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Numerical Analysis Reports

DEPARTMENTS OF MATHEMATICS

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Contents

This Annual Report serves to publicize the work that has taken place in the Manchester Centre for Computational Mathematics during 2002. *Along with other MCCM technical reports, information about the M.Sc. in Applied Numerical Computing, and MCCM seminar details, it is available from the MCCM Web page at* `http://www.ma.man.ac.uk/MCCM`

Edited by F. Tisseur

1 A Message from the Director

Numerical Analysis at Manchester continues to thrive and evolve. In 2002 we were pleased to welcome Tony Shardlow to a Lectureship at the University of Manchester. Tony did his PhD at Stanford and came to us from his previous position at Durham University. He brings expertise in stochastic differential equations and their applications. We also said goodbye to Research Associates Bobby Cheng, who took up a position as Numerical Analyst at The MathWorks, Natick, USA, and Evelyn Buckwar, who returned to Berlin to a position at Humboldt Universität.

MCCM maintains an active visitor programme, with visits for periods ranging from a few days to several months, often supported by EPSRC Visiting Fellowships. Long-term visitors in 2002 were Professors Niloufer Mackey and Steve Mackey, on sabbatical from Western Michigan University.

One of the main items of news was the proposal in April 2002 of a "merger" between the University of Manchester and UMIST (to be more precise, the dissolution of the two universities and the creation of a new one). The proposal was agreed by the Councils of the universities in March 2003, following confirmation of the necessary funding from various sources. The new university is to be created in September 2004.

The merger is good news for MCCM. The Numerical Analysis Groups at the two universities have been collaborating strongly since the formation of MCCM in 1992 and the new Numerical Analysis Group will be one of the largest and broadest in the UK.

Looking ahead, a workshop *New Frontiers in Computational Mathematics* is to be held at the University of Manchester in January 2004, organized by MCCM. The aims of the workshop are to bring together international leaders and talented young academics, including research students, for fruitful discussions of current challenges and future directions in Computational Mathematics. More details will appear shortly on the MCCM Web page.

Nicholas J. Higham
Director of MCCM

2 Members

Christopher T. H. Baker

Professor of Mathematics, University of Manchester
D.Phil., Oxford University, 1964

I am now employed on a part-time basis. (I work full-time, but take holidays!) I have concentrated upon postgraduate PhD supervision and research, much of it collaborative. I have hosted Mr Hagen Gilsing, as a PhD student visiting from the Humboldt University in Berlin. The after-effects of RAE2001 took their toll on journal publication; though a number of reports have been prepared, their publication in the journals has been delayed. My collaborators have included Drs Buckwar, Paul, Rihan, Song and Tian and Professors Bocharov and Ford, and the areas of my work include (in no special order!):

- The numerical solution of stochastic delay differential equations, with Dr Buckwar.
- Mathematical models with time-lag in the biosciences. with Prof Genna Bocharov (Moscow), Dr Chris Paul and Dr Fathalla Rihan (now at Salford); parameter identification methodologies, sensitivity, etc.
- Identification of the initial function in modelling with DDEs (with Eugene Parmuzin). The reduction of an identification problem to an integral equation, and discrete analogues.
- The numerical solution of neutral and delay differential equations, with Dr Paul. Discontinuous solutions of NDDEs in hale's form.
- The numerical solution of constrained delay differential equations, with Dr Paul and Dr Hongjiong Tian (now Shanghai).
- Nonlinear dynamics for delay differential equations, with Professor Neville Ford (Chester) and Dr Judy Ford (UMIST).
- The solution of discrete Volterra equations, with Dr Yihong Song, now in Shanghai.
- The variation of parameters formulae for Volterra integral equations with Ephraim (now Dr) Agyingi.

Appointments and Professional Activities

Research professor (part-time)

Professor emeritus, University of Manchester.

Honorary visiting professor, Chester College

Founding-director, MCCM

Member of the College of the EPSRC Mathematic Programme

Editor, Journal of Computational & Applied Mathematics

Editor, Journal of Integral Equations & Applications

Editor, J Hellenic Math. Soc.

Honorary editor, Communications on Applied Nonlinear Analysis

Member of the accreditation board, Computer Abstracts

Referee for a number of journals and publishers.

Publications

Baker, C. T. H.; Paul, C. A. H.; Tian, H. Differential algebraic equations with after-effect. J. Comput. Appl. Math. 140 (2002), no. 1-2, 63–80.

Numerical Analysis Reports

396 C. T. H. Baker, J. Ford and N. Ford Bifurcation in Stochastic delay differential equations – 1: Numerical Investigation, January 2002.

398 C. T. H. Baker and Y. Song Discrete Volterra Operators, Fixed Point Theorems & their Application, March 2002.

400 C. T. H. Baker and Y. Song Discrete Volterra Equations—Periodic Solutions of Discrete Volterra Equations, May 2002.

02 Y. Song and C. T. H. Baker Discrete Volterra Equations — Linearized Stability Analysis of Discrete Volterra Equations, June 2002.

403 Y. Song and C. T. H. Baker Discrete Volterra Equations — Perturbation theory for discrete Volterra equations, June 2002.

414 E O Agyingi and C T H Baker Variation of Parameters Formulae for Volterra Integral Equations, November 2002.

Lectures

Various talks in the UK.

Philip I. Davies

Research Associate, University of Manchester
Ph.D. University of Manchester, 2000

I am continuing my work on the EPSRC-funded project "Numerical Analysis of Matrix Functions". Together with Nick Higham we have developed and analysed a general purpose algorithm for the computation of matrix functions. MATLAB code for this algorithm has been made available for download on the project website `http://www.maths.man.ac.uk/~ieuan/NAMF`.

Professional Activities

Referee for Linear Algebra and Applications.

Tutor at LMS-EPSRC Short Instructional Course: 10th Summer School in Numerical Analysis, University of Durham, United Kingdom, July 14-19, 2002.

Publications

P. I. Davies and N. J. Higham. A Schur–Parlett Algorithm for Computing Matrix Functions. Numerical Analysis Report 404, Manchester Centre for Computational Mathematics, Manchester, July 2002. 23 pp. To appear in SIAM J. Matrix Anal. Appl.

P. I. Davies and M. I. Smith. Updating the Singular Value Decomposition. Numerical Analysis Report 405, Manchester Centre for Computational Mathematics, Manchester, Aug 2002. 30 pp. Submitted to the Journal of Computational and Applied Mathematics.

Lectures

Householder Symposium XV, Peebles, Scotland, June 2002. "A Schur-Parlett Algorithm for Computing Matrix Functions."

J. T. Edwards

Head of Department, Chester College
Ph.D. University of Birmingham, 1972

I have continued to work on numerical and analytical solutions of integro-differential equations and have broadened my activities to include work on some singular integral equations and various discrete problems. I collaborated with Neville Ford, Jason Roberts, Sophy Thomas and Charles Simpson at Chester on various numerical stability and qualitative analyses for both continuous and discrete problems and I also worked with Pavel Dubovski during his visit from Moscow in May 2002. I have assisted in the organisation of various seminar days in Chester during 2002. I was co-author of papers presented at the Special Meeting honouring Gerhard Wanner in Geneva in June 2002.

Appointments and Professional Activities

Head of Mathematics Department, Chester College.

Honorary Research Fellow, University of Manchester.

