

Bibliography

- [1] M. R. Abdel-Aziz. Safeguarded use of the implicit restarted Lanczos technique for solving non-linear structural eigensystems. *Internat. J. Numer. Methods Engrg.*, 37:3117–3133, 1994.
- [2] A. Abramow and M. Neuhaus. Bemerkungen über Eigenwertprobleme von Matrizen höherer Ordnung. In *Les mathématiques de l'ingénieur*, pages 176–179. Mém. Publ. Soc. Sci. Arts Lett. Hainaut, Vol. hors Série, Maison Léon Losseau, Mons, France, 1958.
- [3] G. Adams, A. Bojanczyk, and F. T. Luk. Computing the PSVD of two 2×2 triangular matrices. *SIAM J. Matrix Anal. Appl.*, 15(2):366–382, 1994.
- [4] L. Ahlfors. *Complex Analysis*. McGraw-Hill, New York, 1966.
- [5] J. I. Aliaga, D. L. Boley, R. W. Freund, and V. Hernández. A Lanczos-type method for multiple starting vectors. *Math. Comp.* 69:1577–1601, 2000.
- [6] P. R. Amestoy and I. S. Duff. Vectorization of a multiprocessor multifrontal code. *Internat. J. Supercomputer Appl.*, 3:41–59, 1989.
- [7] P. R. Amestoy and I. S. Duff. Memory management issues in sparse multifrontal methods on multiprocessors. *Internat. J. Supercomputer Appl.*, 7:64–82, 1993.
- [8] P. R. Amestoy, I. S. Duff, J.-Y. L'Excellent, and J. Koster. A fully asynchronous multifrontal solver using distributed dynamic scheduling. Technical Report RAL-TR-1999-059, Rutherford Appleton Laboratory, Oxfordshire, UK, 1999. Software available at <http://www.pallas.de/parasol>.
- [9] G. S. Ammar, W. B. Gragg, and L. Reichel. Dwndating Szegő polynomials and data fitting applications. *Linear Algebra Appl.*, 172:315–336, 1992.
- [10] G. S. Ammar and C. He. On an inverse eigenvalue problem for unitary Hessenberg matrices. *Linear Algebra Appl.*, 218:263–271, 1995.
- [11] G. S. Ammar, L. Reichel, and D. C. Sorensen. Algorithm 730: An implementation of a divide and conquer method for the unitary eigenproblem. *ACM Trans. Math. Software*, 20:161–170, 1994.
- [12] E. Anderson, Z. Bai, C. Bischof, S. Blackford, J. Demmel, J. Dongarra, J. Du Croz, A. Greenbaum, S. Hammarling, A. McKenney, and D. Sorensen. *LAPACK Users' Guide*. SIAM, Philadelphia, Third edition, 1999.
- [13] P. J. Anderson and G. Loizou. A Jacobi type method for complex symmetric matrices. *Numer. Math.*, 25:347–363, 1976.

- [14] I. Andersson. Experiments with the conjugate gradient algorithm for the determination of eigenvalues of symmetric matrices. Technical Report UMINF-4.71, University of Umeå, Sweden, 1971.
- [15] P. Arbenz and G. H. Golub. On the spectral decomposition of Hermitian matrices modified by low rank perturbations with applications. *SIAM J. Matrix Anal. Appl.*, 9:40–58, 1988.
- [16] T. Arias, A. Edelman, and S. Smith. Curvature in conjugate gradient eigenvalue computation with applications. In J. G. Lewis, editor, *Proceedings of the 1994 SIAM Applied Linear Algebra Conference*, pages 233–238. SIAM, Philadelphia, 1994.
- [17] M. Arioli, I. S. Duff, and D. Ruiz. Stopping criteria for iterative solvers. Report RAL-91-057, Central Computing Center, Rutherford Appleton Laboratory, Oxfordshire, UK, 1992.
- [18] V. I. Arnold. On matrices depending on parameters. *Russian Math. Surveys*, 26:29–43, 1971.
- [19] W. E. Arnoldi. The principle of minimized iterations in the solution of the matrix eigenvalue problem. *Quart. Appl. Math.*, 9:17–29, 1951.
- [20] E. Artin. *Geometric Algebra*. Interscience, New York, 1957.
- [21] C. Ashcraft and R. Grimes. SPOOLES: An object-oriented sparse matrix library. In *Proceedings of the Ninth SIAM Conference on Parallel Processing*. SIAM, Philadelphia, 1999. Software available at <http://www.netlib.org/linalg/spooles>.
- [22] J. Baglama, D. Calvetti, and L. Reichel. Iterative methods for the computation of a few eigenvalues of a large symmetric matrix. *BIT*, 36(3):400–421, 1996.
- [23] J. Baglama, D. Calvetti, and L. Reichel. Fast Leja points. *Electron. Trans. Numer. Anal.*, 7:124–140, 1998.
- [24] J. Baglama, D. Calvetti, L. Reichel, and A. Ruttan. Computation of a few close eigenvalues of a large matrix with application to liquid crystal modeling. *J. Comput. Phys.*, 146:203–226, 1998.
- [25] Z. Bai. The CSD, GSVD, their applications and computations. Preprint Series 958, Institute for Mathematics and Its Applications, University of Minnesota, Minneapolis, April 1992. Available at <http://www.cs.ucdavis.edu/~bai>.
- [26] Z. Bai. Error analysis of the Lanczos algorithm for the nonsymmetric eigenvalue problem. *Math. Comp.*, 62:209–226, 1994.
- [27] Z. Bai. A spectral transformation block Lanczos algorithm for solving sparse non-Hermitian eigenproblems. In J. G. Lewis, editor, *Proceedings of the Fifth SIAM Conference on Applied Linear Algebra*, pages 307–311. SIAM, Philadelphia, 1994.
- [28] Z. Bai, D. Day, J. Demmel, and J. Dongarra. A test matrix collection for non-Hermitian eigenvalue problems. Technical Report CS-97-355, University of Tennessee, Knoxville, 1997. LAPACK Working Note #123, Software and test data available at <http://math.nist.gov/MatrixMarket/>.
- [29] Z. Bai, D. Day, and Q. Ye. ABLE: An adaptive block lanczos method for non-hermitian eigenvalue problems. *SIAM J. Matrix Anal. Appl.*, 20:1060–1082, 1999.

- [30] Z. Bai and J. Demmel. Design of a parallel nonsymmetric eigenroutine toolbox, Part I. In R. F. Sincovec et al., editors, *Proceedings of the Sixth SIAM Conference on Parallel Processing for Scientific Computing*. SIAM, Philadelphia, 1993. Long version available as Computer Science Report CSD-92-718, University of California, Berkeley, 1992.
- [31] Z. Bai and J. Demmel. Using the matrix sign function to compute invariant subspaces. *SIAM J. Matrix Anal. Appl.*, 19:205–225, 1998.
- [32] Z. Bai, J. Demmel, and M. Gu. An inverse free parallel spectral divide and conquer algorithm for nonsymmetric eigenproblems. *Numer. Math.*, 76:279–308, 1997.
- [33] Z. Bai and J. W. Demmel. On swapping diagonal blocks in real Schur form. *Linear Algebra Appl.*, 186:73–95, 1993.
- [34] Z. Bai, P. Feldmann, and R. W. Freund. How to make theoretically passive reduced-order models passive in practice. In *Proceedings of the IEEE 1998 Custom Integrated Circuits Conference*, pages 207–210. IEEE Press, Piscataway, NJ, 1998.
- [35] Z. Bai and R. W. Freund. A band symmetric Lanczos process based on coupled recurrences with applications. Technical Report Numerical Analysis Manuscript, Bell Laboratories, Murray Hill, NJ, USA, 1998.
- [36] Z. Bai and G. Golub. Some unusual matrix eigenvalue problems. In J. Palma, J. Dongarra, and V. Hernandez, editors, *Proceedings of VECPAR'98 - Third International Conference for Vector and Parallel Processing*, Lecture Notes in Computer Science. Vol. 1573, pages 4–19. Springer-Verlag, New York, 1999.
- [37] Z. Bai and G. W. Stewart. Algorithm 776. SRRIT — A FORTRAN subroutine to calculate the dominant invariant subspaces of a nonsymmetric matrix. *ACM Trans. Math. Software*, 23:494–513, 1998.
- [38] S. Balay, W. Gropp, L. C. McInnes, and B. Smith. PETSc 2.0 Users Manual. Technical Report ANL-95/11 - Revision 2.0.28, Argonne National Laboratory, Argonne, IL, 2000. Software available at <http://www.mcs.anl.gov/petsc>.
- [39] R. E. Bank. Analysis of a multilevel inverse iteration procedure for eigenvalue problems. *SIAM J. Numer. Anal.*, 19(5):886–898, 1982.
- [40] J. Barlow and J. Demmel. Computing accurate eigensystems of scaled diagonally dominant matrices. *SIAM J. Numer. Anal.*, 27(3):762–791, 1990.
- [41] R. Barrett, M. Berry, T. Chan, J. Demmel, J. Donato, J. Dongarra, V. Eijkhout, R. Pozo, C. Romine, and H. van der Vorst. *Templates for the Solution of Linear Systems: Building Blocks for Iterative Methods*. SIAM, Philadelphia, 1994.
- [42] K.-J. Bathe and E. L. Wilson. *Numerical Methods in Finite Element Analysis*. Prentice Hall, Englewood Cliffs, NJ, 1976.
- [43] P. Benner and H. Faßbender. The symplectic eigenvalue problem, the butterfly form, the SR algorithm, and the Lanczos method. *Linear Algebra Appl.*, 275/276:19–47, 1998.

