutation matrices that commute with the class of matrices under consideration. The advantage of this approach is that there is a wealth of information available about permutation matrices. One disadvantage is that the information on permutation matrices is of low multiplicative order relative to the size of the matrix is limited. The speakers in this minisymposium will report on a number of advances in the basic structure, spectral theory, and decomposition of these matrices.

Organizers: James R. Weaver, University of West Florida and Jeffrey L. Stuart, University of Southern Mississippi

10:30 Some Generalizations of Centrosymmetric Matrices
Hsin-Chu Chen, University of Illinois, Urbana

11:00 Perhermitian and Centrohermitian Matrices
Ronald G. Bates, Hartnell College

11:30 Linear Transformations Which Preserve PH and CH
Richard D. Hill, Idaho State University; Steven R. Waters, Pacific UnionCollege; Ronald G. Bates, Hartnell College; and Joseph R. Siler, Pittsburg State University

12:00 On K-real and K-Hermitian Matrices
Steven R. Waters, Pacific Union College and Richard D. Hill, Idaho State University

CP15/Nolte Room

Systems and Control Theory

Chair: Dianne P. O'Leary, University of Maryland, College Park

10:30 Constrained Matrix Liapunov Equations
Dianne P. O'Leary, Jewel B. Barlow, and Moghen M. Monahemi, University of Maryland, College Park

10:45 Pole Placement for Discrete Systems Using Projective Controls and LQ Modification
A.S. Arar and *M.E. Sawan*, Wichita State University

11:00 Canonical Wiener-Hopf Factorization of Rectangular Rational Matrix Functions
Marek Rakowski, North Carolina State University

11:15 Continuous Spectral Data of Non-square Rational Matrix Functions
Richard E. Faulkenberry, Southeastern Massachusetts University

11:30 Q-Degeneracy over R of Polynomial Matrix
Xiaochang Alex Wang, Texas Tech University

11:45 Numerical Properties of the Matrix Sign Function Solution of Algebraic Riccati Equations
Judith D. Gardiner and Andrew Pitonyak, Ohio State University

12:00 The Interconnected Stabilization of Feedback Multidelay Time-varying Control System
Yang Huizhong, Jiangnan University, People's Republic of China

12:15 Wavelet Retrieval Approximation: An Efficient Wavelet Representation
Shidong Li and James T. Lo, University of Maryland, Baltimore County

Saturday Afternoon, September 14

12:30

Lunch

2:00-3:00/Concurrent Sessions (Minisymposia and Contributed)

MS22/University Ballroom

Iterative Methods for Non-Hermitian Systems (continued)

(See column one, MS22 for description)

Organizer: John E. de Pillis, University of California, Riverside

2:00 Krylov Subspace Methods for Non-Hermitian Cyclic Matrices
Roland Freund, RIACS, NASA Ames Research Center; Gene H. Golub, Stanford University; and Marlis Hochbruck, Universitat Karlsruhe, Germany

2:30 **Monotonic Sequences and Rates of Convergence of Asynchronized Iterative Methods**
Ludwig Elsner, Universität Bielefeld, Germany and Michael Neumann, University of Connecticut

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MS26/Hubert Humphrey Room
Matrix Perturbation Theory

Matrix perturbation theory, a significant mathematical dicipline in its own right, has applications in many fields, including statistics, signal processing, and the analysis of numerical algorithms. This minisymposium presents a selection of topics from matrix perturbation theory, including results on structured perturbations.

Organizer: G.W. Stewart, University of Maryland, College Park

2:00 **Perturbation Theory for QR**
Beresford N. Parlett, University of California, Berkeley

2:30 **What Perturbations Reveal About the Unperturbed Matrix**
Lloyd N. Trefethen, Cornell University

Minisymposium 26 continues at 3:30 PM. See next column for further information.

MS27/Nolte Room
Applied and Numerical Linear Algebra in Control Theory

Linear and numerical linear algebra techniques are increasingly being used to study theoretical properties and develop numerically effective algorithms for many linear control problems. However, there are several areas where more attention is needed. They include study of perturbations and the development of effective algorithms for large-scale and parallel computations. Lack of activities in these areas has been clearly outlined in the recent panel report on Future Directions in Control Theory.