Publications

J T Edwards, N J Ford & J A Roberts *Numerical approaches to bifurcations in solutions to integro-differential equations*, Proceedings of the fifth Hellenic-European Conference on Computer Mathematics and its applications (E A Lipitakis, Ed), 1, (2002) 109-116.

J T Edwards, N J Ford & J A Roberts *The numerical simulation of the qualitative behaviour of Volterra integro-differential equations*, In J Levesley, I J Anderson & J C Mason (Eds) Algorithms for Approximation IV, University of Huddersfield, 2002, 86-93.

N J Ford & J T Edwards *Boundedness and stability of difference equations*, J. Comput. Appl. Math. 140 (2002) 275-289.

J T Edwards, N J Ford & A C Simpson *The Numerical Solution of Linear Multi-term Fractional Differential Equations: Systems of Equations*, J. Comput. Appl. Math. 148, (2002) 401-418.

Research Grants

I received a grant from the London Mathematical Society to support a month-long visit to Chester by Professor Pavel Duboski from Moscow to enable us to begin working on Volterra integral equations and problems in visco-elasticity.

Judith M. Ford

EPSRC Postdoctoral Research Fellow, UMIST;
Honorary Research Fellow, Chester College
Ph.D. University of Liverpool, 2001

I took up my current post as EPSRC Postdoctoral Research Fellow at UMIST in June. Before that I was a Senior Research Assistant working in the Earth Sciences Department at the University of Liverpool on a project concerned with numerical simulation of grain boundary diffusion creep in polymineralic rocks. This project raised some interesting issues in Numerical Analysis concerning the solution of equations which cannot be precisely defined and I have been working with Neville Ford on convergence and stability analysis of such problems.

The main focus of my current research is my project, "Saddle-point systems: is multiresolution analysis the key to effective preconditioning?" in which I am exploring ways of applying wavelet techniques for approximating dense matrices to the solution of saddle-point systems arising from finite element discretization, by sparse approximation of the Schur complement. In this I am collaborating with David Silvester and Catherine Powell at UMIST and also have contact with Ke Chen and Stuart Hawkins at Liverpool.

In November I hosted a visit by Eugene Tyrtyshnikov of the Institute of Numerical Mathematics at the Russian Academy of Sciences and I am working with him on combining wavelet compression with Kronecker product approximation for preconditioning. We have developed an algorithm for solving very large dense linear systems relating to functions defined on a two-dimensional grid. Progress is being made towards applying a similar approach to approximate the dense Schur complements of certain saddle-point systems.

I have also done some preliminary work with Christopher Baker and Neville Ford on some numerical investigations into bifurcations in solutions of Stochastic Delay Differential Equations.

Appointments and Professional Activities

Honorary Research Fellow, Chester College.

Organiser of informal applied mathematics seminars at UMIST

Referee of several articles for academic journals.

Publications

Judith Ford & Ke Chen. *Speeding up the solution of thermal EHL problems*, International Journal of Numerical Methods in Engineering, 53 10 2002, 2305- 2310.

J. M. Ford, J. Wheeler, & A. B. Movchan. *Computer simulation of grain boundary creep*, Acta Materialia, 50 15 2002, 3941-3955.

Christopher T. H. Baker, Judith Ford & Neville J. Ford. *Numerical investigation of bifurcations in stochastic delay differential equations*, MCCM Report 396, 2002.

Judith M. Ford. *An improved DWT-based preconditioner for dense matrix problems*, MCCM Report 412, 2002.

J. M. Ford & E. E. Tyrtyshnikov. *Combining Kronecker product approximation with discrete wavelet transforms to solve dense, function-related linear systems*, MCCM Report 418, 2002.

Lectures

Invited lecture to members of the Geography Department at Chester College (March) on numerical simulation of rock deformation.

Research Grants

EPSRC Postdoctoral Research Fellowship "Saddle-point systems: is multiresolution analysis the key to effective preconditioning?" Funded for 2 years from June 2002 (value £89,467). Grant GR/R95982/01.

Neville J. Ford

Professor of Computational Applied Mathematics, Chester College;
Honorary Research Fellow, Manchester University
Ph.D. University of Liverpool, 1991

My research continues to focus on numerical and analytical approaches to various classes of functional differential equations. I lead the Applied Mathematics Research Group at Chester College, and co-ordinate our programme of international visits and visitors. We have an occasional seminar day programme organised jointly with Christopher Baker.

We have several international co-operations that are current:

- With Teresa Diogo and Pedro Lima (IST, Lisbon) we are working on numerical solutions of some singular integral equations which do not have a unique solution. The work is supported by the British Council and links to the project of Sophy Thomas, a Chester PhD student.
- With Sjoerd Verduyn Lunel (Leiden) we continue to work on the detection of small solutions. With my student, Pat Lumb, we have developed a computer software package to detect the presence of small solutions automatically.
- With Kai Diethelm (Braunschweig) and Alan Freed (NASA), I have been developing efficient algorithms for the solution of differential equations of fractional order. Again this is linked to work of a PhD student, Joseph Connolly.

Within the Chester group, I have continued to work with John Edwards and Jason Roberts on bifurcating solutions to integro-differential equations and their discrete analogues. I have also worked with Christopher Baker and Judy Ford on Stochastic Delay Differential Equations (and bifurcating solutions). Finally, I have been working with John Edwards on the qualitative behaviour of Volterra Difference Equations.

I visited Kai Diethelm (Braunschweig). I was visited by Kevin Burrage (Queensland), Vladimir Kolmanovski (Moscow and Mexico), Eugenie Tyrtyshnikov (Moscow), Wen Chen (Simula Labs, Oslo). I also worked with Alan Freed (NASA) during my visit to Braunschweig.

Appointments and Professional Activities

Director, Applied Mathematics Research Group, Chester College.

Honorary Research Fellow, University of Manchester.

Director of Chester-Manchester Research Unit on Problems with Memory and After-effect.

Member of EPSRC Peer Review College.

Reviewer for Zentralblatt Mathematik and Mathematical Reviews.

Publications

N J Ford & J T Edwards *Boundedness and stability of difference equations*, Journal of Computational and Applied Mathematics 140 (2002) 275-289.

J T Edwards, N J Ford & J A Roberts *Numerical approaches to bifurcations in solutions to integro-differential equations*, Proceedings of the fifth Hellenic-European Conference on Computer Mathematics and its applications (E A Lipitakis, Ed), 1, (2002) 109-116.

J T Edwards, N J Ford & J A Roberts *The numerical simulation of the qualitative behaviour of Volterra integro-differential equations*, In J Levesley, I J Anderson & J C Mason (Eds) Algorithms for Approximation IV, University of Huddersfield, 2002, 86-93.

N J Ford & K Diethelm *Analysis of Fractional Differential Equations*, Journal of Mathematical Analysis and Applications, 265 (2002) 229-248.

N J Ford & K Diethelm *Numerical solution of the Bagley Torvik equation*, BIT 42 (2002) 490-507.

N J Ford, K Diethelm & A D Freed *A predictor corrector approach for the numerical solution of fractional differential equations*, Nonlinear Dynamics, 29 (2002) 3-22.

N J Ford & S M Verduyn Lunel *Characterising small solutions in delay differential equations through numerical approximations*, Applied Mathematics and Computation 131 (2002) 253-270.

N J Ford & A C Simpson *Numerical approaches to the solution of some fractional differential equations*, Proceedings of the fifth Hellenic-European Conference on Computer Mathematics and its applications (E A Lipitakis, Ed), 1, 2002, 93-100.