- [44] P. Benner, H. Fassbender, and D. Watkins. SR and SZ algorithms for the symplectic (butterfly) eigenproblem. *Linear Algebra Appl.*, 287:41–76, 1999.
- [45] P. Benner, V. Mehrmann, and H. Xu. A new method for computing the stable invariant subspace of a real hamiltonian matrix. *J. Comput. Appl. Math.*, 86:17–43, 1997.
- [46] P. Benner, V. Mehrmann, and H. Xu. A numerical stable, structure preserving method for computing the eigenvalues of real Hamiltonian or symplectic pencils. *Numer. Math.*, 78:329–358, 1998.
- [47] P. Benner, V. Mehrmann, and H. Xu. A note on the numerical solution of complex Hamiltonian and skew-Hamiltonian eigenvalue problem. *Electron. Trans. Numer. Anal.*, 8:115–126, 1999.
- [48] L. Bergamaschi, G. Gambolati, and G. Pini. Asymptotic convergence of conjugate gradient methods for the partial symmetric eigenproblem. *Numer. Linear Algebra Appl.*, 4(2):69–84, 1997.
- [49] M. Berry. Large scale singular value computations. *Internat. J. Supercomputer Appl.*, 6(1):13–49, 1992.
- [50] Å. Björck. *Numerical Solutions for Least Squares Problems*. SIAM, Philadelphia, 1996.
- [51] Å. Björck and V. Pereyra. Solution of vandermonde systems of equations. *Math. Comp.*, 24:893–903, 1970.
- [52] L. S. Blackford, J. Choi, A. Cleary, E. D’Azevedo, J. Demmel, I. Dhillon, J. Dongarra, G. Henry, A. Petitet, K. Stanley, D. Walker, and R. Whaley. *ScaLAPACK Users’ Guide*. SIAM, Philadelphia, 1997.
- [53] A. Bojanczyk and P. Van Dooren. On propagating orthogonal transformations in a product of 2×2 triangular matrices. In *Numerical Linear Algebra*. de Gruyter, Berlin, 1993.
- [54] A. Bojanczyk, P. Van Dooren, L. M. Ewerbring, and F. T. Luk. An accurate product SVD algorithm. *J. Signal Processing*, 25:189–201, 1991.
- [55] D. Boley. The algebraic structure of pencils and block Toeplitz matrices. *Linear Algebra Appl.*, 279:255–279, April 1998.
- [56] D. Boley and G. H. Golub. A survey of matrix inverse eigenvalue problems. *Inverse Problems*, 3:595–622, 1987.
- [57] F. Bourquin. Analysis and comparison of several component mode synthesis methods on one-dimensional domains. *Numer. Math.*, 58(1):11–33, 1990.
- [58] F. Bourquin. Component mode synthesis and eigenvalues of second order operators: discretization and algorithm. *RAIRO Modél. Math. Anal. Numér.*, 26(3):385–423, 1992.
- [59] F. Bourquin. A domain decomposition method for the eigenvalue problem in elastic multistructures. In *Asymptotic Methods for Elastic Structures (Lisbon, 1993)*, pages 15–29. de Gruyter, Berlin, 1995.
- [60] F. Bourquin and P. G. Ciarlet. Modelling and justification of eigenvalue problems for junctions between elastic structures. *J. Funct. Anal.*, 87(2):392–427, 1989.
- [61] W. W. Bradbury and R. Fletcher. New iterative methods for solution of the eigenproblem. *Numer. Math.*, 9:259–267, 1966.

- [62] J. H. Bramble. *Multigrid Methods*. Longman Scientific & Technical, Harlow, UK, 1993.
- [63] J. H. Bramble, J. E. Pasciak, and A. V. Knyazev. A subspace preconditioning algorithm for eigenvector/eigenvalue computation. *Adv. Comput. Math.*, 6(2):159–189, 1996.
- [64] A. Brandt, S. McCormick, and J. Ruge. Multigrid methods for differential eigenproblems. *SIAM J. Sci. Statist. Comput.*, 4(2):244–260, 1983.
- [65] C. Brezinski, M. Redivo Zaglia, and H. Sadok. Avoiding breakdown and near-breakdown in Lanczos type algorithms. *Numer. Algorithms*, 1:261–284, 1991.
- [66] W. L. Briggs. *A Multigrid Tutorial*. SIAM, Philadelphia, 1987.
- [67] A. Bunse-Gerstner, R. Byers, V. Mehrmann, and N. K. Nichols. Numerical computation of an analytic singular value decomposition of a matrix valued function. *Numer. Math.*, 60:1–39, 1991.
- [68] A. Bunse-Gerstner and C. He. On the Sturm sequence of polynomials for unitary Hessenberg matrices. *SIAM J. Matrix Anal. Appl.*, 16:1043–1055, 1995.
- [69] A. Bunse-Gerstner and V. Mehrmann. The quaternion QR algorithm. *Numer. Math.*, 55:83–95, 1989.
- [70] J. V. Burke, A. S. Lewis, and M. L. Overton. Optimizing matrix stability. *Proc. Amer. Math. Soc.*, 1999, to appear.
- [71] R. Byers. A Hamiltonian QR-algorithm. *SIAM J. Sci. Statist. Comput.*, 7:212–229, 1986.
- [72] R. Byers. Solving the algebraic Riccati equation with the matrix sign function. *Linear Algebra Appl.*, 85:267–279, 1987.
- [73] R. Byers, C. He, and Mehrmann. The matrix sign function method and the computation of invariant subspaces. *SIAM J. Matrix Anal. Appl.*, 18:615–632, 1997.
- [74] Z. Q. Cai, J. Mandel, and S. McCormick. Multigrid methods for nearly singular linear equations and eigenvalue problems. *SIAM J. Numer. Anal.*, 34:178–200, 1997.
- [75] C. Carey, G. H. Golub, and K. H. Law. A Lanczos-based method for structural dynamics re-analysis problems. Manuscript na-93-03, Computer Science Department, Stanford University, Stanford, CA, 1993.
- [76] J. Carrier, L. Greengard, and V. Rokhlin. A fast adaptive multipole algorithm for particle simulations. *SIAM J. Sci. Statist. Comput.*, 9:669–686, 1988.
- [77] F. Chaitin-Chatelin and V. Frayssé. *Lectures on Finite Precision Computations*. SIAM, Philadelphia, 1996.
- [78] T. F. Chan, E. Gallopoulos, V. Simoncini, T. Szeto, and C. H. Tong. A quasi-minimal residual variant of the Bi-CGSTAB algorithm for nonsymmetric systems. *SIAM J. Sci. Comput.*, 15:338–347, 1994.
- [79] F. Chatelin. *Eigenvalues of Matrices*. Wiley, New York, 1993.
- [80] I. Chavel. *Riemannian Geometry—A Modern Introduction*. The Cambridge University Press, Cambridge, UK, 1993.

- [81] T.-Y. Chen. Balancing sparse matrices for computing eigenvalues. Master's thesis, University of California, Berkeley, May 1998.
- [82] T.-Y. Chen and J. Demmel. Balancing sparse matrices for computing eigenvalues. *Linear Algebra Appl.*, 309:261–287, 2000.
- [83] X. Chi and M. Gu. Updating the SVD. CAM technical report, Department of Mathematics, University of California, Los Angeles, 2000.
- [84] M. T. Chu. Inverse eigenvalue problems. *SIAM Rev.*, 40:1–39, 1998.
- [85] B. D. Craven. Complex symmetric matrices. *J. Austral. Math. Soc.*, 10:341–354, 1969.
- [86] C. R. Crawford. Algorithm 646 PDFIND: A routine to find a positive definite linear combination of two real symmetric matrices. *ACM Trans. Math. Software*, 12:278–282, 1986.
- [87] C. R. Crawford and Y. S. Moon. Finding a positive definite linear combination of two Hermitian matrices. *Linear Algebra Appl.*, 51:37–48, 1983.
- [88] M. Crouzeix, B. Philippe, and M. Sadkane. The Davidson method. *SIAM J. Sci. Comput.*, 15:62–76, 1994.
- [89] J. K. Cullum and W. E. Donath. A block Lanczos algorithm for computing the q algebraically largest eigenvalues and a corresponding eigenspace for large, sparse symmetric matrices. In *Proceedings of the 1994 IEEE Conference on Decision and Control*, pages 505–509. IEEE Press, Piscataway, NJ, 1974.
- [90] J. K. Cullum and R. A. Willoughby. Computing eigenvalues of very large symmetric matrices—an implementation of a Lanczos algorithm with no reorthogonalization. *J. Comput. Phys.*, 44:329–358, 1981.
- [91] J. K. Cullum and R. A. Willoughby. *Lanczos Algorithms for Large Symmetric Eigenvalue Computations. Volume 1, Theory*. Birkhäuser, Boston, 1985.
- [92] J. K. Cullum and R. A. Willoughby. *Lanczos Algorithms for Large Symmetric Eigenvalue Computations. Volume 2, Programs*. Birkhäuser, Boston, 1985.
- [93] J. K. Cullum and R. A. Willoughby. A practical procedure for computing eigenvalues of large sparse nonsymmetric matrices. In J. K. Cullum and R. A. Willoughby, editors, *Large Scale Eigenvalue Problems*, pages 193–240. Elsevier Science Publishers, 1986.
- [94] J. K. Cullum and R. A. Willoughby. A QL procedure for computing the eigenvalues of complex symmetric tridiagonal matrices. *SIAM J. Matrix Anal. Appl.*, 17:83–109, 1996.
- [95] H. Dai and P. Lancaster. Numerical methods for finding multiple eigenvalues of matrices depending on parameters. *Numer. Math.*, 76:189–208, 1997.
- [96] J. W. Daniel, W. B. Gragg, L. Kaufman, and G. W. Stewart. Reorthogonalization and stable algorithms for updating the Gram-Schmidt QR factorization. *Math. Comp.*, 30:772–795, 1976.
- [97] D. F. Davidenko. The method of variation of parameters as applied to the computation of eigenvalues and eigenvectors of matrices. *Soviet Math. Dokl.*, 1:364–367, 1960.

- [98] D. F. Davidenko. On the computation of eigenvalues and eigenvectors of matrices. *Dokl. Akad. Nauk SSSR*, 141:277–280, 1961.
- [99] E. R. Davidson. The iterative calculation of a few of the lowest eigenvalues and corresponding eigenvectors of large real symmetric matrices. *J. Comput. Phys.*, 17:87–94, 1975.
- [100] E. R. Davidson. Matrix eigenvector methods. In G. H. F. Diercksen and S. Wilson, editors, *Methods in Computational Molecular Physics*, pages 95–113. Reidel, Boston, 1983.
- [101] C. Davis and W. Kahan. The rotation of eigenvectors by a perturbation. III. *SIAM J. Numer. Anal.*, 7:1–46, 1970.
- [102] G. J. Davis. Numerical solution of a quadratic matrix equation. *SIAM J. Sci. Comput.*, 2:164–175, 1981.
- [103] T. A. Davis and I. S. Duff. A combined unifrontal/multifrontal method for unsymmetric sparse matrices. Technical Report TR-95-020, Computer and Information Sciences Department, University of Florida, Gainesville, 1995. Software available at <http://www.netlib.org/linalg/umfpack2.2.tgz>.
- [104] D. Day. *Semi-Duality in the Two-Sided Lanczos Algorithm*. Ph.D. thesis, University of California, Berkeley, 1993.
- [105] D. Day. An efficient implementation of the nonsymmetric Lanczos algorithm. *SIAM J. Matrix Anal. Appl.*, 18:566–589, 1997.
- [106] I. De Hoyos. Points of continuity of the Kronecker canonical form. *SIAM J. Matrix Anal. Appl.*, 11(2):278–300, April 1990.
- [107] J. de Leeuw and W. Heiser. Theory of multidimensional scaling. In P. R. Krishnaiah and L. N. Kanal, editors, *Handbook of Statistics, Vol. 2*, pages 285–316. North-Holland, Amsterdam, 1982.
- [108] B. De Moor. On the structure of generalized singular value and QR decompositions. *SIAM J. Matrix Anal. Appl.*, 15(1):347–358, 1994.
- [109] G. De Samblanx. *Filtering and restarting projection methods for eigenvalue problems*. PhD Thesis, Katholieke Universiteit Leuven, Department of Computer Science, 3001 Heverlee, Belgium, 1998.
- [110] G. De Samblanx and A. Bultheel. Nested Lanczos: implicitly restarting a Lanczos algorithm. *Numer. Algorithms*, 18:31–50, 1998.
- [111] E. De Sturler. A parallel restructured version of GMRES(m). Technical Report Tech. Report Preprint 91-085, Delft University of Technology, Delft, The Netherlands, 1992.
- [112] E. De Sturler and H. A. van der Vorst. Communication cost reduction for krylov methods on parallel computers. In W. Gentzsch and U. Harms, editors, *High Performance and Networking Tools, Vol. 2*, Lecture Notes in Computer Science. Vol. 797, pages 190–195. Springer-Verlag, Berlin, 1994.
- [113] R. S. Dembo, S. C. Eisenstat, and T. Steihaug. Inexact Newton methods. *SIAM J. Numer. Anal.*, 19:400–408, 1982.
- [114] J. Demmel. *Applied Numerical Linear Algebra*. SIAM, Philadelphia, 1997.

