Curriculum Vitae
Distinguished University Professor G. W. Stewart

Department of Computer Science
Institute for Advanced Computer Studies
Program for Applied Mathematics and Scientific computing

The University of Maryland
College Park
August 22, 2006

1. Personal Data

Born October 1, 1940, Washington, D.C.

Married (Astrid Schmidt-Nielsen)

Home Address: 417 7th St. NE.
Washington, DC 20002
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A.B. University of Tennessee, 1962
Ph.D. (Mathematics), University of Tennessee, 1968

2. Employment

2.1. In higher education

University of Texas at Austin (68–72)
  Assistant Professor, Computer Science (68–70)
  Associate Professor, Computer Science (70–72)
  Research Mathematician, Computation Center (78–72)

Carnegie-Mellon University (72–74)
  Associate Professor, Mathematics and Computer Science (72–74).

University of Maryland at College Park (74–present)
  Associate Professor, Computer Science (74–76)
  Professor, Computer Science (76–06)
  Distinguished University Professor, Computer Science (06–present)
  Research Professor, Institute for Physical Sciences and Technology (76–90)
  Research Professor, Institute for Advanced Computer Studies (90–present)

2.2. Other

Student Trainee and Programmer: Computing Technology Center, Union Carbide, Oak Ridge, Tennessee, Summers 1959-62; full time 1963, 1965-66.

Programmer: General Electric Computer Division, Phoenix, Arizona, 1964-65.

Summer Faculty Member: IBM Thomas J. Watson Research Center, 1973.

Visiting Scientist: Applied Mathematics Division, Argonne National Laboratory, Argonne, Ill., June 1975, June 1976, June 1977, June 1978, June 1979.

Consultant: Applied Mathematics Division, Argonne National Laboratory, Argonne, Ill., 1974-1983.

Consultant: Scientific Computing Division, National Institute of Standards and Technology (formerly NBS), Gaithersburg, MD, 1979-present.

3. Honors

The F. L. Bauer prize, awarded by the Technical University of Munich, 1998
Elected to the National Academy of Engineering, 2004.
Distinguished University Professor, University of Maryland, 2006.

4. Professional Service

4.1. Elected office

Chairman: Special Interest Group on Numerical Analysis (SIGNUM) (1980-84)

4.2. Professional societies

National Academy of Engineering
Society for Industrial and Applied Mathematics

4.3. Editorial boards

Numerische Mathematik
Electronic Transactions on Numerical Analysis
SIAM Review
Linear Algebra and its Applications (Distinguished editor 2004–)
SIAM Journal on Numerical Analysis (1970-1984)
Communications in Statistics (to 1990)
Mathematics of Computation (to 1999)

4.4. Meetings organized

Co-chairman: SIAM National Meeting in Austin Texas, 1972
Session Organizer: SIAM Meeting in Troy, NY, 1975
Co-chairman: Matrix Methods in Optimization, Argonne National Laboratory, 1976
Session Organizer: Workshop on Robust Software, Ninth Annual Symposium on the Interface of Computer Science and Statistics, Boston, 1976
Program Committee: Sparse Matrix Conference, Knoxville, TN, 1978
Co-organizer: Delaware Conference on Statistical And Numerical Analysis, Newark, 1981,1982
Program Committee: International Workshop on Applied Mathematics and Performance/Reliability Models of Computer/Communication Systems, Pisa, Italy, 1983
Organizer: Special Session on Applied Mathematics and Statistics, American Statistical Association Meeting, Philadelphia, 1984
Program committee Symposium on the Interface of Computer Science and Statistics, Denver, 1985
Organizer (With K. Kennedy): NSF Workshop on Alternate Sources of Funding in the Computer Sciences, Washington, 1986
Session Organizer: Symposium on the Interface of Computer Science and Statistics, Fort Colins, 1986
Program Committee: 2nd International Workshop on Performance/Reliability Models of Computer/Communication Systems, Rome, 1987
Organizer (with R. Ward): Gatlinburg Conference on Numerical Algebra, Fairfield Glade, TN, 1987
Program Committee: Conference on Approximation Theory and Numerical Linear Algebra, Kent, OH, 1989
Program Committee: Statistical Analysis of Measurement Error Models and Applications, Humboldt, CA, 1989
Organizer: Workshop on Matrix Theory, Probability Theory, and Markov Chains, Institute for Mathematics and Its Applications, Minneapolis, MN, 1992.
Organizer (with J. Varah) Householder Symposium, Whistler, British Columbia, 1999.
Program Committee: Third International Conference on Matrix Analytic Methods, 2002.
Program Committee: for the International Conference on the Numerical Solution of Markov Chains, 2003
Program Committee: for IMACS International Symposium on Iterative Methods in Scientific Computing (2003)

4.5. Miscellaneous

Coordinator for the Argonne National Laboratory LINPACK project (1974–1979)
Member of the supervisory board for the Biomedical Data Package (BMDP) (c. 1980) Member of the Executive Committee for the Householder Symposium (1978–2003)
Director of the Laboratory for Parallel Computation at the University of Maryland (1983)
Chairman: Householder Prize Committee (1989)
Member IMACS Technical Committee on Linear Algebra
Member National Advisory Committee for the Statistical and Applied Mathematical Sciences Institute

5. Theses Directed

M.S. Kiho Lee Kim, "A Numerical Study of a Variant of the Rayleigh Quotient Iteration," 1970

M.S. Margaret Blevins, "An Algorithm for Calculating the Eigenvalues of a Diagonally Dominant Matrix," 1972

M.S. Connice Bavely, "An Algorithm for Block Diagonalizing a Matrix," 1976

M.S. Kevyn Salsburg, "Simultaneous Conjugate Gradient Iteration," 1978

M.S. Kathy Schmidt, "A Study of Variable Selection Strategies," 1979

Ph.D. Eric Hill, "Out of Core Manipulation of Dense Matrices," 1977

Ph.D. Nancy David, "A First Order Theory of Hypothesis Testing," 1982

Ph.D. Robert van de Geign "Implementing the QR-Algorithm on an Array of Processors," 1987

Ph.D. Xiaobai Sun, "An Unified Theory of Uncoupled Markov Chains," 1991.

M.S. John Meyer, "Parallel Simultaneous Iteration," 1991.