J T Edwards, N J Ford & A C Simpson *The Numerical Solution of Linear Multi-term Fractional Differential Equations: Systems of Equations*, Journal of Computational and Applied Mathematics 148, (2002) 401-418.

N J Ford & P M Lumb *Numerical approaches to delay equations with small solutions*, Proceedings of the fifth Hellenic-European Conference on Computer Mathematics and its applications (E A Lipitakis, Ed), 1, 2002, 101-108.

N J Ford & P M Lumb *Systems of delay equations with small solutions: a numerical approach*, In J Levesley, I J Anderson & J C Mason (Eds) Algorithms for Approximation IV, University of Huddersfield, 2002, 94-101.

Lectures

Invited lecture during visit to the University of Braunschweig (May).

I co-organised (with Christopher Baker) various seminar days in Manchester and Chester.

Lecture at 60th Birthday meeting for Gerhard Wanner, Geneva, June 2002. (Plus two lectures by PhD students Pat Lumb and Stewart Norton)

Lecture at Special Meeting on Chebyshev Approximation and Computational Mathematics, Huddersfield, November 2002.

Research Grants

My group received a grant from the Leverhulme Trust to support an International Visiting Professorship in Chester for Professor Gennady Bocharov from INMRAS, Moscow.

T. L. Freeman

Senior Lecturer in Computer Science & Mathematics, University of Manchester
Ph.D. University of Liverpool, 1974

My research interests remain centred on the solution of practical problems in Science and Engineering on high performance computers. This includes development and analysis of numerical algorithms on parallel computers, and the development of numerical libraries and programming tools for parallel computers.

I act as Deputy Director of the Centre for Novel Computing (CNC), an interdisciplinary research group in the Department of Computer Science whose mission is the investigation of techniques and tools to support high performance (parallel) computing. Through the CNC I am involved directly in a number of research projects:

Object-Oriented Description of High-Performance Numerical Algorithms. There is a perception that a clean, high-level, abstract description of an application must adversely affect performance; in fact, for most high-performance application development, the first thing that is sacrificed in order to obtain high performance, is a high-level abstract description of the application. Our view is that one should maintain the high-level abstract description for as long as possible and only sacrifice this abstraction when it is essential for performance; in an ideal scenario, the high-level abstraction would be maintained throughout, and "compilers" would take care of restructuring for performance. Thus far we have designed an Object-Oriented Numerical Linear Algebra Library; we are able characterise the circumstances in which a Java-implementation of the library could have Fortran-like performance if the Java compilers implemented some well-known optimisation techniques.

Numerical Algorithms for Grid Computing. The Grid provides a dynamic, distributed, heterogeneous computing environment for numerical computations. The objective of these projects is to investigate techniques by which numerical algorithms can adapt to make optimal use of such a computing environment.

Appointments

Deputy Director, Centre for Novel Computing, Department of Computer Science, University of Manchester.

External examiner for the M.Sc. taught course, Royal Military College of Science, Shrivenham.

Professional Activities

Editor, Parallel and Distributed Computing Practices.

Member of the Technical Committee of the series of International Workshops on High Performance Scientific and Engineering Computing with Applications(HPSECA), Toronto, Canada, August, 2000; Valencia, Spain, September, 2001; Vancouver, Canada, August, 2002; Kaohsiung, Taiwan, ROC, October 2003.

Member of the IASTED Technical Committee on "Parallel & Distributed Computing & Systems" for the period 2001-2004.

Research Grants

Principal investigator (with Professor J. R. Gurd, Department of Computer Science) of the project, *An Overhead Profiler for Single-Address-Space Parallel Programs*, (£132,790) funded by the EPSRC from October 1999.

Co-investigator of the project, *High-Performance Object-Oriented Computational Science*, funded by the EPSRC Strategic Equipment Initiative, (£60,000), June 2000.

Co-investigator (with Professor J. R. Gurd and Dr. R. Sakellariou, Department of Computer Science) of the project, *Tools and Techniques to Support the Development of HPC Applications that are Efficient, Maintainable and Extendible*, funded by the EPSRC Joint Research Equipment Initiative, (£119,943), from March 2001.

Co-investigator (with Mr. W. T. Hewitt, Manchester Visualisation Centre) of the project, *North West Research Centre for Advanced Virtual Prototyping*, funded by the North West Science Review and administered by EPSRC, (£228,860), from April 2001.

Co-investigator (with Mr. G. D. Riley and Dr. M. K. Bane, Department of Computer Science) of the project, *SOFTIAM: Integrated Assessment Modelling Using Distributed Software Components*, funded by NERC (Tyndall Centre for Climate Change), (£155,428), from July 2002.

Publications

Tabirca, T., Freeman, L. and Tabirca, S. (2002) *An $O(\log\ p)$ Parallel Algorithm for Feedback Guided Dynamic Loop Scheduling*, Parallel Algorithms and Applications, **17**, pp. 157–164.

Tabirca, T., Freeman, L. and Tabirca, S. (2002) *A Theoretical Application of Feedback Guided Dynamic Loop Scheduling*, In **Proceedings of the NATO Advanced Research Workshop on Advanced Environments, Tools and Applications for Cluster Computing**, ed. D. Grigoras, A. Nicolau, B. Toursel and B. Folliot, Lecture Notes in Computer Science, vol. 2326, pp. 287–292, Springer-Verlag, Berlin.

Tabirca, T., Freeman, L., Tabirca, S. and Yang. L. T. (2002) *An Application of Feedback Guided Dynamic Loop Scheduling to the Shortest Path Problem*, In **Proceedings of the International Conference on Parallel and Distributed Processing Techniques and Applications (PDPTA'02)**, ed. H.R.Arabnia,CSREA Press, Bogart, Georgia, pp. 1786–1789.

Tabirca, T., Freeman, L. and Tabirca, S (2002) *A Convergence Proof of FGDLS When the Workload is Monotone*, In **Proceedings International Symposium on Parallel and Distributed Computing**, ed. D. Grigoras, Alexandru Ioan Cruza University Press, Iasi, pp. 132–141.

Luján, M., Gurd, J. R., Freeman, T. L. and Miguel, J. (2002) *Elimination of Java Array Bounds Checks in the Presence of Indirection*, In **Proceedings of the ACM SIGPLAN JavaGrande-ISCOPE 2002 Conference**, pp. 76 –85, ACM Press.

Luján, M., Gurd, J. R., Freeman, T. L. (2002) *OoLaLa - How and When Can It Be Optimised?*, In **Proceedings of the ACM SIGPLAN JavaGrande-ISCOPE 2002 Conference**, p. 234, ACM Press.

Lecture

Seminar at University College, Cork, August, 2002.

Nicholas J. Higham

Richardson Professor of Applied Mathematics, University of Manchester
Ph.D. University of Manchester, 1985

The second edition of my 1996 SIAM monograph *Accuracy and Stability of Numerical Algorithms* was published in hardback in August 2002. The book was completely revised, with new material added and numerous improvements made to the original material. Associated with the book is the *Matrix Computation Toolbox for MATLAB* (`http://www.ma.man.ac.uk/~higham/mctoolbox`), which supersedes my earlier Test Matrix Toolbox. It contains functions for constructing test matrices, computing matrix factorizations (including block $\mathrm{LDL}^{\mathrm{T}}$ factorizations for symmetric matrices), visualizing matrices, and carrying out direct search optimization.