- [115] J. Demmel. Accurate SVDs of structured matrices. *SIAM J. Matrix Anal. Appl.*, 21(3):562–580, 2000.
- [116] J. Demmel and A. Edelman. The dimension of matrices (matrix pencils) with given Jordan (Kronecker) canonical forms. *Linear Algebra Appl.*, 230:61–87, 1995.
- [117] J. Demmel and W. Gragg. On computing accurate singular values and eigenvalues of matrices with acyclic graphs. *Linear Algebra Appl.*, 185:203–217, 1993.
- [118] J. Demmel, M. Gu, S. Eisenstat, I. Slapničar, K. Veselić, and Z. Drmač. Computing the singular value decomposition with high relative accuracy. *Linear Algebra Appl.*, 299:21–80, 1999.
- [119] J. Demmel and B. Kågström. Computing stable eigendecompositions of matrix pencils. *Linear Algebra Appl.*, 88/89:139–186, 1987.
- [120] J. Demmel and B. Kågström. Accurate solutions of ill-posed problems in control theory. *SIAM J. Matrix Anal. Appl.*, 9(1):126–145, 1988.
- [121] J. Demmel and B. Kågström. The generalized Schur decomposition of an arbitrary pencil $A - \lambda B$: Robust software with error bounds and applications. Part I: Theory and algorithms. *ACM Trans. Math. Software*, 19(2):160–174, 1993.
- [122] J. Demmel and B. Kågström. The generalized Schur decomposition of an arbitrary pencil $A - \lambda B$: Robust software with error bounds and applications. Part II: Software and applications. *ACM Trans. Math. Software*, 19(2):175–201, 1993.
- [123] J. Demmel and W. Kahan. Accurate singular values of bidiagonal matrices. *SIAM J. Sci. Statist. Comput.*, 11:873–912, 1990.
- [124] J. Demmel and K. Veselić. Jacobi’s method is more accurate than QR . *SIAM J. Matrix Anal. Appl.*, 13(4):1204–1245, 1992.
- [125] J. W. Demmel, L. Dieci, and M. Friedman. *SIAM J. Sci. Comput.*, 22(1):81–94, 2000.
- [126] J. W. Demmel, S. C. Eisenstat, J. R. Gilbert, X. S. Li, and J. W. H. Liu. A supernodal approach to sparse partial pivoting. *SIAM J. Matrix Anal. Appl.*, 20(3):720–755, 1999. Software available at <http://www.nersc.gov/~xiaoye/SuperLU>.
- [127] J. W. Demmel, J. R. Gilbert, and X. S. Li. An asynchronous parallel supernodal algorithm for sparse Gaussian elimination. *SIAM J. Matrix Anal. Appl.*, 20(4):915–952, 1999. Software available at <http://www.nersc.gov/~xiaoye/SuperLU>.
- [128] I. Dhillon. *A New $O(n^2)$ Algorithm for the Symmetric Tridiagonal Eigenvalue/Eigenvector Problem*. Ph.D. thesis, University of California, Berkeley, 1997.
- [129] I. S. Dhillon. Current inverse iteration software can fail. *BIT*, 38(4):685–704, 1998.
- [130] D. C. Dobson. An efficient method for band structure calculations in 2D photonic crystals. *J. Comput. Phys.*, 149(2):363–376, 1999.
- [131] J. Dongarra, J. Gabriel, D. Kolling, and J. Wilkinson. The eigenvalue problem for Hermitian matrices with time reversal symmetry. *Linear Algebra Appl.*, 60:27–42, 1984.

- [132] J. J. Dongarra, J. R. Bunch, C. B. Moler, and G. W. Stewart. *LINPACK Users' Guide*. SIAM, Philadelphia, 1979.
- [133] J. J. Dongarra, J. Du Croz, S. Hammarling, and R. J. Hanson. An extended set of FORTRAN basic linear algebra subprograms. *ACM Trans. Math. Software*, 14:1–32, 1988.
- [134] J. J. Dongarra, J. DuCroz, I. S. Duff, and S. Hammarling. A set of level 3 basic linear algebra subprograms. *ACM Trans. Math. Software*, 16:1–17, 1990.
- [135] J. J. Dongarra, I. S. Duff, D. C. Sorensen, and H. A. van der Vorst. *Numerical Linear Algebra for High-Performance Computers*. SIAM, Philadelphia, PA, 1998.
- [136] Z. Drmač. A posteriori computation of the singular vectors in a preconditioned Jacobi SVD algorithm. *IMA J. Numer. Anal.*, 19:191–213, 1999.
- [137] I. S. Duff. Direct methods. Technical Report RAL-98-056, Rutherford Appleton Laboratory, Oxfordshire, UK, 1998.
- [138] I. S. Duff, A. M. Erisman, and J. K. Reid. *Direct Methods for Sparse Matrices*. Clarendon Press, Oxford, UK, 1986.
- [139] I. S. Duff, R. G. Grimes, and J. G. Lewis. Sparse matrix test problems. *ACM Trans. Math. Software*, 15:1–14, 1989.
- [140] I. S. Duff and J. K. Reid. The multifrontal solution of indefinite sparse symmetric linear equations. *ACM Trans. Math. Software*, 9(3):302–325, September 1983.
- [141] I. S. Duff and J. K. Reid. MA47, a Fortran code for direct solution of indefinite sparse symmetric linear systems. Technical Report RAL-95-001, DRAL, Chilton Didcot, UK, 1995.
- [142] I. S. Duff and J. K. Reid. The design of MA48, a code for the direct solution of sparse unsymmetric linear systems of equations. *ACM Trans. Math. Software*, 22:187–226, 1996.
- [143] I. S. Duff and J. A. Scott. Computing selected eigenvalues of large sparse unsymmetric matrices using subspace iteration. *ACM Trans. Math. Software*, 19:137–159, 1993.
- [144] I. S. Duff and J. A. Scott. The design of a new frontal code for solving sparse unsymmetric systems. *ACM Trans. Math. Software*, 22(1):30–45, 1996.
- [145] R. J. Duffin. A minimax theory for overdamped networks. *J. Rational Mech. Anal.*, 4:221–233, 1955.
- [146] E. G. D'yakonov. Iteration methods in eigenvalue problems. *Math. Notes*, 34:945–953, 1983.
- [147] E. G. D'yakonov. *Optimization in solving elliptic problems*. CRC Press, Boca Raton, FL, 1996. Translated from the 1989 Russian original; translated, edited, and with a preface by Steve McCormick.
- [148] E. G. D'yakonov and A. V. Knyazev. Group iterative method for finding lower-order eigenvalues. *Moscow University, Ser. 15, Computational Math. and Cybernetics*, 2:32–40, 1982.
- [149] E. G. D'yakonov and A. V. Knyazev. On an iterative method for finding lower eigenvalues. *Russian J. Numer. Anal. Math. Modelling*, 7(6):473–486, 1992.

- [150] E. G. D'yakonov and M. Yu. Orekhov. Minimization of the computational labor in determining the first eigenvalues of differential operators. *Math. Notes*, 27(5–6):382–391, 1980.
- [151] A. Edelman, T. A. Arias, and S. T. Smith. The geometry of algorithms with orthogonality constraints. *SIAM J. Matrix Anal. Appl.*, 20:303–353, 1999.
- [152] A. Edelman, E. Elmroth, and B. Kågström. A geometric approach to perturbation theory of matrices and matrix pencils. Part I: Versal deformations. *SIAM J. Matrix Anal. Appl.*, 18(3):653–692, 1997.
- [153] A. Edelman, E. Elmroth, and B. Kågström. A geometric approach to perturbation theory of matrices and matrix pencils. Part II: A stratification-enhanced staircase algorithm. *SIAM J. Matrix Anal. Appl.*, 20(3):667–699, 1999.
- [154] A. Edelman and Y. Ma. Staircase failures explained by orthogonal versal forms. *SIAM J. Matrix Anal. Appl.*, 21(3):1004–1025, 2000.
- [155] A. Edelman and S. T. Smith. On conjugate gradient-like methods for eigen-like problems. *BIT*, 36:494–508, 1996. See also Loyce Adams and J. L. Nazareth, editors, *Proc. Linear and Nonlinear Conjugate Gradient-Related Methods*, SIAM, Philadelphia, 1996.
- [156] V. Eijkhout. Distributed sparse data structures for linear algebra operations. Technical Report CS 92-169, Computer Science Department, University of Tennessee, Knoxville, TN, 1992. LAPACK Working Note #50, <http://www.netlib.org/lapack/lawns/lawn50.ps>.
- [157] S. C. Eisenstat and I. C. F. Ipsen. Relative perturbation techniques for singular value problems. *SIAM J. Numer. Anal.*, 32:1972–1988, 1995.
- [158] L. Eldén. Algorithms for the regularization of ill-conditioned least-squares problems. *BIT*, 17:134–145, 1977.
- [159] E. Elmroth, P. Johansson, and B. Kågström. Computation and presentation of graphs displaying closure hierarchies of Jordan and Kronecker structures. Technical Report UMINF-99.12, Department of Computing Science, Umeå University, Umeå, Sweden, 1999.
- [160] E. Elmroth and B. Kågström. The set of 2-by-3 matrix pencils—Kronecker structures and their transitions under perturbations. *SIAM J. Matrix Anal. Appl.*, 17(1):1–34, 1996.
- [161] T. Ericsson. A generalised eigenvalue problem and the Lanczos algorithm. In J. K. Cullum and R. A. Willoughby, editors, *Large Scale Eigenvalue Problems*, pages 95–119. Elsevier Science Publishers (North-Holland), Amsterdam, 1986.
- [162] T. Ericsson and A. Ruhe. The spectral transformation Lanczos method for the numerical solution of large sparse generalized symmetric eigenvalue problems. *Math. Comp.*, 35:1251–1268, 1980.
- [163] V. Faber and T. A. Manteuffel. Necessary and sufficient conditions for the existence of a conjugate gradient method. *SIAM J. Numer. Anal.*, 21(2):352–362, 1984.
- [164] C. Farhat and M. Geradin. On a component mode synthesis method and its application to incompatible substructures. *Comput. & Structures*, 51(5):459–473, 1994.
- [165] H. Faßbender, D. S. Mackey, and N. Mackey. Hamilton and Jacobi come full circle: Jacobi algorithms for structured Hamiltonian eigenproblems. *To appear in Linear Algebra Appl.*, 2000.