Ph.D. Misha Kilmer, "Iterative Regularization," 1998

Ph.D. Che-Rung Lee, "Residual Krylov Methods" in progress

6. Grants, Contracts, and Awards

Office of Naval Research for research in numerical analysis:

1971	$18,808	1976	$19,696
1972	$16,511	1978	$11,136
1973	$19,511	1979	$43,164
1974	$15,106	1980	$46,820
1975	$15,884		

National Science Foundation for research under the LINPACK project: 1976-8: $58,343.

Office of Naval Research for research into computational methods for the analysis of categorical data: 1978-9: $19,323.

Air Force Office of Sponsored Research for research in Parallel Matrix Computations: 1982-4: $265,861: 1985-1987: c. $300,000. 1987-1991: c. $300,000.

National Science Foundation for research in the Numerical Treatment of Markov Chains: 210,000: 1992-1995.

National Science Foundation Coordinated Experimental Research Program for A Testbed for Parallel Algorithms: 1983-89: $4,547,577.

Office of Naval Research for Evaluation of Numerical Methods for Underwater Acoustics: $100,000.

National Science Foundation, Numerical Methods for Ill-Posed Problems and Eigenvalue Problems, 1999–2001.

National Science Foundation, Krylov Methods, 2002–2005.

7. Publications

In my area authors are normally listed in alphabetical order. I have played a significant role in almost all the following multiauthored publications and a leading role in many of them.

Many of my more recent publications are available by anonymous ftp from

`ftp://ftp.cs.umd.edu/pub/stewart/reports/`

or through my home page at

`http://www.cs.umd.edu/~stewart`

7.1. Books

1. *Introduction to Matrix Computations,* Academic Press, New York (1974).
2. (with J. J. Dongarra, J. R. Bunch, and C. B. Moler), *LINPACK Users Guide,* SIAM, Philadelphia (1979).
3. (With J.-G. Sun) *Matrix Perturbation Theory,* Academic Press, 1990.
4. Translation of Gauss, *Theoria Combinationis Observationum,* SIAM. 1995.
5. *Afternotes on Numerical Analysis,* SIAM, 1996.
6. *Afternotes Goes to Graduate School,* SIAM, 1998.
7. *Matrix Algorithms: Volume I. Basic Decompositions,* SIAM, 1998.
8. *Matrix Algorithms: Volume II. Eigensystems,* SIAM, 2001.
9. *Computer Science for Scientific Computing,* in preparation.

7.2. Journal publications

10. "A Modification of Davidon's Minimization Method to Accept Difference Approximations to Derivatives," *Journal of the ACM* (1967) 72-83.
11. "A generalization of a theorem of Fan on Gerschgorin disks," *Numerische Mathematik* **10** (1967) 162.
12. (with D. W. Lick) "The Numerical Treatment of a Thin Plate Heat Transfer Problem," *Communications of the ACM* **11** (1968) 639-641.
13. "On the Continuity of the Generalized Inverse," *SIAM Journal on Applied Mathematics* **17** (1969) 33-45.
14. "Accelerating the Orthogonal Iteration for the Eigenvectors of a Hermitian Matrix," *Numerische Mathematik* **13** (1969) 362-367.
15. "Some Iterations for Factoring a Polynomial," *Numerische Mathematik* **13** (1969) 458-471.
16. "On Lehmer's Method for Finding the Zeros of a Polynomial," *Mathematics of Computation* **23** (1969) 829-836.
17. "On Samelson's Iteration for Factoring Polynomials," *Numerische Mathematik* **15** (1970) 306-314.
18. "Incorporating Origin Shifts into the QR Algorithm for Symmetric Tridiagonal Matrices," *Communications of the ACM* **13** (1970) 365-367.

19. "Algorithm 394: Eigenvalues and Eigenvectors of a Real Symmetric Matrix," *Communications of the ACM* **13** (1970) 369-371.
20. "On the Convergence of Sebastiao e Silva's Method for Finding a Zero of a Polynomial," *SIAM Review* **12** (1970) 458-460.
21. (with A. S. Householder), "The Numerical Factorization of a Polynomial," *SIAM Review* **13** (1971) 438-446.
22. "Error Analysis of the Algorithm for Shifting the Zeros of a Polynomial by Synthetic Division," *Mathematics of Computation* **25** (1971) 135-139.
23. "On a Companion Operator for Analytic Functions," *Numerische Mathematik* **18** (1971) 26-43.
24. "Error Bounds for Approximate Invariant Subspaces for Closed Linear Operators," *SIAM Journal on Numerical Analysis* **8** (1971) 796-808.
25. "On the Sensitivity of the Eigenvalue Problem $Ax = \lambda Bx$," *SIAM Journal on Numerical Analysis* **9** (1972) 669-696.
26. (with R. H. Bartels), "Algorithm 432: The Solution of the Matrix Equation $AX - XB = C$," *Communications of the ACM* **15** (1972) 820-826.
27. (with L. L. Hoberrock), "Input Requirements and Parametric Errors for Systems Identification under Periodic Excitement," *Transactions of the AMSE* **94** (1972) 296-302.
28. (with C. B. Moler), "An Algorithm for Generalized Matrix Eigenvalue Problems," *SIAM Journal on Numerical Analysis* **10** (1973) 241-256.
29. "Error and Perturbation for Subspaces Associated with Certain Eigenvalue Problems," *SIAM Review* **15** (1973) 727-764.
30. "Conjugate Direction Methods for Solving Systems of Linear Equations," *Numerische Mathematik* **21** (1973) 285-297.
31. "The Convergence of Multipoint Iterations to Multiple Zeros," *SIAM Journal on Numerical Analysis* **21** (1973) 1105-1120.
32. "Some Iterations for Factoring a Polynomial II. A Generalization of the Secant Method," *Numerische Mathematik* **22** (1973) 33-36.
33. (with T. Soderstrom), "On the Numerical Properties of an Iteration for Computing the Moore-Penrose Generalized Inverse," *SIAM Journal on Numerical Analysis* **11** (1974) 61-74.
34. (with M. M. Blevins) "Calculating Eigenvectors of Diagonally Dominant Matrices," *Journal of the ACM* **21** (1974) 261-271.
35. "Modifying Pivot Elements in Gaussian Elimination," *Mathematics of Computation* **28** (1974) 537-542.
36. "The Convergence of the Method of Conjugate Gradients at Isolated Extreme Points of the Spectrum," *Numerische Mathematik* **24** (1975) 85-93.
37. "Gerschgorin Theory for the Generalized Eigenvalue Problem $Ax = \lambda Bx$", *Mathematics of Computation* **29** (1975) 600-606.
38. (with G. H. Golub and Virginia Klema) "Rank Degeneracy and Least Squares Problems," University of Maryland Computer Science TR-751, 1976. [Note: Although this report was

never published, I include it here because it represents a significant research contribution that is frequently cited.]