Philip Davies and I developed a new algorithm and associated MATLAB software for computing a matrix function $f(A)$, for a wide class of functions f. The algorithm reduces the matrix to Schur form and applies the (block) Parlett recurrence to compute a function of a triangular matrix. Our contributions include a blocking and reordering strategy for the Schur form and a convergence test for the evaluation of the Taylor series of "atomic" diagonal blocks. Our numerical experiments show the method to be competitive with existing special-purpose $f(A)$ algorithms and more robust and numerically reliable than MATLAB 6.5's function `funm`.

Two students completed their PhD theses this year. Harikrishna Patel's thesis is on the indefinite least squares problem, and we completed two papers jointly with EPSRC Visiting Fellow Adam Bojanczyk (Cornell University). Matthew Smith's thesis treats the numerical computation of matrix functions, and in our final piece of work we developed a numerical method for computing the matrix cosine using a Padé approximant in conjunction with the double angle formula $\cos(2A) = 2\cos(A)^2 - I$.

Professors Niloufer Mackey and Steve Mackey from Western Michigan University visited from August 2002 until April 2003, supported by an EPSRC Visiting Fellowship. They are working with Françoise Tisseur and I on structured matrix computations, and we have begun by using a group framework to obtain a general theory, tools and algorithms. The collaboration is proving very fruitful, with several papers written or in progress.

Appointments and Professional Activities

Director of Manchester Centre for Computational Mathematics.

Head of Numerical Analysis Group.

Director of M.Sc. in Applied Numerical Computing.

Member of Executive Committee of the Centre for Novel Computing in the Department of Computer Science, University of Manchester.

Editorial board, SIAM Journal on Matrix Analysis and Applications.

Editorial board, IMA Journal of Numerical Analysis.

Editorial board, Linear Algebra and Applications.

Editorial board, Foundations of Computational Mathematics.

Editorial board, SIAM News.

Member of Executive Committee of Foundations of Computational Mathematics.

Member of EPSRC Peer Review College.

Chair of the SIAM Activity Group on Linear Algebra.

Chair of (permanent) organizing committee of Householder Symposia.

Organizer of minisymposium "Matrix Pseudospectra and Applications" (with L. N. Trefethen), SIAM Annual Meeting, Philadelphia, July 2002.

Member of organizing committee of Eighth SIAM Conference on Applied Linear Algebra, College of William and Mary, Williamsburg, July 2003.

Organizer, with F. Tisseur, of One Day Meeting on Structured Eigenvalue Problems, University of Manchester, November 2002.

Publications

(These publications are available from my Web page at `http://www.ma.man.ac.uk/~higham/`)

A. Bojanczyk, N. J. Higham, and H. Patel. Solving the indefinite least squares problem by hyperbolic QR factorization. Numerical Analysis Report No. 397, Manchester Centre for Computational Mathematics, Manchester, England, Jan. 2002. *SIAM J. Matrix Anal. Appl.*, 24(4):914–931, 2003.

A. Bojanczyk, N. J. Higham, and H. Patel. The equality constrained indefinite least squares problem: Theory and algorithms. Numerical Analysis Report No. 413, Manchester Centre for Computational Mathematics, Manchester, England, Oct. 2002. 11 pp. Revised January 2003. To appear in BIT.

P. I. Davies and N. J. Higham. A Schur–Parlett algorithm for computing matrix functions. Numerical Analysis Report No. 404, Manchester Centre for Computational Mathematics, Manchester, England, July 2002. 22 pp. Revised March 2003. To appear in SIAM J. Matrix Anal. Appl.

N. J. Higham. *Accuracy and Stability of Numerical Algorithms*. Society for Industrial and Applied Mathematics, Philadelphia, PA, USA, second edition, 2002. ISBN 0-89871-521-0. xxx+680 pp.

N. J. Higham. Computing the nearest correlation matrix—A problem from finance. *IMA J. Numer. Anal.*, 22(3):329–343, 2002.

N. J. Higham. *J*-orthogonal matrices: Properties and generation. Numerical Analysis Report No. 408, Manchester Centre for Computational Mathematics, Manchester, England, Sept. 2002. 15 pp. Revised March 2003. To appear in SIAM Rev.

N. J. Higham. The Matrix Computation Toolbox for MATLAB (version 1.0). Numerical Analysis Report No. 410, Manchester Centre for Computational Mathematics, Manchester, England, Aug. 2002. 19 pp.

N. J. Higham. Review of "Arnold Neumaier. Introduction to Numerical Analysis. Cambridge University Press, 2001". *SIAM Rev.*, 44(3):492–493, Sept. 2002.

N. J. Higham. Review of "Michael Overton, Numerical Computing with IEEE Floating Point Arthmetic: Including One Theorem, One Rule of Thumb, and One Hundred and One Exercises. Society for Industrial and Applied Mathematics, Philadelphia, PA, USA, 2001". *SIAM Rev.*, 44(2): 287–288, June 2002.

N. J. Higham and M. I. Smith. Computing the matrix cosine. Numerical Analysis Report No. 411, Manchester Centre for Computational Mathematics, Manchester, England, Sept. 2002. 15 pp. Revised April 2003. To appear in Numerical Algorithms.

N. J. Higham and F. Tisseur. More on pseudospectra for polynomial eigenvalue problems and applications in control theory. *Linear Algebra Appl.*, 351–352:435–453, 2002.

N. J. Higham, F. Tisseur, and P. M. Van Dooren. Detecting a definite Hermitian pair and a hyperbolic or elliptic quadratic eigenvalue problem, and associated nearness problems. *Linear Algebra Appl.*, 351–352:455–474, 2002.

Lectures

UK and Republic of Ireland Section of SIAM, Annual Meeting, University of Leeds, January 2002, "How to Detect and Destroy Definiteness of Generalized and Quadratic Eigenvalue Problems".

ERCIM Working Group on Matrix Computations and Statistics, INRIA/IRISA, Rennes, February 2002, "Computing the Nearest Correlation Matrix—A Problem from Finance".

Householder XV Symposium, Peebles, June 2002. "Solving the Indefinite Least Squares Problem by Hyperbolic QR Factorization".

SIAM Annual Meeting, Philadelphia, July 2002. Talk in minisymposium "Indefinite Matrix Problems' and Hyperbolic Transformations": "Solving the Indefinite Least Squares Problem by Hyperbolic QR Factorization".

Seminars at Rome (La Sapienza), Pisa, and Oxford.

Research Grants

Principal investigator on project "Numerical Analysis of Matrix Functions" funded by EPSRC Mathematics Committee for three years from February 2001 (value £129,092). Grant GR/R22612.

EPSRC Visiting Fellowship for Professor A. Bojanczyk (Cornell University) on project "Hyperbolic Transformations: Numerical Algorithms and Stability", August 2001–January 2002. Grant GR/R22414 (value £8159).

Principal investigator on Masters Training Package "Numerical Analysis and Computing" funded by EPSRC for one year from September 2001 (value £51,897). Grant GR/RN26883/01.

London Mathematical Society conference grant for "XVth Householder Symposium on Numerical Linear Algebra", (value £2000), June 2002.

EPSRC grant "XVth Householder Symposium on Numerical Linear Algebra", with A. Ramage (PI), A. J. Wathen and P. A. Knight (value £25,625), June 2002. Grant GR/R63028/01.