The speakers in this session will present results of recent studies on perturbation analyses of several basic linear control problems and also discuss algorithms for large-scale and parallel solutions of these problems. The effective use of appropriate tools from linear and numerical linear algebra will be emphasized in the talks.

Organizer: Biswa N. Datta, Northern Illinois University

2:00 **A Condition Number for Single-Input Eigenvalue Assignment**
Mark Arnold and Biswa N. Datta, Northern Illinois University

2:30 **Singular Pencils: Numerical Sensitivity of Kronecker Form**
Daniel Boley, University of Minnesota, Minneapolis

Minisymposium 27 continues at 3:30 PM. See next column for further information.

CP16/Regents Room
Parallel Algorithms for Linear Systems 1

Chair: Jack J. Dongarra, Oak Ridge National Laboratory

2:00 **A Supernodal Cholesky Factorization Algorithm for Shared-Memory Multiprocessors**
Esmond G. Ng and *Barry W. Peyton*, Oak Ridge National Laboratory

2:15 **Parallelizable Preconditioned Conjugate Gradient Methods for the Cray Y-MP and Connection Machine**
William H. Holter, I.M. Navon and Thomas C. Oppe, Florida State University

2:30 **Solving Almost Block Diagonal System on Cray Y-MP 8/864 Multiprocessor Using Level 3 BLAS**
Marcin Paprzycki, University of Texas at Permian Basin, Odessa and Ian Gladwell, Southern Methodist University

2:45 **Practical Considerations for Linear Algebra Algorithms on Cray Y-MP 8/864 Multiprocessor**
Marcin Paprzycki and Cliff Cyphers, University of Texas at Permian Basin, Odessa

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3:00-3:30/University Ballroom Foyer
Coffee

3:30-5:30/Concurrent Sessions (Minisymposia and Contributed)

MS26/Hubert Humphrey Room
Matrix Perturbation Theory (continued)

(See column one, MS26 for description)

Organizer: G.W. Stewart, University of Maryland, College Park

3:30 **Perturbation Theory and Error Bounds for Underdetermined Linear Systems**
James W. Demmel, University of California, Berkeley and *Nicholas Higham*, University of Manchester, United Kingdom

4:00 **Structured Error Analysis in Linear Algebra**
James Demmel, University of California, Berkeley

4:30 **A Perturbation Theorem for Small Singular Values**
G.W. Stewart, organizer

MS27/Nolte Room
Applied and Numerical Linear Algebra in Control Theory (continued)

(See column one, MS27 for description)

Organizer: Biswa N. Datta, Northern Illinois University

3:30 **On Stability of Descriptor Systems**
Ralph Byers, University of Kansas and Nancy K. Nichols, University of Reading, United Kingdom

4:00 **Norms, Seminorms and Sub-Multiplicativity**
Moshe Goldberg, Technion-Israel Institute of Technology, Israel

4:30 **A Parallel Algorithm for the Multi-input Observer Matrix Equation and its Implementations**
Christian H. Bischof, Argonne National Laboratory, Biswa N. Datta, and *A. Purkayastha*, Northern Illinois University

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CP17/University Ballroom
Inequalities and Core Linear Algebra

Chair: Roy Mathias, College of William and Mary

3:30 **The Use of Schur Product in Proving Matrix Inequalities**
Roy Mathias, College of William and Mary

3:45 **On the London-Hoffman Inequality for the Sum of Elements of Powers of Nonnegative Matrices**
Jorma Kaarlo Merikoski and Ari Virtanen, University of Tampere, Finland

4:00 **Low-Dimensional Techniques to Derive Inequalities for Symmetric Matrices**
Andrew V. Knyazev, USSR Academy of Sciences, USSR

4:15 **Refined Interlacing Properties**
Richard O. Hill, Jr., Michigan State University and Beresford N. Parlett, University of California, Berkeley