39. (with W. B. Gragg), "A Stable Variant of the Secant Method for Solving Nonlinear Equations," *SIAM Journal on Numerical Analysis* **14** (1976) 889-903.
40. "Simultaneous Iteration for Computing Invariant Subspaces of a Non-Hermitian Matrix," *Numerische Mathematik* **25** (1976) 123-136.
41. (with J. Daniel, W. B. Gragg, Linda Kaufman), "Reorthogonalization and Stable Algorithms for Updating the Gram-Schmidt QR Factorization," *Mathematics of Computation* **30** (1976) 772-795.
42. "The Economical Storage of Plane Rotations," *Numerische Mathematik* **25** (1976) 137-138.
43. "HQR3 and EXCHNG: FORTRAN Programs for Calculating the Eigenvalues of a Real Upper Hessenberg Matrix in a Prescribed Order," *ACM Transactions on Mathematical Software* **2** (1976) 275-280
44. "Perturbation Bounds for the QR Factorization of a Matrix," *SIAM Journal on Numerical Analysis* **14** (1977) 509-518.
45. "On the Perturbation of Pseudo-inverses, Projections, and Linear Least Squares Problems," *SIAM Review* **19** (1977) 634-662.
46. (with C. B. Moler), "On the Householder-Fox Algorithm for Decomposing a Projection," *Journal of Computational Physics* **28** (1978) 82-91.
47. (with C. A. Bavely), "An Algorithm for Computing Reducing Subspaces by Block Diagonalization," *SIAM Journal on Numerical Analysis* **16** (1979) 359-367.
48. "Perturbation Bounds for the Definite Generalized Eigenvalue Problem," *Linear Algebra and its Applications* **23** (1979) 69-86.
49. "A Note on the Perturbation of Singular Values," *Linear Algebra and its Applications* **28** (1979) 213-216.
50. "The Effects of Rounding Error on an Algorithm for Downdating the Cholesky Factorization," *Journal of the Institute for Mathematics and its Applications* **23** (1979) 203-213.
51. (with D. P. O'Leary and J. S. Vandergraft), "Estimating the Largest Eigenvalue of a Positive Definite Matrix," *Mathematics of Computation* **33** (1979) 1289-1292.
52. (with A. K. Cline, C. B. Moler, and J. H. Wilkinson), "An Estimate for the Condition Number of a Matrix," *SIAM Journal on Numerical Analysis* **16** (1979) 368-375.
53. "The Efficient Generation of Random Orthogonal Matrices with an Application to Condition Estimators," *SIAM Journal on Numerical Analysis* **17** (1980) 403-404.
54. "The Behavior of a Multiplicity Independent Root-finding Scheme in the Presence of Rounding Error," *BIT* **20** (1980) 526-528.
55. "On the Implicit Deflation of Nearly Singular Systems of Linear Equations," *SIAM Journal on Scientific and Statistical Computing* **2** (1981) 136-140.
56. "Constrained Definite Hessians Tend to be Well Conditioned," *Mathematical Programming* (1981).
57. "Computing the CS Decomposition of a Partitioned Orthogonal Matrix," *Numererische Mathematik* **40** (1982) 297-306.

58. "Computable Error Bounds for Aggregated Markov Chains," *Journal of the ACM* **30** (1983) 271-285.
59. "Rank Degeneracy," *SIAM Journal on Scientific and Statistical Computing* **5** (1984) 403-413.
60. "A Second Order Perturbation Expansion for Small Singular Values," *Linear Algebra and Its Applications* **56** (1984) 231–235.
61. (with D. F. McAllister and W. J. Stewart) "On a Rayleigh-Ritz Refinement Technique for Nearly Uncoupled Stochastic Matrices," *Linear Algebra and Its Applications* **60** (1984) 1–25.
62. "A Note on Complex Division," *ACM Transactions on Mathematical Software* **11** (1985) 238-241.
63. "On the Invariance of Perturbed Null Vectors under Column Scaling," *Numerische Mathematik* **44** (1984) 61–66.
64. "On the Asymptotic Behavior of Scaled Singular Value and QR Decompositions," *Mathematics of Computation* **43** (1984) 483-489.
65. "A Jacobi-like Algorithm for Computing the Schur Decomposition of a Non-Hermitian Matrix," *SIAM Journal on Scientific and Statistical Computing* **6** (1985) 853-864.
66. (with D. P. O'Leary) "Data-flow Algorithms for Parallel Matrix Computations," *Communications of the ACM* **28** (1985) 840-853.
67. (with P. Gill, W. Murray, M. Saunders, M. Wright) "Properties of a Representation of a Basis for the Null Space," *Mathematical Programming* **33** (1985) 172-186.
68. (with D. P. O'Leary and R. van de Geijn) DOMINO*: A Message Passing Environment for Parallel Computation*, University of Maryland Computer Science TR-1648, 1986 (documentation of a system distributed over NETLIB).
69. (with D. P. O'Leary) "Assignment and Scheduling in Parallel Matrix Factorization," *Linear Algebra and Its Applications* **77** (1986) 275-299.
70. (with G. Golub and A. Hoffman) "A Generalization of the Eckart-Young Matrix Approximation Theorem," *Linear Algebra and Its Applications* **88/89** (1987) 317-327.
71. "Collinearity and Least Squares Regression," *Statistical Science* **2** (1987) 68-100.
72. (with D. P. O'Leary) "From Determinacy to Systaltic Arrays," *IEEE Transactions on Computers* **c-36** (1987) 1355-1359.
73. "A Parallel Implementation of the QR Algorithm," *Parallel Computing* **5** (1987) 187-196.
74. "A Curiosity Concerning the Representation of Integers in Noninteger Bases," *Mathematics of Computation* **51** (1988) 755–756.
75. (with C. D. Meyer) "Derivatives and Perturbatons of Eigenvectors," *SIAM Journal on Numerical Analysis* **25** (1988) 679–691.
76. (with D. A. Buell et al.) "Parallel Algorithms and Architectures. Report of a Workshop," *The Journal of Supercomputing* **1** (1988) 301–325.
77. "On Scaled Projections and Pseudo Inverses," *Linear Algebra and Its Applications* **112** (1989) 189–194.
78. (with G. N. Stenbakken and T. M. Souders) "Ambiguity Groups and Testability," *IEEE*

Transactions on Instrumentation **38** (1989) 941–947.