Co-investigator with F. Tisseur on EPSRC Visiting Fellowship for Professor N. Mackey (W. Michigan University) on project "Structured Eigenvalue Problems: Theory and Numerics", September 2002–April 2003. Grant GR/S15563/01 (value £9958).

Grant of £2700 from the Royal Society for an 8-week study visit by Dr Z. Liu (Changsha, P.R. China) under the Society's agreement with the China Association for Science and Technology.

Christopher A. H. Paul

Research Fellow/Computer Support, Officer/Procurement Officer, University of Manchester
PhD. University of Manchester, 1992

This past year it has been increasingly challenging to balance the increased demands of both computer support and procurement with finding time to do research. A record number of postgraduate students in the Department, combined with increasing numbers of staff using laptops for research, has led to a corresponding increase in computer support requests.

I have continued my collaboration with Profs. Baker and Bocharov (RAS, Moscow) and Dr. Rihan on the mathematical modelling of cell proliferation using retarded differential equations. I gave a seminar at Bristol University on the propagation of discontinuities in retarded differential equations that brought together several areas that I have worked on over the past ten years. The preparation for this seminar subsequently led me to discover a previously unremarked continuity problem for a class of neutral delay differential equations, the consequence of which is that most (if not all) numerical codes for solving this class of NDDE produce incorrect solutions (*see MCCM report 417*).

Appointments and Professional Activities

Computer Support Officer, Department of Mathematics.

Procurement Officer, Department of Mathematics.

Chair of the Faculty of Science & Engineering Computer Components Procurement subgroup.

Member of the University Computer Working Strategy Group.

Referee for Journal of Computational and Applied Mathematics.

Internal Ph.D. Examiner for Ephraim Eagyingi.

Member of EPSRC College 2003 onwards.

Publications

C.T.H. Baker, C.A.H. Paul and H. Tian, Differential algebraic equations with after-effect. J. Comput. Appl. Math., 140 (2002), pp. 63–80.

C.T.H. Baker and C.A.H. Paul, Piecewise continuous solutions of neutral delay differential equations, MCCM report 417 (in preparation)

C.T.H. Baker, G.A. Bocharov, C.A.H. Paul and F.A. Rihan, Models with delays for cell population dynamics: identification, selection and analysis – Part I, MCCM report 425.

Lectures

Seminar speaker at Bristol University's Applied Nonlinear Mathematics Group, "Impact of discontinuities in modelling with delay equations"

J. A. Roberts

Assistant, Mathematics Department, Chester College
Ph.D. Liverpool University, 2000

I am continuing my work on stability and bifurcations in numerical solutions of integral and integro-differential equations. I have been developing some collaborative links with potential coworkers in this area and have recently succeeded in obtaining a NATO grant to support a visitor.

Publications

J T Edwards, N J Ford & J A Roberts *Numerical approaches to bifurcations in solutions to integro-differential equations*, Proceedings of the fifth Hellenic-European Conference on Computer Mathematics and its applications (E A Lipitakis, Ed), 1, (2002) 109-116.

J T Edwards, N J Ford & J A Roberts *The numerical simulation of the qualitative behaviour of Volterra integro-differential equations*, In J Levesley, I J Anderson & J C Mason (Eds) Algorithms for Approximation IV, University of Huddersfield, 2002, 86-93.

Tony Shardlow

Lecturer, University of Manchester
Ph.D. Stanford, 1997

I joined the Numerical Analysis group in Manchester in September 2002 from Durham. It's a pleasure to join such a stimulating group of mathematicians. My own research is focused on Stochastic Differential Equations.

Projects include Dissipative Particle Dynamics, a method of simulating constant temperature thermodynamics used in industry (for example, by Unilever) to model multi-phase flows. I have developed a simple method for simulating this system and with postdoc Yubin Yan am trying to develop a strong theoretical understanding of the equations.

I also work together with Evelyn Buckwar at Humbold Universität. We have analysed the weak convergence properties of a Euler method for a general class of stochastic delay equations with distributed delay. I plan to continue my work with the Berlin group (Buckwar and Gilsing) by developing a software package for solving SDEs within MATLAB.

Research Grants

Principal Investigator on project "Implicit Methods for Dissipative Particle Dynamics", EPSRC.

Principal Investigator on project "Numerics for Stochastic Differential Equations", Nuffield.

Co-investigator, "Conference on SDEs and SPDEs: numerical methods and applications," with G. Lord and G. Lyther, EPSRC.

Publications

Shardlow, T. A coupled Cahn-Hilliard particle system, Electron. J. Diff. Eqns., Vol. 2002 (2002), No. 73, pp. 1-21.

Shardlow, T. Splitting for Dissipative Particle Dynamics SIAM J. Sci. Comput., vol 24, no. 4, 1267-1282 (2003).

Lectures

"Dissipative Particle Dynamics," BAMC session on Granular an Particle Laden Flow, Warwick, March 2002.

David J. Silvester

Reader, UMIST
Ph.D. University of Manchester, 1984

My research effort continues to revolve around writing a research textbook: *Finite Elements and Fast Iterative Solvers*, to be published by Oxford University Press in the Numerical Mathematics and Scientific Computation Series. This project involves two erudite collaborators; Professor Howard Elman (University of Maryland) and Dr Andy Wathen (Oxford University Computing Laboratory). We expect to finish writing the book over the Summer, and we anticipate publication before the end of 2003.

My research student Syamsudhuha successfully submitted his Ph.D thesis on "A Study of Multigrid Methodology for Convection-diffusion Equations" in May. He is currently writing up some of this work before returning back to the University of Riou, Indonesia.

Research avenues that I am actively exploring at present include groundwater flow modelling (with my Ph.D student Catherine Powell), wavelet preconditioners (with Dr Judy Ford, EPSRC postdoctoral fellow), anisotropic mesh refinement (with Dr David Kay and Professor Mark Ainsworth) and adaptivity for the Navier-Stokes equations (with David Kay, Dr David Griffiths and Dr Philip Gresho, latterly an EPSRC Visiting Fellow at UMIST).

Other project proposals currently being prepared or being considered by the EPSRC that I plan to contribute to include: fractal finite elements (with Professor David Broomhead and Dr Keith Davey); modelling sensors for measuring moisture in grain (with Dr Andy Gibson and Dr Grant Campbell); and fluid-structure interaction in modelling lung-biomechanics (with Dr Matthias Heil, from the University of Manchester).

Professional Activities

Editorial board, SIAM Journal on Scientific Computing.

Editorial board, International Journal for Numerical Methods in Fluids.

Member of EPSRC Peer Review College 2000–present.

Research Grants

Investigator on MTP project "Applied Numerical Computing", EPSRC funded M.Sc programme, April 2002—September 2007 (value £565,000). Grant GR/R59984/01.

Publications

All of these publications are available via the WWW, see `http://www.ma.umist.ac.uk/djs/`

Elman, H., Silvester, D. and Wathen, A., Performance and analysis of saddle point preconditioners for the discrete steady-state Navier-Stokes equations, Numerische Mathematik, 90: 665–688, 2002.

Elman, H., Silvester, D. and Wathen, A., Block Preconditioners for the Discrete Incompressible Navier-Stokes Equations, International Journal for Numerical Methods in Fluids 40:333-344, 2002.

Wathen, A., Loghin, D, Kay, D., Elman, H., and Silvester, D., A preconditioner for the 3D Oseen equations, Oxford University Computing Laboratory Report # 02/04, 2002.