- [166] P. Feldmann and R. W. Freund. Reduced-order modeling of large linear subcircuits via a block Lanczos algorithm. In *Proceedings of the 32nd Design Automation Conference*, pages 474–479. ACM, New York, 1995.
- [167] Y. T. Feng and D. R. J. Owen. Conjugate gradient methods for solving the smallest eigenpair of large symmetric eigenvalue problems. *Internat. J. Numer. Methods Engrg.*, 39(13):2209–2229, 1996.
- [168] K. V. Fernando and B. N. Parlett. Accurate singular values and differential qd algorithms. *Numer. Math.*, 67:191–229, 1994.
- [169] R. Fletcher. Conjugate gradient methods for indefinite systems. *Lecture Notes in Mathematics*, Vol. 506, pages 73–89. Springer-Verlag, Berlin, 1976.
- [170] R. Fletcher. *Practical Methods of Optimization*. Wiley, New York, second edition, 1987.
- [171] D. R. Fokkema. *Subspace Methods for Linear, Nonlinear, and Eigen Problems*. Ph.D. thesis, Utrecht University, Utrecht, the Netherlands, 1996.
- [172] D. R. Fokkema, G. L. G. Sleijpen, and H. A. van der Vorst. Jacobi-Davidson style QR and QZ algorithms for the partial reduction of matrix pencils. *SIAM J. Sci. Comput.*, 20:94–125, 1998.
- [173] R. W. Freund. Conjugate gradient-type methods for linear systems with complex symmetric coefficient matrices. *SIAM J. Sci. Statist. Comput.*, 13:425–448, 1992.
- [174] R. W. Freund. A transpose-free quasi-minimal residual algorithm for non-Hermitian linear systems. *SIAM J. Sci. Comput.*, 14:470–482, 1993.
- [175] R. W. Freund. Computing minimal partial realizations via a Lanczos-type algorithm for multiple starting vectors. In *Proceedings of the 36th IEEE Conference on Decision and Control*, pages 4394–4399. IEEE Press, Piscataway, NJ, 1997.
- [176] R. W. Freund. Reduced-order modeling techniques based on Krylov subspaces and their use in circuit simulation. In *Applied and Computational Control, Signals, and Circuits, Vol. 1*, pages 435–498. Birkhäuser, Boston, 1999.
- [177] R. W. Freund and P. Feldmann. Reduced-order modeling of large linear passive multi-terminal circuits using matrix-Padé approximation. In *Proceedings of the Design, Automation and Test in Europe Conference 1998*, pages 530–537. IEEE Computer Society Press, Los Alamitos, CA, 1998.
- [178] R. W. Freund, M. H. Gutknecht, and N. M. Nachtigal. An implementation of the look-ahead Lanczos algorithm for non-Hermitian matrices. *SIAM J. Sci. Comput.*, 14:137–158, 1993.
- [179] R. W. Freund and N. M. Nachtigal. QMR: A quasi-minimal residual method for non-Hermitian linear systems. *Numer. Math.*, 60:315–339, 1991.
- [180] R. W. Freund and N. M. Nachtigal. QMRPACK: A package of QMR algorithms. *ACM Trans. Math. Software*, 22:46–77, 1996.
- [181] S. Friedland, J. Nocedal, and M. L. Overton. The formulation and analysis of numerical methods for inverse eigenvalue problems. *SIAM J. Numer. Anal.*, 24:634–667, 1987.

- [182] C. Fu, X. Jiao, and T. Yang. Efficient sparse LU factorization with partial pivoting on distributed memory architectures. *IEEE Trans. Parallel and Distributed Systems*, 9(2):109–125, 1998. Software available at <http://www.cs.ucsb.edu/research/S+>.
- [183] Z. Fu and E. M. Dowling. Conjugate gradient eigenstructure tracking for adaptive spectral estimation. *IEEE Trans. Signal Processing*, 43(5):1151–1160, 1995.
- [184] K. Gallivan, E. Grimme, and P. Van Dooren. A rational Lanczos algorithm for model reduction. *Numer. Algorithms*, 12:33–64, 1996.
- [185] G. Gambolati, G. Pini, and M. Putti. Nested iterations for symmetric eigenproblems. *SIAM J. Sci. Comput.*, 16(1):173–191, 1995.
- [186] G. Gambolati, F. Sartoretto, and P. Florian. An orthogonal accelerated deflation technique for large symmetric eigenproblems. *Comput. Methods Appl. Mech. Engrg.*, 94(1):13–23, 1992.
- [187] F. Gantmacher. *The Theory of Matrices, Vols. I and II* (transl.). Chelsea, New York, 1959.
- [188] I. Garcia-Planas. Kronecker stratification of the space of quadruples of matrices. *SIAM J. Matrix Anal. Appl.*, 19(4):872–885, 1998.
- [189] G. Geist, G. Howell, and D. Watkins. The BR eigenvalue algorithm. *SIAM J. Matrix Anal. Appl.*, 20(4):1083–1098, 1999.
- [190] M. Genseberger and G. L. G. Sleijpen. Alternative correction equations in the Jacobi-Davidson method. Preprint 1073, Department of Mathematics, Utrecht University, Utrecht, the Netherlands, 1998.
- [191] A. George and J. Liu. *Computer Solution of Large Sparse Positive Definite Systems*. Prentice-Hall, Englewood Cliffs, NJ, 1981.
- [192] P. E. Gill, W. Murray, and M. H. Wright. *Practical Optimization*. Academic Press, New York, second edition, 1981.
- [193] I. Gohberg, T. Kailath, and V. Olshevsky. Fast gaussian elimination with partial pivoting for matrices with displacement structure. *Math. Comp.*, 64(212):1557–1576, 1995.
- [194] I. Gohberg, P. Lancaster, and L. Rodman. *Matrix Polynomials*. Academic Press, New York, 1982.
- [195] I. Gohberg and V. Olshevsky. Complexity of multiplication with vectors for structured matrices. *Linear Algebra Appl.*, 202:163–192, 1994.
- [196] I. Gohberg and V. Olshevsky. Fast algorithms with preprocessing for matrix-vector multiplication problems. *J. Complexity*, 10(4):411–427, 1994.
- [197] G. Golub and R. Underwood. The block Lanczos method for computing eigenvalues. In J. Rice, editor, *Mathematical Software III*, pages 364–377. Academic Press, New York, 1977.
- [198] G. Golub and C. Van Loan. *Matrix Computations*. The Johns Hopkins University Press, Baltimore, third edition, 1996.
- [199] G. Golub and J. H. Wilkinson. Ill-conditioned eigensystems and the computation of the Jordan canonical form. *SIAM Rev.*, 18(4):578–619, 1976.

- [200] G. H. Golub, Z. Zhang, and H. Zha. Large sparse symmetric eigenvalue problems with homogeneous linear constraints: The Lanczos process with inner-outer iterations. *Linear Algebra Appl.*, 309:289–306, 2000.
- [201] W. B. Gragg. The QR algorithm for unitary Hessenberg matrices. *J. Comput. Appl. Math.*, 16:1–8, 1986.
- [202] W. B. Gragg and L. Reichel. A divide and conquer method for unitary and orthogonal eigenproblems. *Numer. Math.*, 57:695–718, 1990.
- [203] W. B. Gragg and T.-L. Wang. Convergence of the shifted QR algorithm for unitary Hessenberg matrices. Technical Report NPS-53-90-007, Naval Postgraduate School, Monterey, CA, 1990.
- [204] J. F. Grcar. *Analyses of the Lanczos Algorithm and the Approximation Problem in Richardson's Method*. Ph.D. thesis, University of Illinois at Urbana-Champaign, 1981.
- [205] L. Greengard and V. Rokhlin. A fast algorithm for particle simulations. *J. Comput. Phys.*, 73:325–348, 1987.
- [206] R. G. Grimes, J. G. Lewis, and H. D. Simon. A shifted block Lanczos algorithm for solving sparse symmetric generalized eigenproblems. *SIAM J. Matrix Anal. Appl.*, 15:228–272, 1994.
- [207] E. Grimme, D. Sorensen, and P. Van Dooren. Model reduction of state space systems via an implicitly restarted Lanczos method. *Numer. Algorithms*, 12:1–32, 1996.
- [208] M. Gu, J. Demmel, and I. Dhillon. Efficient computation of the singular value decomposition with applications to least squares problems. Computer Science Dept. Technical Report CS-94-257, University of Tennessee, Knoxville, 1994. LAPACK Working Note #88, <http://www.netlib.org/lapack/lawns/lawn88.ps>.
- [209] J.-S. Guo, W.-W. Lin, and C.-S. Wang. Numerical solutions for large sparse quadratic eigenvalue problems. *Linear Alg. Appl.*, 225:57–89, 1995.
- [210] A. Gupta, G. Karypis, and V. Kumar. Highly scalable parallel algorithms for sparse matrix factorization. *IEEE Trans. Parallel and Distributed Systems*, 8:502–520, 1997. Software available at <http://www.cs.umn.edu/~mjoshi/pspaces>.
- [211] A. Gupta, E. Rothberg, E. Ng, and B. W. Peyton. Parallel sparse Cholesky factorization algorithms for shared-memory multiprocessor systems. In R. Vichnevetsky, D. Knight, and G. Richter, editors, *Advances in Computer Methods for Partial Differential Equations–VII*, pages 622–628. IMACS, New Brunswick, NJ, 1992.
- [212] I. Gustafsson. A class of first order factorization methods. *BIT*, 18:142–156, 1978.
- [213] M. H. Gutknecht. A completed theory of the unsymmetric Lanczos process and related algorithms, Part I. *SIAM J. Matrix Anal. Appl.*, 13:594–639, 1992.
- [214] M. H. Gutknecht. A completed theory of the unsymmetric Lanczos process and related algorithms, Part II. *SIAM J. Matrix Anal. Appl.*, 15:15–58, 1994.
- [215] W. Hackbusch. On the computation of approximate eigenvalues and eigenfunctions of elliptic operators by means of a multi-grid method. *SIAM J. Numer. Anal.*, 16(2):201–215, 1979.