79. (With D. P. O'Leary) "Computing the Eigenvalues and Eigenvectors of Arrowhead Matrices," *Journal of Computational Physics,* **90** (1990) 497–505.
80. "Communication and Matrix Computation on Large Message Passing Systems," *Parallel Computing* **16** (1990) 27–40.
81. "Stochastic Perturbation Theory," *SIAM Review,* **32** (1990) 576–610.
82. "Two Simple Residual Bounds for the Eigenvalues of Hermitian Matrices," *SIAM J. Mat. Anal. Appl.* **12** (1991) 205–208.
83. (with G. Zhang) "Eigenvalues of Graded Matrices and the Condition of Numbers of a Multiple Eigenvalue," *Numerische Mathematik* **58** (1991) 703–712.
84. (with G. Zhang) "On a Direct Method for the Solution of Nearly Uncoupled Markov Chains," *Numerische Mathematik* **59** (1991) 1–12
85. "An Updating Algorithm for Subspace Tracking," *IEEE Transactions on Signal Processing* **40** (1992) 1535–1541.
86. "Error Analysis of QR Updating with Exponential Windowing," *Mathematics of Computation* **59** (1992) 135–140.
87. (with P. Schweitzer) "The Laurent Expansion of Pencils that are Singular at the Origin," *Linear Algebra and Its Applications,* **183** (1993) 237–254.
88. (with R. Mathias) "A Block QR Algorithm and the Singular Value Decomposition," *Linear Algebra and Its Applications* **182** (1993) 91–100.
89. "Updating A Rank-Revealing ULV Decomposition," *SIAM Journal on Matrix Analysis and Applciations,* **14** (1993) 494–499.
90. "On the Perturbation of LU, Cholesky, and QR Factorizations," *SIAM Journal on Matrix Analysis and Applications,* **14** (1993) 1141–1146.
91. "On the Early History of the Singular Value Decomposition," *SIAM Review,* **35** (1993) 551–566.
92. "On the Perturbation of Markov Chains with Nearly Transient States," *Numerische Mathematik,* **65** (1993) 135–141.
93. (with A. Edelman) "Scaling for Orthogonality," *IEEE Transactions on Signal Processing,* **41** (1993) 1676–1677.
94. "Updating URV Decompositions in Parallel," *Parallel Computing* **20** (1994) 151–172.
95. "On the Convergence of Multipoint Iterations," *Numerische Mathematic* **68** (1994) 143–147.
96. "Perturbation Theory for Rectangular Matrix Pencils," *Linear Algebra and Its Applications.* **208/209** (1994) 297–301.
97. "On the Solution of Block Hessenberg Systems," *Numerical Linear Algebra with Applications,* **2** (1995) 287–296.
98. (with K. J. Liu, D. P. O'Leary, and Y-J Wu) "URV ESPRIT for Tracking Time-Varying Signals," *IEEE Transactions on Signal Processing* **42** (1994) 3441–3449
99. "On Sequential Updates and Downdates," *IEEE Transactions on Signal Processing,* **43** (1995) 2642–2648.
100. "Gauss, Statistics, and Gaussian Elimination," CS-TR-3307, 1994. *Journal of Computation*

and *Graphical Statistics,* 1995.

101. "On Graded QR Decompositions of Products of Matrices," *Electronic Transactions in Numerical Analysis* **3** (1995) 39–49.
102. (with Urs von Matt) "Rounding Errors in Solving Block Hessenberg Systems," *Mathematics of Computation,* **65** (1996) 115–136.
103. (with X. Chang and C. C. Paige) "New perturbation analyses for the Cholesky factorization." *IMA Journal of Numerical Analysis,* **16** (1996) 457–484.
104. "On the Perturbation of LU and Cholesky Factors," IMA Journal on Numerical Analysis, **17** (1997) 1-6.
105. "The Triangular Matrices of Gaussian Elimination and Related Decompositions," IMA Journal on Numerical Analysis, **17** (1997) 7–16.
106. "On Markov Chains with Sluggish Transients," *Communication in Statistics, Stochastic Models,* **13** (1997) 85–95.
107. (with Z. Bai) "Algorithm 776: SRRIT: A Fortran Subroutine to Calculate the Dominant Invariant Subspace of a Nonsymmetric Matrix," ACM Transactions on Mathematical Software **23** (1997) 494–513.
108. "On the Weighting Method for Least Squares Problems with Linear Equality Constraints," University of Maryland, Department of Computer Science TR–3709, June, 1997. To appear in *Bit.*
109. (With M. A. Stewart) "On Hyperbolic Triangularization," *SIAM Journal on Matrix Analysis and Applications,* **16** (1998) 847–860.
110. "The QLP Approximation to the Singular Value Decomposition," *SIAM Journal on Scientific Computation* **20** (1999) 1336–1348.
111. (with D. P. O'Leary) "On the Convergence of a New Rayleigh Quotient Method with Applications to Large Eigenproblems," *Electronic Transactions on Numerical Analysis* **7** (1998) 182–189.
112. "On the Adjugate Matrix," *Linear Algebra and its Applications,* **283** (1998), 151–164.
113. (with R. F. Boisvert, J J. Dongarra, R. Pozo, K. A. Remington) "Developing numerical libraries in Java," *Concurrency: Practice and Experience,* **10** (1998) 1117–1129.
114. "Four Algorithms for the The Efficient Computation of Truncated Pivoted QR Approximations to a Sparse Matrix," *Numerische Mathematik,* **83** (1999) 313–323.
115. (with M. Kilmer) "Iterative Regularization and MINRES," SIAM Journal on Matrix Analysis and Applications 21 (1999) 613–628.
116. "The Decompositional Approach to Matrix Computations," *Computing in Science and Engineering,* **2** (2000) 50–59.
117. (With R.-C. Li) "A New Relative Perturbation Theorem for Singular Subspaces," *Linear Algebra and Its Applications* **313** 41–51.
118. (With Z-X Jia) "An Analysis of the Rayleigh–Ritz Method for Approximating Eigenspaces," *Mathematics of Computation,* **70** (2000) 637–647.
119. "A Generalization of Saad's Theorem on Rayleigh-Ritz Approximations," *Linear Algebra and Its Applications* **327** (2001) 115–120.