Powell, C. and Silvester, D. Optimal preconditioning for Raviart-Thomas mixed formulations of second-order elliptic problems, Manchester Centre for Computational Mathematics Report # 399, 2002.

Mihajlović, M. and Silvester, D. Efficient parallel solvers for the biharmonic equation, Manchester Centre for Computational Mathematics Report # 406, 2002.

Powell, C. and Silvester, D. Black-box preconditioning for mixed formulation of self-adjoint elliptic PDEs, Manchester Centre for Computational Mathematics Report # 415, 2002.

Lectures

Invited speaker at a *Conference on Challenges in Scientific Computing,* held at the Weierstrass Institute, Berlin, October 2002. All expenses paid by the organisers.

Invited talk at the *15th Householder Symposium*, Peebles, Scotland, June 2002. All expenses paid by the organisers.

R. W. Thatcher

Senior Lecturer, UMIST
Ph.D. University of London, 1972

My work on least squares techniques for fluid flow has been restricted to the joint work with Paul Bolton, who obtained his PhD during 2002. Paul is writing up some of his results including concerns about modelling incompressibility in least squares methods and extending our stress/stream function approach to modelling the Navier Stokes equations.

My main area of research over the last twelve months has continued to be concerned with Numerical Modelling in Combustion. Much of the recent work has been concerned with modelling the edges of flames, concentrating on the stability of solutions and flame edges at large Lewis numbers, and some work has continued in modelling flame balls. All the work in combustion has been done in collaboration with John Dold at UMIST and the work on flame edges with our jointly supervised student Alessandro Omon-Arancibia. A new research student, Eman Al-Sarairah, has just begun work on modelling flames.

Appointments and Professional Activities

Head of the Mathematics Department, UMIST.

Member of the Academic Planning Committee at UMIST.

Publications

Oscillatory flame edge propagation, isolated flame tubes and stability in a non-premixed counterflow, (with J. W. Dold and A. A. Omon-Arancibia), Combustion Theory and Modelling **6** (2002), 487-502.

From one step to chain-branching premixed flame asymptotics (with J. W. Dold, A. A. Omon-Arancibia and J. Redman), to appear in the Proceedings of the Combustion Institute.

Flame balls with thermally sensitive intermediate kinetics (with J. W. Dold, R. O. Webber and A. A. Shah), to appear in Combustion Theory and Modelling.

Ruth M. Thomas

Senior Lecturer, UMIST
Ph.D. University of Manchester, 1979

In 2002, I worked on two main research projects. The first project concerns the numerical solution of periodic initial value problems with oscillatory solution. I collaborated with Dr. John Coleman of the University of Durham on developing collocation methods for solving problems of this type.

In the second project, I worked on moving mesh methods for parabolic partial differential equations, in particular for problems arising when modelling the propagation of a narrow flame in a detonator delay element. This work was in collaboration with a research student, Thebe Basebi, who was awarded the Ph.D. degree in July 2002.

Appointments and Professional Activities

External Examiner, M.Sc. Course in Computational Mathematics and Modelling, University of Brunel.

Referee of numerous papers for academic journals.

Referee of several research proposals for the EPSRC.

Departmental responsibilities include being Assistant Head of Department, Director of Undergraduate Studies and Undergraduate Tutor.

Publications

T. Basebi and R. M. Thomas. A Study of Moving Mesh Methods Applied to a Thin Flame Propagating in a Detonator Delay Element. *Computers and Mathematics with Applications*, **45**, 131-163 (2003).

Françoise Tisseur

Colin Roscoe Lecturer in Numerical Analysis, University of Manchester
Ph.D. University of St. Etienne, 1997

Over the past year I continued my work on structured matrices and generalized and polynomial eigenvalue problems.

In joint work with Jean-Pierre Dedieu (Toulouse University, France), Myong-Hi Kim (SUNY at Old Westbury, USA) and Michael Shub (IBM T. J. Watson Research Center, USA), we derived upper and lower bounds for the ϵ-pseudosolution set $g(B(x,\epsilon))$ of an analytic function g between two Hilbert spaces, where $g(x)$ expresses the solution of an equation depending on x and $B(x,\epsilon)$ is the closed ball about x with radius ϵ. We applied our results to the implicit function associated with the polynomial eigenvalue problem. This allowed us to provide and upper and lower bounds for the pseudospectrum of the polynomial eigenvalue problem. I presented these results together with some joint research with Nick Higham on pseudospectra for matrix polynomials as an invited plenary speaker at the triennial Householder Symposium XV on numerical linear algebra.

As part of my effort to investigate the numerical solution of symmetric indefinite generalized eigenvalue problems, I first worked on the reduction in a finite number of steps of a symmetric pair to some simple symmetric forms. This is a crucial step before deriving and applying any eigensolvers. I investigated three methods reducing the symmetric pair to tridiagonal-diagonal form. Two of them employ more stable versions of Brebner and Grad's pseudosymmetric Givens and pseudosymmetric Householder reductions, while the third is new and based on a combination of Householder reflectors and hyperbolic rotations. I proved an optimality condition for the transformations used in the third reduction. With S. D. Garvey (University of Nottingham), M. I. Friswell (University of Wales, Swansea) and J. E. T. Penny (University of Aston, Birmingham), we showed how to simultaneously reduce a pair of symmetric matrices to tridiagonal form by congruence transformations. One advantage of this approach is that no assumption is needed on the nonsingularity of the matrices in the pair.

Following my visit to Pisa in April, I started working with Dario Bini and Luca Gemignani on a robust implementation of Aberth's Method for computing the eigenvalues of symmetric-diagonal pairs. In parallel I started to study the HZ algorithm for symmetric-diagonal pairs with Ph.D student Michael Berhanu. Our plan is to compare these two approaches.

I was awarded an EPSRC Visiting Fellowship for Professor Niloufer Mackey (Western Michigan University) starting in September 2002, finishing in April 2003. We worked together with Steve Mackey (Western Michigan University) on structured matrices arising in the context of a nondegenerate bilinear or sesquilinear form. We constructed a variety of structure-preserving transformations belonging to the automorphism groups of these forms, and imitating the action of Givens rotations, Householder reflectors, and Gauss transformations. We also describe transformations for performing structured scaling actions. It is expected that this work will aid in the derivation of new structure-preserving factorizations, as well as in the development of new structure-preserving algorithms. Several papers are submitted or in preparation.

Professional Activities

Organizer, with N. J. Higham, of One Day Meeting on Structured Eigenvalue Problems, University of Manchester, November 2002.

Publications

N. J. Higham and F. Tisseur. More on Pseudospectra for Polynomial Eigenvalue Problems and Applications in Control Theory. *Linear Algebra and Appl.*, 351/352:435–453, 2002.

N. J. Higham, F. Tisseur and P. M. Van Dooren. Detecting a Definite Hermitian Pair and a Hyperbolic or Elliptic Quadratic Eigenvalue Problem, and Associated Nearness Problems. *Linear Algebra and Appl.*, 351/352:455–474, 2002.

J.-P. Dedieu, M.-H. Kim, M. Shub and F. Tisseur. Implicit Gamma Theorems (I): Pseudoroots and Pseudospectra. Numerical Analysis Report 394, Manchester Centre for Computational Mathematics, July 2002 (revised version). *Foundations of Comp. Math.*, 3:1-31, 2003.