- [216] W. Hackbusch. Multigrid solutions to linear and nonlinear eigenvalue problems for integral and differential equations. *Rostock. Math. Kolloq.*, (25):79–98, 1984.
- [217] W. Hackbusch. Multigrid eigenvalue computation. In *Advances in Multigrid Methods (Oberwolfach, 1984)*, pages 24–32. Vieweg, Braunschweig, Germany, 1985.
- [218] W. Hackbusch. *Multigrid Methods and Applications*. Springer-Verlag, Berlin, 1985.
- [219] M. Heath, E. Ng, and B. Peyton. Parallel algorithms for sparse linear systems. *SIAM Rev.*, 33:420–460, 1991.
- [220] M. T. Heath and P. Raghavan. Performance of a fully parallel sparse solver. *Internat. J. Supercomputer Appl.*, 11(1):49–64, 1997. Software available at <http://www.netlib.org/scalapack>.
- [221] R. Heeg. *Stability and Transistion of Attachment-Line Flow*. Ph.D. thesis, Universiteit Twente, Enschede, the Netherlands, 1998.
- [222] S. Helgason. *Differential Geometry, Lie Groups, and Symmetric Spaces*. Academic Press, New York, 1978.
- [223] B. Hendrickson and R. Leland. The Chaco User’s Guide: Version 2.0. Technical Report SAND94–2692, Sandia National Laboratories, 1994.
- [224] P. Henon, P. Ramet, and J. Roman. A mapping and scheduling algorithm for parallel sparse fan-in numerical factorization. In P. Amestoy, P. Berger, M. Daydé, I. Duff, V. Frayssé, L. Giraud, and D. Ruiz, editors, *EuroPar’99 Parallel Processing*, Lecture Notes in Computer Science, Vol. 1685, pages 1059–1067. Springer-Verlag, New York, 1999.
- [225] M. R. Hestenes and W. Karush. Solutions of $Ax = \lambda Bx$. *J. Res. Nat. Bur. Standards*, 47:471–478, 1951.
- [226] M. R. Hestenes and E. Stiefel. Methods of conjugate gradients for solving linear systems. *J. Res. Nat. Bur. Standards*, 49:409–436, 1954.
- [227] V. Heuveline and M. Sadkane. Arnoldi-Faber method for large non-Hermitian eigenvalue problems. *Electron. Trans. Numer. Anal.*, 7:62–76, 1997.
- [228] N. J. Higham. *Accuracy and Stability of Numerical Algorithms*. SIAM, Philadelphia, 1996.
- [229] N. J. Higham. QR factorization with complete pivoting and accurate computation of the SVD. *Linear Algebra Appl.*, 309:153–174, 2000.
- [230] N. J. Higham. Stability analysis of algorithms for solving confluent Vandermonde-like systems. *SIAM J. Matrix Anal. Appl.*, 11:23–41, 1990.
- [231] D. Hinrichsen and J. O’Halloran. Orbit closures of singular pencils. *J. Pure and Applied Algebra*, 81:117–137, 1992.
- [232] K. Hirao and H. Nakatsuji. A generalization of the Davidson’s method to large nonsymmetric eigenvalue problem. *J. Comput. Phys.*, 45(2):246–254, 1982.
- [233] R. A. Horn and C. R. Johnson. *Matrix Analysis*. Cambridge University Press, Cambridge, UK, 1985.

- [234] A. S. Householder. *The Theory of Matrices in Numerical Analysis*. Blaisdell, New York, 1964. Dover edition, 1975.
- [235] L. J. Huang and T.-Y. Li. Parallel homotopy algorithm for symmetric large sparse eigenproblems. *J. Comput. Appl. Math.*, 60(1-2):77–100, 1995.
- [236] S. A. Hutchinson, L. V. Prevost, J. N. Shadid, and R. S. Tuminaro. Aztec user’s guide, version 2.0 Beta. Technical Report SAND95-1559, Sandia National Laboratories, Albuquerque, NM, 1998.
- [237] T. Hwang and I. D. Parsons. A multigrid method for the generalized symmetric eigenvalue problem. I. Algorithm and implementation. *Internat. J. Numer. Methods Engrg.*, 35(8):1663–1676, 1992.
- [238] T. Hwang and I. D. Parsons. A multigrid method for the generalized symmetric eigenvalue problem. II. Performance evaluation. *Internat. J. Numer. Methods Engrg.*, 35(8):1677–1696, 1992.
- [239] E.-J. Im. *Automatic Optimization of Sparse Matrix - Vector Multiplication*. Ph.D. thesis, University of California, Berkeley, May 2000.
- [240] E.-J. Im and K. A. Yelick. Optimizing sparse matrix vector multiplication on SMPs. In *Proceedings of the Ninth SIAM Conference on Parallel Processing for Scientific Computing*, SIAM, Philadelphia, 1999.
- [241] C. G. J. Jacobi. Ueber ein leichtes Verfahren, die in der Theorie der Säcularstörungen vorkommenden Gleichungen numerisch aufzulösen. *J. Reine Angew. Math.*, 30:51–94, 1846.
- [242] A. Jennings. *Matrix Computation for Engineers and Scientists*. Wiley, New York, 1977.
- [243] Z. Jia. A block incomplete orthogonalisation method for large nonsymmetric eigenproblems. *BIT*, 35:516–539, 1995.
- [244] Z. Jia. Polynomial characterizations of the approximate eigenvectors by the refined Arnoldi method and an implicitly restarted refined Arnoldi algorithm. *Linear Algebra Appl.*, 287:191–214, 1998.
- [245] Z. Jia. A refined iterative algorithm based on the block Arnoldi process for large unsymmetric eigenproblems. *Linear Algebra Appl.*, 270:171–189, 1998.
- [246] Z. Jia and G. W. Stewart. An analysis of the Rayleigh-Ritz method for approximating eigenspaces. Technical Report TR-4015, Department of Computer Science, University of Maryland, College Park, 1999.
- [247] Z. Jia and G. W. Stewart. On the convergence of Ritz values, Ritz vectors and refined Ritz vectors. Technical Report TR-3986, Department of Computer Science, University of Maryland, College Park, 1999.
- [248] P. Johansson. Stratigraph users’ guide. version 1.1. Technical Report UMINF-99.11, Department of Computing Science, Umeå University, Umeå, Sweden, 1999.
- [249] M. T. Jones and M. L. Patrick. The Lanczos algorithm for the generalized symmetric eigenproblem on shared-memory architectures. *Appl. Numer. Math.*, 12:377–389, 1993.
- [250] B. Kågström. How to compute the Jordan normal form — the choice between similarity transformations and methods using the chain relations. Technical Report UMINF-91.81, Department of Numerical Analysis, Institute of Information Processing, University of Umeå, Umeå, Sweden, 1981.

- [251] B. Kågström. RGSVD—an algorithm for computing the Kronecker canonical form and reducing subspaces of singular $A - \lambda B$ pencils. *SIAM J. Sci. Statist. Comput.*, 7(1):185–211, 1986.
- [252] B. Kågström and A. Ruhe. ALGORITHM 560: An algorithm for the numerical computation of the Jordan normal form of a complex matrix [F2]. *ACM Trans. Math. Software*, 6(3):437–443, 1980.
- [253] B. Kågström and A. Ruhe. An algorithm for the numerical computation of the Jordan normal form of a complex matrix. *ACM Trans. Math. Software*, 6(3):389–419, 1980.
- [254] B. Kågström and P. Wiberg. Extracting partial canonical structure for large scale eigenvalue problems. Technical Report UMINF-98.13, Department of Computing Science, Umeå University, Umeå, Sweden, 1998. Submitted to *Numerical Algorithms*.
- [255] W. Kahan. Accurate eigenvalues of a symmetric tridiagonal matrix. Technical Report CS41, Computer Science Department, Stanford University, Stanford, CA, 1966 (revised June 1968).
- [256] W. Kahan, B. N. Parlett, and E. Jiang. Residual bounds on approximate eigensystems of nonnormal matrices. *SIAM J. Numer. Anal.*, 19:470–484, 1982.
- [257] T. Kailath and A.H. Sayed, editors. *Fast Reliable Algorithms for Matrices with Structure*. SIAM, Philadelphia, 1999.
- [258] W. Karush. An iterative method for finding characteristics vectors of a symmetric matrix. *Pacific J. Math.*, 1:233–248, 1951.
- [259] G. Karypis and V. Kumar. Metis, Version 4.0. University of Minnesota/Army HPC Research Center, Mineapolis, 1998.
- [260] H. M. Kim and R. R. Craig, Jr. Structural dynamics analysis using an unsymmetric block Lanczos algorithm. *Internat. J. Numer. Methods Engrg.*, 26:2305–2318, 1988.
- [261] H. M. Kim and R. R. Craig, Jr. Computational enhancement of an unsymmetric block Lanczos algorithm. *Internat. J. Numer. Methods Engrg.*, 30:1083–1089, 1990.
- [262] S. Kim and A. Chronopoulos. An efficient nonsymmetric Lanczos method on parallel vector computers. *J. Comput. Appl. Math.*, 42:357–374, 1992.
- [263] D. R. Kincaid, J. R. Respass, D. M. Young, and R. G. Grimes. Algorithm 586 – ITPACK 2C: A Fortran package for solving large sparse linear systems by adaptive accelerated iterative methods. *ACM Trans. Math. Software*, 8(3):302–322, 1982.
- [264] A. V. Knyazev. Computation of eigenvalues and eigenvectors for mesh problems: Algorithms and error estimates. Dept. of Numerical Math., USSR Academy of Sciences, Moscow, 1986. (In Russian.)
- [265] A. V. Knyazev. Convergence rate estimates for iterative methods for mesh symmetric eigenvalue problem. *Soviet J. Numer. Anal. Math. Modelling*, 2(5):371–396, 1987.
- [266] A. V. Knyazev. A preconditioned conjugate gradient method for eigenvalue problems and its implementation in a subspace. In *International Ser. Numerical Mathematics, v. 96, Eigenwertaufgaben in Natur- und Ingenieurwissenschaften und ihre numerische Behandlung, Oberwolfach*, 1990, pages 143–154, Birkhauser, Basel, 1991.