120. "Backward Error Bounds for Approximate Krylov Subspaces," *Linear Algebra and Its Applications,* **340** (2002) 81–86.
121. "On the Eigensystems of Graded Matrices," *Numerische Mathematik,* **90** (2001) 349–370.
122. "A Krylov–Schur Algorithm for Large Eigenproblems," *SIAM Journal on Matrix Analysis and Applications,* **23** (2001) 601–614.
123. "Adjusting the Rayleigh Quotient in Semiorthogonal Lanczos Methods," *SIAM Journal on Scientific Computing,* **24** (2002) 201–207.
124. "Addendum to 'A Krylov-Schur Algorithm for Large Eigenproblem'," *SIAM Journal on Matrix Analysis and Applications,* **24** (2002) 599–601.
125. "On the Powers of a Matrix with Perturbations," *Numerische Mathematik* **96** (2003) 363–376.
126. "Memory Leaks in Derived Types Revisited," *The Fortran Forum* **22** (2003) 25–27.
127. "Building an Old-Fashioned Sparse Solver," UMIACS TR-2003-95 CMSC TR-4527. Submitted to *SIAM Review.*
128. "Error Analysis of the Quasi-Gram–Schmidt Algorithm," UMIACS TR-2004-17 CMSC TR-4572. To appear in *SIAM Journal on Matrix Analysis and Applications.*
129. "An Elsner-Like Theorem for Generalized Eigenvalue Problems," *Linear Algebra and Its Applications* **390** (2004) 1–5.
130. (with M. W. Berry and S. A. Pulatova) "Computing Sparse Reduced-Rank Approximations to Sparse Matrices," *ACM Transactions on Mathematical Software (TOMS)* **31** (2005) 252–269.
131. "A Note on Generalized and Hypergeneralized Projectors" *Linear Algebra and Its Application* 412 (2006) 408–411.
132. (with Che Rung Lee) "EIGENTEST: A Test Matrix Generator for Large-Scale Eigenproblems," UMIACS TR-2006-07 CMSC TR-4783. Submitted to ACM Transactions on Mathematical Software.

7.3. Conference proceedings, book, chapters, reviews, etc.

133. (with A. S. Householder), "Bigradients, Hankel Determinants and the Pade Table," in *Constructive Aspects of the Fundamental Theorem of Algebra,* Dejon and Henrici eds., John Wiley & Sons, New York, 1969.
134. "The Numerical Treatment of Large Eigenvalue Problems," *Proceedings of the IFIP Congress,* Stockholm (1974) 666-672.
135. "Methods of Simultaneous Iteration for Calculating Eigenvectors of Matrices," in *Topics in Numerical Analysis II. Proceedings of the Royal Irish Academy Conference on Numerical Analysis, 1974,* John J. H. Miller ed., Academic Press, New York (1974) 185-196.
136. "Eigenvalue and Eigenvector," in *Encyclopedia of Computer Science,* R. Balzer ed., Vol. 3, 103-112.
137. "A Bibliographical Tour of the Large, Sparse Generalized Eigenvalue Problem," in *Sparse Matrix Computations,* J. R. Bunch and D. J. Rose eds., Academic Press, New York, 1976, 113-130.

138. "Computer Systems and Matrix Computations," *Ninth Annual Symposium on the Interface of Computer Science and Statistics*, Boston, 1976.
139. "Research, Development, and LINPACK," in *Mathematical Software III,* John Rice ed., Academic Press, New York, 1-14.
140. "Perturbation Theory for the Definite Generalized Eigenvalue Problem," in *Recent Advances in Numerical Analysis,* C. de Boor and G. H. Golub eds., Academic Press, New York, 1978, 193-206.
141. (with Iain Duff eds.) *Sparse Matrix Proceedings,* SIAM, Philadelphia, 1978.
142. Review of *Vorlesungen ueber Numerische Mathematik* by H. Rutishauser, *Bulletin of the AMS* **4** (1978) 660-663.
143. Review of *The Symmetric Eigenvalue Problem,* by B. N. Parlett, *Bulletin of the AMS* ???????.
144. "A Method for Computing the Generalized Singular Value Decomposition," in *Matrix Pencils,* B. Kagstrom and A. Ruhe eds., Springer Verlag, New York, 1983, 207-220.
145. (with J. Dongarra) "LINPACK – a Package for Solving Linear Systems," in *Sources and Development of Mathematical Software,* (W. R. Cowell, Ed.) Prentice Hall, 1984.
146. "On the Structure of Nearly Uncoupled Markov Chains," *Proceedings of The International Workshop on Applied Mathematics and Performance-Reliability Models of Computer-Communication Systems,* North Holland, 1985.
147. "Matrix, Ill-conditioned," *Encyclopedia of Statistics v. 5* (Johnson and Kotz eds.) Wiley, 1985.
148. "Linear Algebra, Computational," *Encyclopedia of Statistics v. 5* (Johnson and Kotz eds.), Wiley (1985).
149. "Collinearity, Scaling, and Rounding Error," in *Computer Science and Statistics: Proceedings of the Seventeenth Symposium on the Interface,* D. M. Allen ed., North Holland, New York, 1985, 195-198.
150. "Communcations in Parallel Algorithms: An Example," in *Computer Science and Statistics: Proceedings of the 18th Symposium on the Interface,* T. J. Boardman ed., North Holland, New York, 1986, 11-14
151. Review of *Matrix Computations* by Gene Golub and Charles F. Van Loan, *Linear Algebra and Its Applications*, **95** (1987) 211-215.
152. "DOMINO: A Transportable Operating System for Parallel Computation," in *Proceedings of the Army Research Workshop on on Parallel Processing and Medium Scale Multiprocessors,* to appear.
153. "Numerical Linear Algebra in Statistical Computing," *The State of the Art in Numerical Analysis,* Iserles and Powell, eds., to appear.
154. "Parallel Linear Algebra in Statistical Computing," in *COMPSTAT, 1988,* D. Edwards and N. E. Raun eds., Physica-Verlag, Heidelberg, 1988.
155. "An Iterative Method for Solving Linear Inequalities," in *Reliable Numerical Computation*, Cox and Hammarling Eds., Clarendon Press, Oxford, 1990.
156. "Perturbation Theory and Least Squares with Errors in the Variables." In *Contemporary Mathematics 112: Statistical Analysis of Measurement Error Models and Applications,* P.