S. D. Garvey, F. Tisseur, M. I. Friswell and J. E. T. Penny. Simultaneous Tridiagonalization of Two Symmetric Matrices, Numerical Analysis Report 407, Manchester Centre for Computational Mathematics, August 2002. To appear in *Int. J. Numer. Meth. Engng.*

F. Tisseur. Tridiagonal-Diagonal Reduction of Symmetric Indefinite Pairs. Numerical Analysis Report 409, Manchester Centre for Computational Mathematics, September 2002.

Lectures

Householder Symposium XV, Peebles, Scotland, June 2002. "Pseudospectra of Matrix Polynomials: Theory, Computation, Visualization, and Applications".

In minisymposium "Numerical Linear Algebra" at British Applied Mathematics Colloquium, University of Warwick, April 2002.

SIAM Annual Meeting, Philadelphia, July 2002. Talk in minisymposium "Matrix Pseudospectra and Applications": "Pseudospectra of Matrix Polynomials: Theory, Computation, Visualization, and Applications".

SIAM Annual Meeting, Philadelphia, July 2002. Talk in minisymposium "Indefinite Matrix Problems' and Hyperbolic Transformations": "Using Hyperbolic Transformations in the Generalized Symmetric Eigenvalue Problem".

Workshop Liens Calcul Numerique - Calcul Formel, Toulouse, France, December 2002, "Recent Developments in Symmetric Quadratic Eigenvalue Problems"

Research Grants

Award to Newly Appointed Lecturers in Science, Engineering and Mathematics from the Nuffield Foundation. Amount of grant: £4,845 (maximum award is £5K), 2001–2003. Grant Number: NAL/00216/G.

Principal Investigator on project "Numerical Analysis of Polynomial Eigenvalue Problems" funded by EPSRC Mathematics Committee under the "Fast Stream" scheme for three years from September 2001 (value £62,553). Grant GR/R45079/01.

Principal Investigator on EPSRC Visiting Fellowship for Prof. N. Mackey (W. Michigan University) on project "Structured Eigenvalue Problems: Theory and Numerics", Sept 2002–April 2003. Grant GR/S15563/01 (value £9958).

3 Visitors

3.1 Long-Term Visitors

Niloufer Mackey

Associate Professor
Western Michigan University
Ph.D. State University of New York at Buffalo, 1995

The first half of 2002 was dominated by teaching and related duties at Western Michigan University where I hold a permanent appointment. However, my activities took a decidedly more research-oriented turn once my teaching duties ended in June, and my long-awaited sabbatical year began.

During the Fall semester I visited Professor Nick Higham and Dr Françoise Tisseur at the Department of Mathematics, University of Manchester, supported by an EPSRC Visiting Fellowship. Together with S. Mackey, work began on a wide range of problems related to structured matrices. We developed an extensive collection of structure-preserving transformations that perform the basic actions on which the majority of the algorithms of numerical linear algebra rely. The notion of Householder transformations was extended to scalar product spaces, giving a complete characterization of these transformations and their mapping properties for a large class of automorphism groups. We investigated the existence of structured versions of several important matrix factorizations, and built structure-preserving iterations for the matrix sign function and the polar decomposition. Work was begun on six papers encompassing many of these results.

Lectures

Colloquium, Department of Mathematics and Statistics, Oakland University, Rochester, MI. March 7, 2002.

Householder Symposium XV, Peebles, Scotland, June 2002. "On n-dimensional Givens transformations".

One Day Meeting on Structured Eigenvalue Problems, University of Manchester November 8, 2002. "Spectral Effects with Quaternions".

Computational Mathematics and Applications Seminars, Oxford University Computing Laboratory, Oxford, England. November 21, 2002. "Spectral Effects with Quaternions".

D. Steven Mackey

Western Michigan University
M. A. State University of New York at Buffalo, 1983

The first half of 2002 was dominated by teaching duties at Western Michigan University where I hold a temporary appointment. However, my activities took a decidedly more research-oriented turn once my appointment ended in June.

During the Fall semester I visited Professor Nick Higham and Dr Françoise Tisseur at the Department of Mathematics, University of Manchester. Together with N. Mackey, work began on a wide range of problems related to structured matrices—see Niloufer Mackey's entry for details.

Lectures

Pi Mu Epsilon, Undergraduate Mathematics Honor Society, Western Michigan University, Kalamazoo. "Green's Theorem on Wheels". April 12, 2002.

One Day Meeting on Structured Eigenvalue Problems, University of Manchester November 8, 2002. "All in the Family: Factorizations in Matrix Groups".

3.2 Medium-Term Visitors

Dr Z. Liu (Changsha, P.R. China). Royal Society-China Association for Science and Technology study visit, October–December 2002.

Professor S. J. Hammarling (NAG Ltd., Oxford). University of Manchester Simon Industrial and Professional Fellow, November 2002.

Professor E. E. Tyrtyshnikov (Institute of Numerical Mathematics, Russian Academy of Sciences, Moscow, Russia). Collaborative visit to UMIST, relating to EPSRC Research Fellowship GR/R95982/01, and to Chester College, November 2002.

4 Joint University of Manchester–UMIST Seminars in Applied Mathematics (including Numerical Analysis)

January 30, 2002, Dr. Vladimir Karlin (Centre for Research in Fire and Explosions) University of Central Lancashire Hydrodynamic flame instability within the framework of the Sivashinsky equation

February 6, 2002, Dr. Alexander Freidin (Inst. of Mech. Eng. Problems, Russian Academy of Sciences) St. Petersburg Two-Phase Deformations in Elastic Solids: Finite Strains and Small Strain Approach

February 27, 2002, Dr. D. Silvester (Department of Mathematics, UMIST) A Posteriori Error Estimation for Elliptic PDEs

March 6, 2002, Dr. Maria Heckl (Department of Mathematics, Keele University) Curve squeal of train wheels: Unstable modes and limit cycles

March 13, 2002, Prof. Samuel Braunstein (School of Informatics, University of Wales) Bangor Quantum Teleportation

March 20, 2002, Dr Valery Smyshlyaev (Department of Mathematical Sciences, University of Bath) Rapidly oscillating media, homogenisation, asymptotics, "higher order" and "nonlocal" effects

April 17, 2002, Prof. Nick Trefethen (Computing Laboratory, Oxford University) Transition in a circular pipe

April 24, 2002, Prof. D. Arrowsmith (School of Mathematical Sciences Queen Mary, University of London) Theory and Modelling of Packet Networks

May 8, 2002, Dr. Stephen Cox (Division of Applied Mathematics, The University of Nottingham) Mixing in a Stokes flow with changing geometry

May 15, 2002, Dr. Valeria Simoncini (Dipartimento di Matematica, Universita di Bologna) Block structured numerical linear algebra problems: two examples stemming from electromagnetics

October 2, 2002, Dr. Tony Shardlow (Dept. of Mathematics University of Manchester) An introduction to Stochastic PDEs

October 9, 2002, Dr. Rob Sturman (School of Mathematics, Leeds University) Cycling chaos: loss of stability and non-ergodic dynamics

October 23, 2002, Dr Spencer J. Sherwin (Dept. of Aeronautics, Imperial College of Science, Technology and Medecine) Algorithms and Arteries: Spectral/hp element methods for arterial flow modelling.

October 30, 2002, Prof. Victor Yudovich (Rostov University) Russia Cosymmetry and its applications

November 6, 2002, Prof. Oliver Jensen (Centre for Mathematical Medicine, University of Nottingham) Self-excited oscillations of flows through collapsible channels.