4:30 **The Hermite Method of Separation of Solutions of Nonlinear Algebraic Systems and Its Applications**
A. Yu. Uteshev and S.G. Shulyak, Leningrad State University, USSR

4:45 **Variational Intervals for Eigenvalues**
Pablo Tarazaga, University of Puerto Rico, Mayaguez

5:00 **Sharp Estimates in Two Operator Inequalities from Perturbation Theory**
Raymond McEachin, Indiana University-Purdue University, Ft. Wayne

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CP18/Faculty Room
Parallel Algorithms for Linear Systems 2

Chair: Åke Björck, Linköping University, Sweden

3:30 **Block Triangular Solver on Distributed Memory Architectures**
Jack J. Dongarra, *Susan Ostrouchov* and Robert van de Geijn, University of Tennessee, Knoxville

3:45 **Block Factorizations on a Cluster of RS/6000s**
Greg Henry and *Adolfy Hoisie*, Cornell University

4:00 **Block-binary GCD for Multiprecision Integers**
Kenneth Weber, Kent State University

4:15 **An Efficient Parallel Iterative Solver for Large Sparse Linear Systems**
Mark T. Johes and *Paul E. Plassmann*, Argonne National Laboratory

4:30 **Performance of Iterative Methods for Nonsymmetric Systems on Parallel MIMD Machines**
John N. Shadid and Ray S. Tuminaro, Sandia National Laboratories, Albuquerque

4:45 **Task Distribution in Distributed Memory Parallel Systems**
Rahul Chattergy, University of Hawaii

5:00 **Provably Accurate Eigensystem Solver for Symmetric Rank-1 Perturbed Matrices**
Ping Tak Peter Tang, Argonne National Laboratory and Danny C. Sorensen, Rice University

5:15 **Parallel Homotopy Algorithms for Real Symmetric Generalized Eigen-problem**
Kuiyuan Li, Tien-Yien Li and Zhonggang Zeng, Michigan State University

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CP19/Regents Room
Iterative Methods in Linear Algebra

Chair: Apostolos Hadjidimos, Purdue University

3:30 **Best Cyclic Repartitioning for Optimal SOR Convergence**
Sofoklis Galanis, University of Ioannina, Greece and *Apostolos Hadjidimos*, Purdue University, West Lafayette

3:45 **Iterative Methods for Nonsymmetric Coupled Systems**
June M. Donato, University of California, Los Angeles

4:00 **Two-stage Iterative Methods**
Daniel B. Szyld, Temple University

Conference Program

4:15 **A Geometric View of Iterative Methods for Solving of a Systemof Linear Equations Using the Newly Formulated Directional Projection Method**
Andrzej S. Kosinski, Emory University

4:30 **Restarting GMRES for Large Nonsymmetric Linear Equations**
Ronald B. Morgan, University of Missouri, Columbia

4:45 **Gaussian Elimination: When is Scaling Beneficial?**
George Poole and Larry Neal, East Tennessee State University

5:00 **Instability in the Back-Substitution Phase of Gaussian Elimination**
Larry Neal and George Poole, East Tennessee State University

5:15 **The Rook's Pivoting Strategy**
Larry Neal and George Poole, East Tennessee State University

5:30
Conference Adjourns

Transportation

Official Carrier for Continental USA and Canada

American Airlines is the official carrier for this conference. In a special arrangement for this conference, you can fly to Minneapolis at a discounted rate from September 8 to September 17, 1991 inclusive.

For those attendees traveling from points in the United States, American Airlines is offering a 45% discount off regular day coach airfares. For those in Canada, the discount is 35%. Each rate requires seven (7) days advance purchase.

You may be able to obtain an even lower airfare. American Airlines also is offering a five percent (5%) discount off any published airfare (including First Class and Ultra Saver fares) for which you qualify, i.e., you must satisfy all rules and restrictions on the fares quoted. Discounts can range from 40% to 70% off regular coach fares.