- [267] A. V. Knyazev. New estimates for Ritz vectors. *Math. Comp.*, 66(219):985–995, 1997.
- [268] A. V. Knyazev. Preconditioned eigensolvers - an oxymoron? *Electron. Trans. Numer. Anal.*, 7:104–123, 1998.
- [269] A. V. Knyazev. Toward the optimal preconditioned eigensolver: Locally optimal block preconditioned conjugate gradient method. Technical Report UCD-CCM 149, Center for Computational Mathematics, University of Colorado, Denver, 2000. Available at <http://www-math.cudenver.edu/ccmreports/rep149.ps.gz>.
- [270] A. V. Knyazev and A. L. Skorokhodov. Preconditioned iterative methods in subspace for solving linear systems with indefinite coefficient matrices and eigenvalue problems. *Soviet J. Numer. Anal. Math. Modelling*, 4(4):283–310, 1989.
- [271] A. V. Knyazev and A. L. Skorokhodov. The preconditioned gradient-type iterative methods in a subspace for partial generalized symmetric eigenvalue problem. *Soviet Math. Dokl.*, 45(2):474–478, 1993.
- [272] A. V. Knyazev and A. L. Skorokhodov. The preconditioned gradient-type iterative methods in a subspace for partial generalized symmetric eigenvalue problem. *SIAM J. Numer. Anal.*, 31(4):1226–1239, 1994.
- [273] S. Kobayashi and K. Nomizu. *Foundations of Differential Geometry*. Wiley, New York, 1969.
- [274] L. Komzsik. *MSC/NASTRAN Numerical Methods User's Guide, Version 70.5*. The MacNeal-Schwendler Corporation, Los Angeles, 1998.
- [275] N. Kosugi. Modification of the Liu-Davidson method for obtaining one or simultaneously several eigensolutions of a large real symmetric matrix. *J. Comput. Phys.*, 55(3):426–436, 1984.
- [276] L. Kronecker. *Algebraische Reduction der Schaaren Bilinearer Formen*. S. B. Akad., Berlin, 1890.
- [277] V. N. Kublanovskaja. On an application to the solution of the generalized latent value problem for λ -matrices. *SIAM J. Numer. Anal.*, 7:532–537, 1970.
- [278] V. N. Kublanovskaya. On a method of solving the complete eigenvalue problem for a degenerate matrix (in Russian). *Zh. Vychisl. Mat. Mat. Fiz.*, 6:611–620, 1966. *USSR Comput. Math. Phys.*, 6(4):1–16, 1968.
- [279] V. N. Kublanovskaya. An approach to solving the spectral problem of $A - \lambda B$. In B. Kågström and A. Ruhe, editors, *Matrix Pencils*, Lecture Notes in Mathematics, Vol. 973, pages 17–29. Springer-Verlag, Berlin, 1983.
- [280] V. N. Kublanovskaya. AB-algorithm and its modifications for the spectral problem of linear pencils of matrices. *Numer. Math.*, 43:329–342, 1984.
- [281] K. Kundert. Sparse matrix techniques. In Albert Ruehli, editor, *Circuit Analysis, Simulation and Design*. North-Holland, Amsterdam, 1986. Software available at <http://www.netlib.org/sparse>.
- [282] Yu. A. Kuznetsov. Iterative methods in subspaces for eigenvalue problems. In A. V. Balakrishnan, A. A. Dorodnitsyn, and J. L. Lions, editors, *Vistas in Applied Math., Numerical Analysis, Atmospheric Sciences, Immunology*, pages 96–113. Optimization Software, New York, 1986.

- [283] Y.-L. Lai, K.-Y. Lin, and W.-W. Lin. An inexact inverse iteration for large sparse eigenvalue problems. *Numer. Linear Algebra Appl.*, 4:425–437, 1997.
- [284] P. Lancaster. *Lambda-Matrices and Vibrating Systems*. Pergamon Press, Oxford, UK, 1966.
- [285] C. Lanczos. An iteration method for the solution of the eigenvalue problem of linear differential and integral operators. *J. Res. Nat. Bur. Standards*, 45:255–282, 1950.
- [286] C. Lanczos. Solution of systems of linear equations by minimized iterations. *J. Res. Nat. Bur. Standards*, 49:33–53, 1952.
- [287] A. Laub. Invariant subspace methods for the numerical solution of Riccati equations. In S. Bittanti, A. Laub, and J. C. Willems, editors, *Riccati Equations*. Springer-Verlag, New York, 1990.
- [288] C. Lawson, R. Hanson, D. Kincaid, and F. Krogh. Basic linear algebra subprograms for FORTRAN usage. *ACM Trans. Math. Software*, 5:308–325, 1979.
- [289] R. B. Lehoucq. *Analysis and Implementation of an Implicitly Restarted Arnoldi Iteration*. Ph.D. thesis, Rice University, Houston, TX, 1995.
- [290] R. B. Lehoucq and K. J. Maschhoff. Implementation of an implicitly restarted block Arnoldi method. Preprint MCS-P649-0297, Argonne National Laboratory, Argonne, IL, 1997.
- [291] R. B. Lehoucq and K. Meerbergen. Using generalized Cayley transformations within an inexact rational Krylov sequence method. *SIAM J. Matrix Anal. Appl.*, 20(1):131–148, 1998.
- [292] R. B. Lehoucq and J. A. Scott. An evaluation of software for computing eigenvalues of sparse non-symmetric matrices. Technical Report MCS-P547-1195, Argonne National Laboratory, Argonne, IL, 1995.
- [293] R. B. Lehoucq and J. A. Scott. Implicitly restarted Arnoldi methods and eigenvalues of the discretized Navier-Stokes equations. Technical Report SAND97-2712J, Sandia National Laboratory, Albuquerque, NM, 1997.
- [294] R. B. Lehoucq and D. C. Sorensen. Deflation techniques within an implicitly restarted Arnoldi iteration. *SIAM J. Matrix Anal. Appl.*, 17:789–821, 1996.
- [295] R. B. Lehoucq, D. C. Sorensen, and C. Yang. *ARPACK Users' Guide: Solution of Large-Scale Eigenvalue Problems with Implicitly Restarted Arnoldi Methods*. SIAM, Philadelphia, 1998.
- [296] A. S. Lewis and M. L. Overton. Eigenvalue optimization. In A. Iserles, editor, *Acta Numerica*, Volume 5, pages 149–190. Cambridge University Press, Cambridge, UK, 1996.
- [297] C.-K. Li and R. Mathias. The Lidskii-Mirsky-Wielandt theorem – additive and multiplicative versions. *Numer. Math.*, 81:377–413, 1999.
- [298] H. Li, P. Aitchison, and A. Woodbury. Methods for overcoming breakdown problems in the unsymmetric Lanczos reduction method. *Internat. J. Numer. Methods Engrg.*, 42:389–408, 1998.
- [299] R.-C. Li. On perturbations of matrix pencils with real spectra. *Math. Comp.*, 62:231–265, 1994.
- [300] R.-C. Li. Relative perturbation theory III: More bounds on eigenvalue variation. *Linear Algebra Appl.*, 266:337–345, 1997.

- [301] R. C. Li. Relative perturbation theory I: Eigenvalue and singular value variations. *SIAM J. Matrix Anal. Appl.*, 19:956–982, 1998.
- [302] R. C. Li. Relative perturbation theory II: Eigenspace and singular subspace variations. *SIAM J. Matrix Anal. Appl.*, 20:471–492, 1999.
- [303] R. C. Li. Relative perturbation theory IV: $\sin 2\theta$ theorems. *Linear Algebra Appl.*, 311:45–60, 2000.
- [304] T.-Y. Li and Z. Zeng. The Laguerre iteration in solving the symmetric tridiagonal eigenproblem, revisited. *SIAM J. Sci. Comput.*, 15:1145–1173, 1994.
- [305] T.-Y. Li and Z. Zeng. Homotopy continuation algorithm for the real nonsymmetric eigenproblem: Further development and implementation. *SIAM J. Sci. Comput.*, 20:1627–1651, 1999.
- [306] X. S. Li and J. W. Demmel. A scalable sparse direct solver using static pivoting. In *Proceedings of the Ninth SIAM Conference on Parallel Processing for Scientific Computing*, SIAM, Philadelphia, 1999. Software available at <http://www.nersc.gov/~xiaoye/SuperLU>.
- [307] W.-W. Lin, V. Mehrmann, and H. Xu. Canonical forms for Hamiltonian and symplectic matrices and pencils. *Linear Algebra Appl.*, 301/303:469–533, 1999.
- [308] R. Lucas. Private communication, 2000. Contact rflucas@lbl.gov.
- [309] S. H. Lui and G. H. Golub. Homotopy method for the numerical solution of the eigenvalue problem of self-adjoint partial differential operators. *Numer. Algorithms*, 10(3-4):363–378, 1995.
- [310] S. H. Lui, H. B. Keller, and T. W. C. Kwok. Homotopy method for the large, sparse, real nonsymmetric eigenvalue problem. *SIAM J. Matrix Anal. Appl.*, 18(2):312–333, 1997.
- [311] J.-C. Luo. Solving eigenvalue problems by implicit decomposition. *Numer. Methods Partial Differential Equations*, 7(2):113–145, 1991.
- [312] J.-C. Luo. A domain decomposition method for eigenvalue problems. In *Fifth International Symposium on Domain Decomposition Methods for Partial Differential Equations* (Norfolk, VA, 1991), pages 306–321. SIAM, Philadelphia, 1992.
- [313] N. Mackey. Hamilton and Jacobi meet again - quaternions and the eigenvalue problem. *SIAM J. Matrix Anal. Appl.*, 16:421–435, 1995.
- [314] S. Yu. Maliassov. On the Schwarz alternating method for eigenvalue problems. *Russian J. Numer. Anal. Math. Modelling*, 13(1):45–56, 1998.
- [315] J. Mandel and S. McCormick. A multilevel variational method for $A\mathbf{u} = \lambda B\mathbf{u}$ on composite grids. *J. Comput. Phys.*, 80(2):442–452, 1989.
- [316] T. Manteuffel. The Tchebyshev iteration for nonsymmetric linear systems. *Numer. Math.*, 28:307–327, 1977.
- [317] R. Mathias. Accurate eigensystem computations by Jacobi methods. *SIAM J. Matrix Anal. Appl.*, 16:977–1003, 1995.
- [318] The MathWorks. *Partial Differential Equation Toolbox User's Guide*, The MathWorks, Natick, MA, 1995.