J. Brown and W. A. Fuller editors, American Mathematical Society, Providence RI, 1990, 171–181.

157. "On the Sensitivity of Nearly Uncoupled Markov Chains," in *Numerical Solutions of Markov Chains,* W. J. Stewart ed., Dekker, New York, 1990.
158. "Perturbation Theory for the Singular Value Decomposition," *SVD and Signal Processing, II*, R. J. Vacarro ed., Elsevier, Amsterdam, 1991
159. (With G. Adams and M. F. Griffin) "Direction-of-Arrival Estimation Using the Rank-Revealing URV Decomposition," *Proceedings of ACASSP-91*.
160. Review of *Handbook for Matrix Computations* by Coleman and Van Loan, *Mathematics of Computation* **56** (1990) 380–381.
161. "Lanczos and Linear Systems," CS-TR 2641, 1991. In *Proceedings of the Cornelius Lanczos International Centenary Conference,* J. D. Brown and M. T. Chu and D. C. Ellison and R. J. Plemmons editors, SIAM Philadelphia, 1993, 134–139.
162. "Jeep: A General Purpose Style File," *TEXand TUG News,* **0** (1991) 3–4.
163. "Gaussian Elimination, Perturbation Theory, and Markov Chains." *Linear Algebra, Markov Chains, and Queuing Models* (Proceedings of an IMA workshop) Meyer and Plemmons eds., Springer, New York, 1993.
164. (with W. J. Stewart and D. F. McAllister) "A Two-Stage Iteration for Solving Nearly Uncoupled Markov Chains." in *Recent Advances in Iterative Methods,* G. Golub, A. Greenbaum, and M. Luskin Editors. Sprinter, New York, 1994.
165. (with E. C. Boman and M. F. Griffin) "Direction of Arrival and The Rank-Revealing URV Decomposition." *Proceedings of ACASSP-92*.
166. Review of *Fundamentals of Matrix Computation* by David S. Watkins, *Mathematics of Computation* **59** (1992) 299–300.
167. "Determining Rank in the Presence of Error," in *Linear Algebra for Large Scale and Real-Time Applications,* Moonen, Golub, and De Moor eds., Kluwer Academic Publishers, Dordrecth, 1992.
168. "On Two Sided Orthogonal Decomposition," to appear in the proceedings of the 15th Biennial Conference on Numerical Analysis, Dundee, 1993.
169. "Lanczos and Linear Systems," in *Proceedings of the Cornelius Lanczos International Centenary Conference,* J. D. Brown, M. T. Chu, D. C. Ellison, and R. J. Plemmons editors, SIAM, Philadelphia, 1993.
170. "Gauss, Statistics, and Gaussian Elimination," Computing Science and Statistics, Proceedings of the 26th Symposium on the Interface, J. Sall and A. Lehman Eds., Interface Foundation, 1994.
171. (With G. Latouche) "Numerical Methods for M/G/1 Type Queues." in *Computations with Markov Chains,* W. J. Stewart editor, Kluwer, Boston, 1995, 571–581
172. "Errors in Variables for Numerical Analysts." To appear in *Proceedings of the Second International Workshop on TLS and Errors-in Variables Modeling,* Sabine Van Huffel editor, SIAM, 19??.

7.4. Technical reports and other work

173. Translation of E. Schroeder, "On Infinitely Many Algorithms for Solving Equations," Oak Ridge National Laboratory translation 1851, 1968.
174. "A Set Theoretic Formulation of Backward Rounding Error Analysis," University of Texas Computation Center TNN-92, 1969.
175. "Projectors and Generalized Inverses," University of Texas Computation Center TNN-97, 1969.
176. "A Note on Non-Hermitian Perturbation of Hermitian Matrices," University of Texas Center for Numerical Analysis CNA 41, 1972.
177. "An Inverse Perturbation Theorem for Linear Least Squares Problems," *SIGNUM Newsletter*, 1975.
178. "Sensitivity Coefficients for the Effects of Errors in the Independent Variables in a Linear Regression," University of Maryland Computer Science TR-571, 1977.
179. "SRRIT — A FORTRAN Subroutine to Calculate the Dominant Invariant Subspaces of a Real Matrix," University of Maryland Computer Science TRR-514, 1977.
180. *The Numerical Analysis of Log Linear Models,* manuscript, 1978.
181. "Assessing the Effects of Variable Error in Linear Regression," University of Maryland Computer Science TR-818, 1979.
182. "A New Method for Solving Linear Inequalities," University of Maryland Computer Science TR-970, 1980.
183. "Matrix Computations on a Hand Held Calculator," *SIGNUM News Letter*, 1981.
184. (with Nancy A. David), "Significance Testing in a Functional Model," University of Maryland Computer Science TR 1204, 1982.
185. (with W. J. Stewart) "An Iterative Method for the Solution of Nearly Decomposable Markov Chains," University of Maryland Computer Science TR 1213, 1982.
186. (with W. J. Stewart and D. F. McAllister) "A Two-Stage Iteration for Solving Nearly Uncoupled Markov Chains," U. M. Computer Science TR 1263, 1984,
187. "A Nonlinear Version of Gauss's Minimum Variance Theorem with Applications to an Errors-in-the-Variables Model," University of Maryland Computer Science TR-1263, 1983.
188. "Bounding the Errors in the Solution of a 2×2 System of Equations." University of Maryland Computer Science TR-1702.
189. "Hypothesis Testing with Errors in the Variables," U. M. Computer Science TR 1735, 1986.
190. "An Iterative Method for Solving Linear Inequalities," U. M. Computer Science TR 1833
191. (with D. O'Leary, R. Pierson, M. Weiser) "The Maryland CRAB: A Module for Building Parallel Computers." U. M. Computer Science TR-1660,
192. "Invariant Subspaces and Capital Punishment," UM-CS-TR-1923, 1987.
193. "The Crab: a Dialog," UM-CS-TR-2025, 1988.
194. "Incremental Condition Calculation and Column Selection," UM-CS-TR2495, 1990. Translation of "On a New Way of Solving the Linear Equations that Arise in the Method of Least Square," by C. G. J. Jacobi, CS-TR-2877, 1992.