To make reservations for either of the above discounted fares:

- Call the American Airlines Convention Desk at the toll free number 1-800-433-1790 seven days a week from 8:00 AM to 11:00 PM (EST). Be sure to mention the SIAM Account Number S07Z1CN. American Airlines will mail your ticket to your home or office.
- You may use your corporate or university travel agent to purchase your ticket. Your agent should call the American Airlines Convention Desk to make your reservation. Make sure your agent mentions the discounts and uses the SIAM Account Number: S07Z1CN.

From Outside Continental USA and Canada

There is no designated carrier from foreign countries to the United States as each country has its own rules and regulations for airfares.

Reminder: When available, you can save money by buying an APEX ticket, but you generally must purchase your ticket at least three weeks (21 days) in advance of your departure date and stay in the United States at least seven days but not longer than two months

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- Take the 4th Street Exit to the University of Minneapolis East Bank to University Avenue Exit #18.
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From Downtown Minneapolis

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- 4th Street Becomes Washington Ave.
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On all directions, follow Harvard Street to the left-hand parking ramp entrance.

Public Transportation from the Airport

The airport is approximately thirty minutes from the hotel. There is an airport shuttle called the Airport Express. It arrives every hour on the half hour outside the baggage claim area 5:30 AM - 11:00 PM, seven days a week. The cost for a one way ticket is $8.00. A round trip ticket is $12.25.

There are a number of cab companies that service the airport. The average one-way cost from the airport to the hotel is $18.00.

Car Rental at the Airport

Dollar Rent-A-Car is the official car rental agency for this conference. The following rates will apply to cars rented at the airport subject to the conditions at right:

Type of Car	Daily Rate	Weekly Rate
Economy	$27.95	$129.00
Intermediate	$29,95	$135.00
Standard	$32.95	$154.00

Conditions for Car Rental

(1) Unlimited free miles.

(2) Rates are valid from September 6 to September 19, 1991 inclusive, and are available at the airport. Cars must be picked up and dropped off at the same location.

(3) You must be 21 years of age and have a valid U.S. or International Drivers License.

(4) You must have one of the following credit cards to rent a car: American Express, MasterCard, Visa, or Diner's Club.

(5) The prices quoted do not include refueling services, tax, optional collision and loss damage waiver (CDW and LDW), or optional personal accident insurance.

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You can make a reservation for car rental by calling (toll free):

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Make sure to give the SIAM account code: CCSIA5, and mention that you are attending the SIAM Conference on Linear Algebra, September 11-14, 1991.

Please make your car rental reservation in advance. On-site availability cannot be guaranteed.

Hotel Information

Radisson Hotel Metrodome
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Reservations: SIAM is holding a block of rooms at the Radisson Hotel on a first come first served basis at the specially discounted rates of $72.00 single and $82.00 double. Please note that all rates are subject to an occupancy/sales tax of 12%. These rooms will be held for our exclusive use until August 23, 1991, after which reservations will depend on availability. A deposit in the amount of one night's room rate is required to confirm reservations.

We urge you to make your reservations as soon as possible. You may do so by telephoning 612-379-8888 or by using the Hotel Reservation Form on the inside back page of this program (domestic mail only). When making reservations, you must identify yourself as an attendee at the SIAM Conference on Linear Algebra to obtain the discounted rate.

Late Arrival Policy: If you plan to arrive after 6:00 PM you must inform the Radisson of your plans and guarantee reservations with a credit card or check in the amount of one night's room rate.

Check In: Check-in time is 3:00 PM, check-out time is 12:00 Noon. If you need to change or cancel your reservation, please be certain to do so 48 hours prior to the date of your arrival to avoid being penalized.

Facilities: The Radisson is equipped with an exercise room. The hotel is within walking distance of the university and attendees can use the university's recreational sports center at a cost of $3.00 per day. The recreational center has an olympic size pool, racquetball and tennis courts, and exercise equipment. Arrangements to use the recreational center can be made through the hotel front desk.

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The Radisson is situated in the heart of the University of Minnesota and is convenient to both the downtown areas of Minneapolis and St. Paul. Down the street from the Radisson is the bustling 7-corners area which offers a unique combination of live theaters, restaurants, entertainment and cultural activities. Downtown Minneapolis is only five minutes away.