November 13, 2002, Prof. Ian Melbourne (Dept. of Mathematics and Statistics, University of Surrey) A new test for chaos in deterministic nonlinear dynamical systems

November 20, 2002, Prof. A. J. M Spencer (School of Mathematical Sciences, University of Nottingham) Modelling granular material mechanics - problems, paradoxes and proposals

November 27, 2002, Prof. Kevin Burrage (Dept. of Mathematics, University of Queensland) Stochastic models and simulations for chemically reacting systems

December 4, 2002, Dr. Tim Field (QinetiQ) Diffusion processes in electromagnetic scattering generating K-distributed noise

December 18, 2002, Dr. James Blowey (Dept. of Mathematical Sciences, University of Durham) Finite Element Approximation of an Allen-Cahn/Cahn-Hilliard System

5 Numerical Analysis Reports

The following reports may be identified by the ISSN number `ISSN 1360-1725` and are available in hard copy (contact The Secretaries, Mathematics Department, University of Manchester, Manchester, M13 9PL, England) and in electronic form via the MCCM web pages at `http://www.ma.man.ac.uk/MCCM/MCCM.html` or `http://www.maths.man.ac.uk/~nareports` to go directly to the reports. Many reports form the basis of papers subsequently published in journals.

The reports are listed in reverse chronological order.

[1] Gareth I. Hargreaves. Interval analysis in MATLAB. Numerical Analysis Report No. 416, Manchester Centre for Computational Mathematics, Manchester, England, December 2002. 49 pp.

[2] Catherine Powell and David Silvester. Black-box preconditioning for mixed formulation of self-adjoint elliptic PDEs. Numerical Analysis Report No. 415, Manchester Centre for Computational Mathematics, Manchester, England, November 2002. Submitted to the conference proceedings of CISC 2002 for publication in Springer Lecture Notes in Computer Science and Engineering.

[3] Adam Bojanczyk, Nicholas J. Higham, and Harikrishna Patel. The constrained indefinite least squares problem: Theory and algorithms. Numerical Analysis Report No. 413, Manchester Centre for Computational Mathematics, Manchester, England, October 2002. 11 pp.

[4] Judith M. Ford. An improved DWT-based preconditioner for dense matrix problems. Numerical Analysis Report No. 412, Manchester Centre for Computational Mathematics, Manchester, England, September 2002.

[5] Nicholas J. Higham and Matthew I. Smith. Computing the matrix cosine. Numerical Analysis Report No. 411, Manchester Centre for Computational Mathematics, Manchester, England, September 2002. 15 pp.

[6] Nicholas J. Higham. The Matrix Computation Toolbox for MATLAB (version 1.0). Numerical Analysis Report No. 410, Manchester Centre for Computational Mathematics, Manchester, England, August 2002. 19 pp.

[7] Françoise Tisseur. Tridiagonal-diagonal reduction of symmetric indefinite pairs. Numerical Analysis Report No. 409, Manchester Centre for Computational Mathematics, Manchester, England, September 2002. 20 pp.

[8] Nicholas J. Higham. J-orthogonal matrices: Properties and generation. Numerical Analysis Report No. 408, Manchester Centre for Computational Mathematics, Manchester, England, September 2002. 15 pp.

[9] Seamus. D. Garvey, Françoise Tisseur, Mike I. Friswell, John E. T. Penny, and Uwe Prells. Simultaneous tridiagonalization of two symmetric matrices. Numerical Analysis Report No. 407, Manchester Centre for Computational Mathematics, Manchester, England, August 2002. 18 pp.

[10] Milan Mihajlovic and David Silvester. Efficient parallel solvers for the biharmonic equation. Numerical Analysis Report No. 406, Manchester Centre for Computational Mathematics, Manchester, England, July 2002. Submitted to Parallel Computing.

[11] Philip I. Davies and Matthew I. Smith. Updating the singular value decomposition. Numerical Analysis Report No. 405, Manchester Centre for Computational Mathematics, Manchester, England, August 2002. 30 pp.

[12] Philip I. Davies and Nicholas J. Higham. A Schur–Parlett algorithm for computing matrix functions. Numerical Analysis Report No. 404, Manchester Centre for Computational Mathematics, Manchester, England, July 2002. 22 pp.

[13] Y. Song and C. T. H. Baker. Perturbation theory for discrete Volterra equations. Numerical Analysis Report No. 403, Manchester Centre for Computational Mathematics, Manchester, England, June 2002. 18 pp.

[14] Y. Song and C. T. H. Baker. Stability in discrete Volterra equations. Numerical Analysis Report No. 402, Manchester Centre for Computational Mathematics, Manchester, England, June 2002. 19 pp.

[15] Manchester Centre for Computational Mathematics. Annual report: January–December 2001. Numerical Analysis Report No. 401, Manchester Centre for Computational Mathematics, Manchester, England, May 2002. 21 pp.

[16] C. T. H. Baker and Y. Song. Periodic solutions of discrete Volterra equations. Numerical Analysis Report No. 400, Manchester Centre for Computational Mathematics, Manchester, England, May 2002. 21 pp.

[17] Catherine Powell and David Silvester. Optimal preconditioning for Raviart-Thomas mixed formulation of second-order elliptic problems. Numerical Analysis Report No. 399, Manchester Centre for Computational Mathematics, Manchester, England, March 2002. Submitted to the SIAM Journal on Matrix Analysis and Applications.

[18] C. T. H. Baker and Y. Song. Discrete volterra operators, fixed point theorems & their application. Numerical Analysis Report No. 398, Manchester Centre for Computational Mathematics, Manchester, England, March 2002. 23 pp.

[19] Adam Bojanczyk, Nicholas J. Higham, and Harikrishna Patel. Solving the indefinite least squares problem by hyperbolic QR factorization. Numerical Analysis Report No. 397, Manchester Centre for Computational Mathematics, Manchester, England, January 2002. 19 pp.

[20] C. T. H. Baker, J. M. Ford, and N. J. Ford. Bifurcations in stochastic delay differential equations—I: Numerical investigation. Numerical Analysis Report No. 396, Manchester Centre for Computational Mathematics, Manchester, England, March 2002. 18 pp.

6 Summary of Meeting on Structured Eigenvalue Problems

A meeting on *Structured Eigenvalue Problems*, organized by Françoise Tisseur and Nick Higham, was held on Friday November 8, 2002 in the Department of Mathematics, University of Manchester.

The programe was:

```
10:30 - 11:15  Coffee/tea.

11:15 - 11:55  Professor Steven Mackey (W. Michigan Univ.)
               "All in the Family: Factorizations in Matrix Groups"

12:00 - 12:40  Professor Niloufer Mackey (W. Michigan Univ.)
               "Exploiting the Quaternion Structure of Real Eigenproblems"

12:45 -  2:00  Lunch.

 2:00 -  2:55  Professor Peter Lancaster (Univ. Calgary)
               "Perturbation theory for analytic matrix functions: the
                semisimple case"

 3:00 -  3:55  Professor Seamus Garvey (Univ. Nottingham)
               "Structure Preserving Transformations
                and Equivalence Flows for Linear Dynamic Systems"

 4:00 - 4:30   Tea/coffee.
```

Approximately 20 people attended, from both the mathematics and engineering communities. Ideas discussed at the meeting are the subject of ongoing investigations.