195. Translation of "On Infinitely Many Algorithms for Solving Equations," by E. Schröder. CS-TR-2990, 1992.
196. "Updating URV Decompositions in Parallel" University of Maryland CS-TR-2880, April 1992.
197. "Implementing an Algorithm for Solving Block Hessenberg Systems" University of Maryland CS-TR-3296, December 1993.
198. "Perron–Frobenius Theory: A New Proof of the Basics," University of Maryland CS-TR-3308, June 1994.
199. "QR Sometimes Beats Jacobi," University of Maryland UMIACS TR-95-32, CS-TR-3434, 1994.
200. On the Perturbation of Schur Complements in Positive Semidefinite Matrices, University of Maryland, CS-TR-3441, March 1995.
201. Stochastic Automata, Tensors Operation, and Matrix Equations, University of Maryland CMSC TR-3535, January 1996.
202. "On Sublinear Convergence," University of Maryland CS-TR-3534, 1995.
203. "On Orthogonalization in the Inverse Power Method," University of Maryland UMIACS TR-99-64 CMSC TR-4071, 1999.
204. "On Fitting Affine Subspaces," UMIACS TR-2004-32 CMSC TR-4589, 2004.
205. "The Gram-Schmidt Algorithm and Its Variations" UMIACS TR-2004-84 CMSC TR-4642, 2004.

8. Invited Addresses

1. "On a Companion Operator for Analytic Functions," SIAM National Meeting, Denver, 1970.
2. "The Generalized Eigenvalue Problem," Fifth Gatlinburg Conference on Numerical Algebra, Los Alamos, 1972.
3. "Methods of simultaneous iteration for large eigenvalue problems," Southeastern Regional Meeting ACM, 1974.
4. "Methods of Simultaneous iteration for calculating eigenvectors of matrices," Conference on Numerical Analysis, Dublin, 1974.
5. "The Numerical Treatment of Large Eigenvalue Problems," IFIP Congress, Stockholm, 1974.
6. "Calculating Dominant Invariant Subspaces of Non-Hermitian Matrices," Sixth Gatlinburg Conference on Numerical Algebra, Munich, 1974.
7. "The Large, Sparse Generalized Eigenvalue Problem," Symposium on Sparse Matrices, Argonne, 1975.
8. "Computer Systems and Matrix Computations," Ninth Symposium on the Interface of Computer Science and Statistics, Boston, March 1976.
9. "Matrix Decompositions and Optimization," Symposium on Matrix Methods in Optimization, Argonne, 1976.
10. "Research, Development, and LINPACK," Army Mathematics Research Center Conference on Mathematical Software, Madison, 1977.

11. "Orthogonal Transformations and Regression Calculations," National Meeting of the American Statistical Association, Chicago, 1977.
12. "Perturbation Theory for the Generalized Eigenvalue Problem," Army Mathematics Research Center Conference Honoring Barkley Rosser, Madison, 1978.
13. "Numerical Linear Algebra," SIAM Spring Meeting, Toronto, 1979.
14. "Rank Degeneracy," Conference on Ill-posed Problems, Newark, 1979.
15. "Matrix Computations on a Hand Held Calculator," ACM National Conference, Nashville, 1980.
16. "Linear Regression and Matrix Decompositions," Delaware Conference on Statistical and Numerical Analysis, Newark, 1980.
17. "Perturbation Theory for Linear Regression," Delaware Conference on Statistical and Numerical Analysis, Newark, 1981.
18. "Stochastic Perturbation Theory," Eighth Gatlinburg Conference on Numerical Algebra, Oxford, 1981.
19. "Computing the Generalized Singular Value Decomposition," Conference on Matrix Pencils, Pitea, 1982.
20. "Inverses, Residuals, and Normal Equations," Southeastern Atlantic Section of SIAM, Knoxville, 1982.
21. "MATLAB and Statistical Computations," Conference on the Interface of Statistics and Computer Science, Houston, 1983.
22. "A Jacobi-like Algorithm for Computing the Schur Decomposition of a Non-Hermitian Matrix," Symposium on Numerical and Complex Analysis, Zurich, 1983.
23. "The Structure of Nearly Uncoupled Markov Chains," International Workshop on Applied Mathematics and Performance-Reliability Models of Computer-Communication Systems, Pisa, 1983.
24. "Data-flow Algorithms for Parallel Matrix Computations," SIAM Conferences on Parallel Processing, Norfolk, 1983.
25. "The Impact of Computer Architecture on Statistical Computing," Joint, SIAM-ASA Conference, Boston, 1984.
26. "Some Problems in the Scaling of Matrices", Meeting in Honor of the Sixty-Fifth Birthday of J. H. Wilkinson, Argonne, 1984.
27. "Collinearity and Rounding Error," at the Conference on the Interface of Statistics and Computer Science, Lexington, 1985.
28. "A Survey of the Algebraic Eigenvalue Problem," IBM Symposium on Sparse Eigenvalue Problems, Oberlech, Austria, 1985. "A Parallel Implementation of Simultaneous Iteration," IBM Symposium on Sparse Eigenvalue Problems, Oberlech, Austria, 1985.
29. (with D. P. O'Leary and R. Vandergeijn) "DOMINO, a Transportable System for Parallel Computing," Army Research Conference on Parallel Computing and Medium Scale Multiprocessors, Stanford, 1986
30. "Communication in Parallel Algorithms: An Example," 18th Symposium on the Interface between Computer Science and Statistics, College Station, Colorado, 1986.