- [319] The MathWorks. *MATLAB User's Guide*, The MathWorks, Natick, MA, 1996.
- [320] S. F. McCormick. A mesh refinement method for $Ax = \lambda Bx$. *Math. Comp.*, 36(154):485–498, 1981.
- [321] S. F. McCormick. *Multilevel Projection Methods for Partial Differential Equations*. SIAM, Philadelphia, 1992.
- [322] K. Meerbergen. The rational Lanczos method for Hermitian eigenvalue problems. Technical Report RAL-TR-1999-025, Rutherford Appleton Laboratory, Chilton, UK, 1999. Available at <http://www.numerical.rl.ac.uk/reports/reports.html>.
- [323] K. Meerbergen and D. Roose. The restarted Arnoldi method applied to iterative linear system solvers for the computation of rightmost eigenvalues. *SIAM J. Matrix Anal. Appl.*, 18:1–20, 1997.
- [324] K. Meerbergen, A. Spence, and D. Roose. Shift-invert and Cayley transforms for detection of rightmost eigenvalues of nonsymmetric matrices. *BIT*, 34:409–423, 1994.
- [325] V. Mehrmann and D. Watkins. Structure-preserving methods for computing eigenpairs of large sparse skew-Hamiltonian/Hamiltonian pencils. Technical Report SFB393/00-02, Technische Universität Chemnitz, Germany, 2000.
- [326] J. Meijerink and H. A. van der Vorst. An iterative solution method for linear systems of which the coefficient matrix is a symmetric M-matrix. *Math. Comp.*, 31:148–162, 1977.
- [327] G. Meurant. *Computer solution of large linear systems*. North-Holland, Amsterdam, 1999.
- [328] C. B. Moler and G. W. Stewart. An algorithm for generalized matrix eigenvalue problems. *SIAM J. Numer. Anal.*, 10:241–256, 1973.
- [329] R. B. Morgan. Davidson's method and preconditioning for generalized eigenvalue problems. *J. Comput. Phys.*, 89:241–245, 1990.
- [330] R. B. Morgan. Theory for preconditioning eigenvalue problems. In *Proceedings of the Copper Mountain Conference on Iterative Methods*, 1990.
- [331] R. B. Morgan. Computing interior eigenvalues of large matrices. *Linear Algebra Appl.*, 154/156:289–309, 1991.
- [332] R. B. Morgan. Generalisations of Davidson's method for computing eigenvalues of large nonsymmetric matrices. *J. Comput. Phys.*, 101:287–291, 1992.
- [333] R. B. Morgan. On restarting the Arnoldi method for large nonsymmetric eigenvalue problems. *Math. Comp.*, 65:1213–1230, 1996.
- [334] R. B. Morgan. Implicitly restarted GMRES and Arnoldi methods for nonsymmetric systems of equations. *SIAM J. Matrix Anal. Appl.*, 21:1112–1135, 2000.
- [335] R. B. Morgan and D. S. Scott. Generalizations of Davidson's method for computing eigenvalues of sparse symmetric matrices. *SIAM J. Sci. Statist. Comput.*, 7:817–825, 1986.
- [336] R. B. Morgan and D. S. Scott. Preconditioning the Lanczos algorithm for sparse symmetric eigenvalue problems. *SIAM J. Sci. Comput.*, 14:585–593, 1993.

- [337] R. B. Morgan and M. Zeng. Harmonic projection methods for large non-symmetric eigenvalue problems. *Numer. Linear Algebra Appl.*, 5:33–55, 1998.
- [338] S. G. Nash and A. Sofer. *Linear and Nonlinear Programming*. McGraw-Hill, New York, 1995.
- [339] E. G. Ng and B. W. Peyton. Block sparse Cholesky algorithms on advanced uniprocessor computers. *SIAM J. Sci. Comput.*, 14(5):1034–1056, 1993.
- [340] B. Nour-Omid, B. N. Parlett, T. Ericsson, and P. S. Jensen. How to implement the spectral transformation. *Math. Comp.*, 48:663–673, 1987.
- [341] S. Oliveira. A convergence proof of an iterative subspace method for eigenvalues problems. In *Foundations of Computational Mathematics (Rio de Janeiro, 1997)*, pages 316–325. Springer-Verlag, Berlin, 1997.
- [342] S. Oliveira. On the convergence rate of a preconditioned subspace eigensolver. *Computing*, 63(3):219–231, 1999.
- [343] W. E. Olmstead, W. E. Davis, S. H. Rosenblat, and W. L. Kath. Bifurcation with memory. *SIAM J. Appl. Math.*, 40:171–188, 1986.
- [344] J. Olsen, P. Jørgensen, and J. Simons. Passing the one-billion limit in full configuration-interaction (FCI) calculations. *Chem. Phys. Lett.*, 169:463–472, 1990.
- [345] T.C. Oppe, W. Joubert, and D. Kincaid. NSPCG’s user’s guide: A package for solving large linear systems by various iterative methods. Technical report, University of Texas, Austin, TX, 1988.
- [346] E. E. Osborne. On pre-conditioning of matrices. *J. Assoc. Comput. Mach.*, 7:338–345, 1960.
- [347] C. C. Paige. *The Computation of Eigenvalues and Eigenvectors of Very Large Sparse Matrices*. Ph.D. thesis, London University, London, England, 1971.
- [348] C. C. Paige. Properties of numerical algorithms related to computing controllability. *IEEE Trans. Automat. Control*, AC-26(1):130–138, 1981.
- [349] C. C. Paige, B. N. Parlett, and H. A. van der Vorst. Approximate solutions and eigenvalue bounds from Krylov subspaces. *Numer. Linear Algebra Appl.*, 2:115–133, 1995.
- [350] C. C. Paige and M. A. Saunders. Solution of sparse indefinite systems of linear equations. *SIAM J. Numer. Anal.*, 12:617–629, 1975.
- [351] C. C. Paige and M. A. Saunders. LSQR: An algorithm for sparse linear equations and sparse least squares. *ACM Trans. Math. Software*, 8:43–71, 1982.
- [352] C. C. Paige and C. F. Van Loan. A Schur decomposition for Hamiltonian matrices. *Linear Algebra Appl.*, 14:11–32, 1981.
- [353] B. N. Parlett. *The Symmetric Eigenvalue Problem*. Prentice-Hall, Englewood Cliffs, NJ, 1980. Reprinted as Classics in Applied Mathematics 20, SIAM, Philadelphia, 1997.
- [354] B. N. Parlett. Reduction to tridiagonal form and minimal realizations. *SIAM J. Matrix Anal. Appl.*, 13(2):567–593, 1992.

- [355] B. N. Parlett. The new qd algorithms. In *Acta Numerica*, pages 459–491. Cambridge University Press, Cambridge, UK, 1995.
- [356] B. N. Parlett. Invariant subspaces for tightly clustered eigenvalues of tridiagonals. *BIT*, 36:542–562, 1996.
- [357] B. N. Parlett and H. C. Chen. Use of indefinite pencils for computing damped natural modes. *Linear Algebra Appl.*, 140:53–88, 1990.
- [358] B. N. Parlett and I. S. Dhillon. Fernando’s solution to Wilkinson’s problem: an application of double factorization. *Linear Algebra Appl.*, 267:247–279, 1997.
- [359] B. N. Parlett and J. Le. Forward instability of tridiagonal QR. *SIAM J. Matrix Anal. Appl.*, 14:279–316, 1993. 316.
- [360] B. N. Parlett and O. A. Marques. An implementation of the dqds algorithm (positive case). *Linear Algebra Appl.*, 309:217–259, 2000.
- [361] B. N. Parlett and C. Reinsch. Balancing a matrix for calculation of eigenvalues and eigenvectors. *Numer. Math.*, 13:293–304, 1969.
- [362] B. N. Parlett and Y. Saad. Complex shift and invert strategies for real matrices. *Linear Algebra Appl.*, 88/89:575–595, 1987.
- [363] B. N. Parlett and D. Scott. The Lanczos algorithm with selective orthogonalization. *Math. Comput.*, 33:217–238, 1979.
- [364] B. N. Parlett, D. R. Taylor, and Z. S. Liu. A look-ahead Lanczos algorithm for nonsymmetric matrices. *Math. Comp.*, 44:105–124, 1985.
- [365] W. V. Petryshyn. On the eigenvalue problem $Tu - \lambda Su = 0$ with unbounded and non-symmetric operators T and S . *Philos. Trans. Roy. Soc. Math. Phys. Sci.*, 262:413–458, 1968.
- [366] B. G. Pfrommer, J. Demmel, and H. Simon. Unconstrained energy functionals for electronic structure calculations. *J. Comput. Phys.*, 150(1):287–298, 1999.
- [367] A. Pokrzywa. On perturbations and the equivalence orbit of a matrix pencil. *Linear Algebra Appl.*, 82:99–121, 1986.
- [368] E. Polak. *Computational Methods in Optimization*. Academic Press, New York, 1971.
- [369] C. Pommerell. *Solution of Large Unsymmetric Systems of Linear Equations*. Ph.D. thesis, Swiss Federal Institute of Technology, Zürich, Switzerland, 1992.
- [370] E. Rothberg. *Exploiting the Memory Hierarchy in Sequential and Parallel Sparse Cholesky Factorization*. Ph.D. thesis, Dept. of Computer Science, Stanford University, Stanford, CA, 1992.
- [371] A. Ruhe. An algorithm for numerical determination of the structure of a general matrix. *BIT*, 10:196–216, 1970.
- [372] A. Ruhe. Algorithms for the nonlinear eigenvalue problem. *SIAM J. Numer. Anal.*, 10:674–689, 1973.