Parking: There is no complimentary parking at the hotel. Hotel guests and conference attendees can park their cars at the parking ramp off of Harvard Street at a rate of $6.50 per day.

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Solving Linear Systems on Vector and Shared Memory Computers

Jack J. Dongarra, Iain S. Duff, Danny C. Sorensen, and Henk A. van der Vorst

1990 / xii + 256 pages / Softcover
List Price: $19.75 / SIAM Member Price: $15.80
Order Code OT23 / ISBN 0-89871-270-X

The recent availability of advanced-architecture computers has had a very significant impact on all spheres of scientific computation including algorithm research and software development in numerical linear algebra. Major elements of these new computers and recent developments in linear equation algorithms for dense and sparse matrices that are designed to exploit these elements are discussed here. Many techniques and current understandings about solving systems of linear equations on vector and shared-memory parallel computers are documented and unified, providing a fast entrance to the world of vector and parallel processing for these linear algebra applications. This book is both a reference and a supplemental teaching text on aspects of scientific computation for use by graduate students, researchers working in computational science, and numerical analysts.

Contents

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About the Authors

Jack J. Dongarra is a computer scientist specializing in numerical algorithms in linear algebra and high-performance computing at Oak Ridge National Laboratory's Mathematical Sciences Section and at the University of Tennessee's Computer Science Department.

Iain S. Duff is Group Leader of Numerical Analysis in the Central Computing Department at the Rutherford Appleton Laboratory. He also is the Project Leader for the Parallel Algorithms Group at CERFACS in Toulouse and is a visiting professor at the University of Strathclyde.

Danny C. Sorensen is Professor of Mathematical Sciences at Rice University.

Henk A. van der Vorst is Professor of Numerical Analysis in the Mathematics Department of Utrecht University in the Netherlands.

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- ❑ Linear algebra and matrix theory.(01)
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- ❑ Economics. (24)
- ❑ Social sciences. (25)
- ❑ Computational mathematics including scientific computing, parallel computing, and algorithm development.(07)
- ❑ Simulation and modeling. (30)
- ❑ Applied mathematics education (K-12, undergraduate curriculum, graduate study and modeling courses). (28)
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	TOTAL $	_____

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Department Chairman: Signature _____ Date _____

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The Method of Equivalence and Its Applications

Robert B. Gardner

1989 • 128 pages • Softcover • ISBN 0-89871-240-8
CBMS-NSF Regional Conference Series in Applied Mathematics
List Price $21.75 • SIAM/CBMS Member Price $17.40 • Order Code CB58

The ideas of Élie Cartan are combined with the tools of Felix Klein and Sophus Lie to present in this book the only detailed treatment of the method of equivalence. An algorithmic description of this method, which finds invariants of geometric objects under infinite dimensional pseudogroups, is presented for the first time.

As part of the algorithm, Gardner introduces several major new techniques. In particular, the use of Cartan's idea of principal components that appears in his theory of Répère Mobile, and the use of Lie algebras instead of Lie groups, effectively a linearization procedure, provide a tremendous simplification. One must know how to convert from one to the other, however, and the author provides the Rosetta stone to accomplish this. In complex problems, it is essential to be able to identify natural blocks in group actions and not just individual elements, and prior to this publication, there was no reference to block matrix techniques.

The Method of Equivalence and Its Applications details ten diverse applications including Lagrangian field theory, control theory, ordinary differential equations, and Riemannian and conformal geometry.

This volume contains a series of lectures, the purpose of which is to describe the equivalence algorithm and to show, in particular, how it is applied to several pedagogical examples and to a problem in control theory called state estimation of plants under feedback. The lectures, and hence the book, focus on problems in real geometry.

This is the only book available that treats this subject in such depth and which includes the algorithm, the use of principal components, and the use of infinitesimal analysis on the Lie algebra level.

The reader should possess a background in calculus on manifolds and a familiarity with abstract linear and multilinear algebra. A first course on manifolds with an introduction to Lie groups and the ability to accept advanced results would be even more helpful. This volume contains asides at various levels involving representation theory of Lie groups and Lie algebras, exterior differential systems, and Lie pseudogroups.