31. "Parallel Scientific Computing," University of Colorado Conference on Computer Science, Boulder, CO, March, 1986.
32. "A Parallel Implementation of the QR Algorithm," International Conference on Vector and Parallel Computing, Loen, Norway, June, 1986.
33. "Numerical Analysis and Mathematical Statistics," Joint National Statistics Conference, Chicago, 1986.
34. "Parallel Computing," Chinese Academy of Science, 1987.
35. "A. S. Householder's Contributions to Numerical Analysis," ACM Conference on the History of Numerical Analysis, Princeton, 1987.
36. "Jim Wilkinson's Contributions to Rounding Error," SIAM International Conference, Paris, 1987
37. "An Iterative Method for Solving Nonlinear Equations," NPL Conference in memory of James Wilkinson, London, 1987.
38. "Communications and Matrix Computations on a Rather Large Number of Processors," Joint National Statistics Conference, San Francisco, 1987.
39. "Continuity in Degenerate Log-linear Models," special invited talk of the Institute for Mathematical Statistics, San Francisco, 1987.
40. "Scaled Pseudo-inverses and Projection," Special Session on Numerical Computation, AMS Regional Meeting, Knoxville, 1988.
41. "Parallel Linear Algebra in Statistical Computation," COMPSTAT Conference, Copenhagen, 1988.
42. "Perturbation Theory and Least Squares with Errors in the Variables," AMS Workshop on Statistical Analysis of Measurement Error Models and Applications, Humboldt, CA, 1989
43. "On the Sensitivity of Nearly Uncoupled Markov Chains," The First International Conference on the Numerica Solution of Markov Chains, Raleigh, NC, 1989.
44. "Perturbation Theory for the Singular Value Decomposition," Second International Conference on the Singular Value Decomposition in Signal Processing, Kingston, RI 1990.
45. "Updatable Rank Revealing Factorizations," International Conference on Total Least Squares, Leuven, Belgium 1991.
46. "Computational Methods for Markov Chains," SIAM Conference on Applied Linear Algebra, Minneapolis, MN 1991.
47. "Gaussian Elimination, Perturbation Theory, and Markov Chains." IMA Workshop on Matrix Theory, Probability Theory, and Markov Chains, Minneapolis, MN 1992.
48. "A Two-Stage Iteration for Solving Nearly Uncoupled Markov Chains." IMA Workshop on Iterative Methods for Sparse and Structured Systems, Minneapolis, MN 1992.
49. "Updatable, Rank Revealing Factorizations," SIAM Regional Conference on Numerical Analysis, Kent, OH, 1992.
50. "Perturbation Theory for Markov Chains," Second Conference of the International Linear Algebra Society, Lisbon, Portugal, 1992.
51. "Detecting Rank Degeneracy in the Presence of Errors," NATO Workshop on Large Scale Linear Algebra, Leuven, Belgium, 1992.

52. "The Numerical Treatment of Markov Chains," NATO Workshop on Large Scale Linear Algebra, Leuven, Belgium, 1992.
53. "On the Solution of Block Hessenberg Systems," Berkeley Symposium in Honor of W. Kahan and B. N. Parlett, Berkeley, California, 1992.
54. "On Two Sided Orthogonal Decomposition," 15th Biennial Conference on Numerical Analysis, Dundee, 1993.
55. "On Scaled QR Factorizations of Products of Matrices," Conference on Numerical Linear Algebra, Oberwolfach, 1994.
56. "Gauss, Statistics, and Gaussian Elimination," Keynote address at the Computer Science Statistics Interface Conference, Raleigh, 1994.
57. (With G. Latouche) "Numerical Methods for M/G/1 Type Queues." Second International Conference on Markov Chains, Raleigh, 1995.
58. "Schur Complements and Spectral Decompositions, or How to Compute Eigenvalues with Gaussian Elimination," Third Symposium on Matrix Analysis and Applications, Kalamazoo, 1995.
59. "On the Triangular Matrices of Gaussian Elimination," AMS Session on Numerical Linear Algebra, Kent, 1995.
60. "Errors in Variables for Numerical Analysts," Second International Workshop on TSL and Errors-in-Varialbes Modeling, Leuven, 1996
61. "On a Gap Revealing Decomposition," Oberwolfach, Germany, 1997
62. "Updating and Downdating, Visiting Scholar Colloquium" Western Michigan University, 1997
63. "A New Rank-Revealing Decomposition" Visiting Scholar Colloquium, Western Michigan University, 1997
64. "Beyond Householder and Wilkinson: Thirty Years of Matrix Computations" Acceptance talk for the Bauer prize, Technical University of Munich, Munich, June 1998.
65. "A Sparse Low-Rank QR Decomposition" American Mathematical Society Regional Meeting, State College, PA, Oct 1998.
66. "A New Relative Perturbation Theorem for Singular Values," SIAM National Meeting, Atlanta, 1999
67. "On the Triangular Matrices of Gaussian Elimination and Related Decomposition," Foundations of Computational Mathematics, Oxford, 1999
68. "The Rounding Error Roler Coaster," SIAM Washington-Baltimore Chapter, Baltimore, 1999
69. "Debugging Matlab," Conference in Honor of Cleve Moler, Boston, 1999
70. "Krylov–Schur Restarting," Conference in Honor of the 40th Anniversary of BIT, Malmo, 2000.
71. "Divide and Prosper Algorithms," AMS Conference of Fast Algorithms, Mt. Holyoak, 2001.
72. 'Gaussian Elimination and Block Hessenberg Matrices," Fourth International Conference on Matrix Analytic Methods, Adelaide, Australia, 2002.
73. "Von Neumann, Goldstine, and Company," SIAM Conference on Computational Science

and Engineering, San Diego, 2003.

74. “Methods for Large-Scale Eigenproblems.” SIAM Conference on Applied Linear Algebra, Williamsburg, 2003.
75. “Matran: A Fortran 95 Wrapper for Matrix Computations,” Seminar on Theoretical and Computational Aspects of Matrix Algorithms, Dagstuhl, Germany, 2003.
76. “Bauer’s Contributions to Numerical Linear Algebra,” Symposium in honor of F. L. Bauer’s 80th Birthday, Munich 2004.
77. “Matran: A Fortran 95 Wrapper for Matrix Computations,” Research Triangle Distinguished Lecture Series, Raleigh, Durham, Chapel Hill, 2005
78. “Error Analysis of the Quasi-Gram–Schmidt Algorithm,” Householder Symposium, Seven Springs, PA, 2005.
79. “Theory of Residual Krylov Methods,” International Workshop on Accurate Solution of Eigenvalue Problems, State College, PA, 2006
80. “Sparse Reduced-Rank Approximations to Sparse Matrices,” Workshop on Algorithms for Modern Massive Data Sets, Stanford, 2006