Contents: Equivalence Problems; Lifting of Equivalence Problems to G-Spaces; The Structure Equations; Reduction of the Structure Group by Normalization; The Inductive Step; e-structures; Global Results and Involutive Structure; Serendipity; Normal Forms and Generalized Geometries; Prolongation.

Registration Information

Please complete the Advance Registration Form on the inside back cover and return it in the envelope provided. We urge attendees to register in advance to take advantage of the lower registration fee. Advance registration must be received by September 4, 1991.

The registration desk will be open as listed below:

Tuesday, September 10	6:00 PM - 9:00 PM
Wednesday, September 11	7:30 AM - 4:30 PM
Thursday, September 12	8:00 AM - 4:30 PM
Friday, September 13	8:00 AM - 4:30 PM
Saturday, September 14	8:00 AM - 2:00 PM

Get-Togethers

SIAM Welcoming Reception
Tuesday, September 10, 1991
7:00 PM - 9:00 PM
Faculty Room
Cash bar and assorted mini hors d'oeuvres.

Banquet
Friday, September 13, 1991 6:30 PM
University Ballroom
Featured Speaker: Alan J. Hoffman, IBM Thomas J. Watson Research Center. The banquet will start at 6:30 PM with a cash bar. Everyone will be seated at 7:00 PM for dinner. Dinner will consist of a choice of Sliced Smoked Tenderloins of Beef, Blackened Red Fish or Sliced Breast of Turkey. There will be vegetarian platters available for those with special needs. Wine will be served with dinner followed by dessert. Dr. Alan J. Hoffman will give his presentation following dessert. Please be certain to mark your dinner selection on the reservation cards. The cost is $23.00.

REGISTRATION FEES

	SIAG/LA*	SIAM Member	Non-Member	Student
Advance	$120	$125	$150	$25
On-Site	$130	$150	$180	$25

* Members of SIAM Activity Group on Linear Algebra.

NOTICE

There will be no prorated fees. No refunds will be issued once the conference has started.

If SIAM does not receive your Advance Registration payment by September 4, 1991, you will be asked to give us a check or a credit card number at the conference. We will not process either until we have ascertained that your registration payment has gone astray. In the event that we receive your payment after September 4, 1991, we will destroy your check or credit card slip.

Credit Cards

SIAM accepts VISA, MasterCard and American Express for the payment of registration fees and special functions. When you complete the Advance Registration Form, please be certain to indicate the type of credit card, the number, and the expiration date.

SIAM Corporate Members

Non-member attendees who are employed by the following institutions are entitled to the SIAM member rate.

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BP America
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General Motors Corporation
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Mathematical Sciences Research Institute
NEC Research Institute
Supercomputing Research Center,
a division of Institute for Defense Analyses
Texaco Inc.
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Hotel Reservation Form

SIAM Conference on Linear Algebra

September 11-14, 1991
Radisson Hotel Metrodome
Minneapolis, Minnesota

PLEASE SEND ME A CONFIRMATION NOTICE

Specially discounted rooms are being held for our exclusive use until August 23, 1991. After that date reservations will depend on availability. Your reservation is not confirmed until acknowledged in writing by the hotel or verified by phone. When making reservations by phone, be certain to identify yourself as an attendee at the SIAM Conference on Linear Algebra. Telephone: 1-612-379-8888.

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Please reserve [ ] Single $72 [ ] Double $82

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Signature _____

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Advance Registration Form

SIAM Conference on Linear Algebra

September 11-14, 1991
Radisson Hotel Metrodome, Minneapolis, Minnesota

Advance registration form must be received at the SIAM office by September 4, 1991. Please make check payable to SIAM.

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Registration Fee:				
Conference	$ _____	$ _____	$ _____	$ _____
Banquet Dinner** ($23)	$ _____	$ _____	$ _____	$ _____
Total	$ _____	$ _____	$ _____	$ _____

*Members of SIAM Activity Group on Linear Algebra.
**Dinner selection [ ] Beef [ ] Turkey [ ] Red Fish [ ] Vegetarian

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