- [373] A. Ruhe. SOR-methods for the eigenvalue problem with large sparse matrices. *Math. Comp.*, 28:695–710, 1974.
- [374] A. Ruhe. Iterative eigenvalue algorithms based on convergent splittings. *J. Comput. Phys.*, 19:110–120, 1975.
- [375] A. Ruhe. Implementation aspects of band Lanczos algorithms for computation of eigenvalues of large sparse symmetric matrices. *Math. Comp.*, 33:680–687, 1979.
- [376] A. Ruhe. The rational Krylov algorithm for nonsymmetric eigenvalue problems, III: Complex shifts for real matrices. *BIT*, 34:165–176, 1994.
- [377] A. Ruhe. Eigenvalue algorithms with several factorizations – a unified theory yet? Technical Report 1998:11, Department of Mathematics, Chalmers University of Technology, Göteborg, Sweden, 1998.
- [378] A. Ruhe. Rational Krylov: A practical algorithm for large sparse nonsymmetric matrix pencils. *SIAM J. Sci. Comput.*, 19(5):1535–1551, 1998.
- [379] A. Ruhe and D. Skoogh. Rational Krylov algorithms for eigenvalue computation and model reduction. In B. Kågström, J. Dongarra, E. Elmroth, and J. Waśniewski, editors, *Applied Parallel Computing. Large Scale Scientific and Industrial Problems.*, volume 1541 of *Lecture Notes in Computer Science*, pages 491–502, 1998.
- [380] A. Ruhe and T. Wiberg. The method of conjugate gradients used in inverse iteration. *BIT*, 12:543–554, 1972.
- [381] H. Rutishauser. Computational aspects of F. L. Bauer’s simultaneous iteration method. *Numer. Math.*, 13:4–13, 1969.
- [382] H. Rutishauser. Simultaneous iteration method for symmetric matrices. *Numer. Math.*, 16:205–223, 1970. Also in [458, pp. 284–301].
- [383] Y. Saad. Chebyshev acceleration techniques for solving nonsymmetric eigenvalue problems. *Math. Comp.*, 42(166):567–588, 1984.
- [384] Y. Saad. Least squares polynomials in the complex plane and their use for solving nonsymmetric linear systems. *SIAM J. Numer. Anal.*, 24(1):155–169, 1987.
- [385] Y. Saad. Numerical solution of large nonsymmetric eigenvalue problems. *Comp. Phys. Comm.*, 53:71–90, 1989.
- [386] Y. Saad. SPARSKIT: A basic tool-kit for sparse matrix computation, version 2, 1994. Software available at <http://www.cs.umn.edu/~saad>
- [387] Y. Saad. *Numerical Methods for Large Eigenvalue Problems*. Halsted Press, New York, 1992.
- [388] Y. Saad. *Iterative Methods for Linear Systems*. PWS Publishing, Boston, 1996.
- [389] Y. Saad and M. H. Schultz. GMRES: A generalized minimal residual algorithm for solving nonsymmetric linear systems. *SIAM J. Sci. Statist. Comput.*, 7:856–869, 1986.
- [390] M. Sadkane. Block-Arnoldi and Davidson methods for unsymmetric large eigenvalue problems. *Numer. Math.*, 64:195–211, 1993.

- [391] M. Sadkane. A block Arnoldi-Chebyshev method for computing the leading eigenpairs of large sparse unsymmetric matrices. *Numer. Math.*, 64:181–193, 1993.
- [392] A. H. Sameh and J. A. Wisniewski. A trace minimization algorithm for the generalized eigenvalue problem. *SIAM J. Numer. Anal.*, 19:1243–1259, 1982.
- [393] B. A. Samokish. The steepest descent method for an eigenvalue problem with semi-bounded operators. *Izv. Vuzov Math.*, 5:105–114, 1958. (In Russian.)
- [394] G. V. Savinov. Investigation of the convergence of a generalized method of conjugate gradients for determining the extremal eigenvalues of a matrix. *Zap. Nauchn. Sem. Leningrad. Otdel. Mat. Inst. Steklov. (LOMI)*, 111:145–150, 1981. (In Russian.)
- [395] O. Schenk, K. Gärtner, and W. Fichtner. Efficient sparse LU factorization with left–right looking strategy on shared memory multiprocessors. *BIT*, 40(1):158–176, 2000.
- [396] W. H. A. Schilders. Personal communication, September 1997.
- [397] D. S. Scott. Solving sparse symmetric generalised eigenvalue problems without factorisation. *SIAM J. Numer. Anal.*, 18:102–110, 1981.
- [398] J. A. Scott. An Arnoldi code for computing selected eigenvalues of sparse unsymmetric matrices. *ACM Trans. Math. Software*, 21:432–475, 1995.
- [399] N. S. Sehmi. A Newtonian procedure for the solution of the Kron characteristic value problem. *J. Sound Vibration*, 100(3):409–421, 1985.
- [400] N. S. Sehmi. *Large order structural eigenanalysis techniques*. Ellis Horwood Series: Mathematics and Its Applications. Ellis Horwood, Chichester, UK, 1989.
- [401] V. A. Shishov. A method for partitioning a high order matrix into blocks in order to find its eigenvalues. *USSR Comput. Math. and Math. Phys.*, 1(1):186–190, 1961.
- [402] H. Simon. Analysis of the symmetric Lanczos algorithm with reorthogonalization methods. *Linear Algebra Appl.*, 61:101–132, 1984.
- [403] H. Simon. The Lanczos algorithm with partial reorthogonalization. *Math. Comp.*, 42:115–142, 1984.
- [404] A. Simpson and B. Tabarrok. On Kron’s eigenvalue procedure and related methods of frequency analysis. *Quart. J. Mech. Appl. Math.*, 21:1–39, 1968.
- [405] J. P. Singh, W.-D. Webber, and A. Gupta. Splash. Stanford parallel applications for shared-memory. *Computer Architecture News*, 20(1):5–44, 1992. Software available at <http://www-flash.stanford.edu/apps/SPLASH>.
- [406] I. Slapnicar. *Accurate Symmetric Reduction by a Jacobi Method*. Ph.D. thesis, Fernuniversität Gesamthochschule Hagen, Germany, 1992.
- [407] I. Slapnicar. Accurate computation of singular values and eigenvalues of symmetric matrices. *Math. Commun.*, 1:153–168, 1996.

- [408] G. L. G. Sleijpen, G. L. Booten, D. R. Fokkema, and H. A. van der Vorst. Jacobi Davidson type methods for generalized eigenproblems and polynomial eigenproblems. *BIT*, 36:595–633, 1996.
- [409] G. L. G. Sleijpen and D. R. Fokkema. Bi-CGSTAB(ℓ) methods for linear equations involving matrices with complex spectrum. *Electron. Trans. Numer. Anal.*, 1:11–32, 1993.
- [410] G. L. G. Sleijpen, D. R. Fokkema, and H. A. van der Vorst. BiCGSTAB(ℓ) and other hybrid Bi-CG methods. *Numer. Algorithms*, 7:75–109, 1994.
- [411] G. L. G. Sleijpen and H. A. van der Vorst. A Jacobi–Davidson iteration method for linear eigenvalue problems. *SIAM J. Matrix Anal. Appl.*, 17:401–425, 1996.
- [412] G. L. G. Sleijpen, H. A. van der Vorst, and E. Meijerink. Efficient expansion of subspaces in the Jacobi–Davidson method for standard and generalized eigenproblems. *Electron. Trans. Numer. Anal.*, 7:75–89, 1998.
- [413] G. L. G. Sleijpen, H. A. van der Vorst, and M. B. van Gijzen. Quadratic eigenproblems are no problem. *SIAM News*, 29:8–9, 1996.
- [414] P. Smit and M. H. C. Paardekooper. The effects of inexact linear solvers in algorithms for symmetric eigenvalue problems. *Linear Algebra Appl.*, 287:337–357, 1998.
- [415] B. F. Smith, P. E. Bjørstad, and W. D. Gropp. *Domain decomposition*. Cambridge University Press, Cambridge, UK, 1996.
- [416] S. T. Smith. Optimization techniques on Riemannian manifolds. *Fields Inst. Commun.*, 3:113–146, 1994.
- [417] E. Snapper and R. Troyer. *Metric Affine Geometry*. Academic Press, New York, 1971.
- [418] P. Sonneveld. CGS: A fast Lanczos-type solver for nonsymmetric linear systems. *SIAM J. Sci. Statist. Comput.*, 10:36–52, 1989.
- [419] D. C. Sorensen. Implicit application of polynomial filters in a k -step Arnoldi method. *SIAM J. Matrix Anal. Appl.*, 13:357–385, 1992.
- [420] D. C. Sorensen. Deflation for implicitly restarted Arnoldi methods. Technical Report TR98-12, Department of Computational and Applied Mathematics, Rice University, Houston, TX, 1998.
- [421] A. Stathopoulos, Y. Saad, and K. Wu. Dynamic thick restarting of the Davidson, and the implicitly restarted Arnoldi methods. *SIAM J. Sci. Comput.*, 19:227–245, 1998.
- [422] G. W. Stewart. Simultaneous iteration for computing invariant subspaces of non-Hermitian matrices. *Numer. Math.*, 25:123–136, 1976.
- [423] G. W. Stewart. Perturbation bounds for the definite generalized eigenvalue problem. *Linear Algebra Appl.*, 23:69–86, 1979.
- [424] G. W. Stewart. Computing the CS decomposition of a partitioned orthogonal matrix. *Numer. Math.*, 40:297–306, 1982.
- [425] G. W. Stewart and J.-G. Sun. *Matrix Perturbation Theory*. Academic Press, New York, 1990.

- [426] W. J. Stewart and A. Jennings. Algorithm 570: LOPSI a simultaneous iteration method for real matrices. *ACM Trans. Math. Software*, 7:230–232, 1981.
- [427] W. J. Stewart and A. Jennings. A simultaneous iteration algorithm for real matrices. *ACM Trans. Math. Software*, 7:184–198, 1981.
- [428] I. Štich, R. Car, M. Parrinello, and S. Baroni. Conjugate gradient minimization of the energy functional: A new method for electronic structure calculation. *Phys. Rev. B.*, 39:4997–5004, 1989.
- [429] E. Suetomi and H. Sekimoto. Conjugate gradient like methods and their application to eigenvalue problems for neutron diffusion equation. *Annals of Nuclear Energy*, 18(4):205, 1991.
- [430] J.-G. Sun. Perturbation bounds for eigenspaces of a definite matrix pair. *Numer. Math.*, 41:321–343, 1983.
- [431] J. G. Sun. Stability and accuracy: Perturbation analysis of algebraic eigenproblems. Technical Report UMINF 98.07, Department of Computing Science, Umeå University, Umeå, Sweden, 1998.
- [432] J. G. Sun. Perturbation analysis of quadratic eigenvalue problems. *BIT*, 1999, submitted.
- [433] D. B. Szyld and O. B. Widlund. Applications of conjugate gradient type methods to eigenvalue calculations. In *Advances in Computer Methods for Partial Differential Equations, III (Proc. Third IMACS Internat. Sympos., Lehigh Univ., Bethlehem, Pa., 1979)*, pages 167–173. IMACS, New Brunswick, NJ, 1979.
- [434] D. R. Taylor. *Analysis of the Look-Ahead Lanczos Algorithm*. Ph.D. thesis, University of California, Berkeley, 1982.
- [435] F. Tisseur. Backward error and condition of polynomial eigenvalue problems. *Linear Algebra Appl.*, 309:339–361, 2000.
- [436] F. Tisseur. Stability of structured Hamiltonian eigensolvers. Numerical Analysis Report No. 357, Manchester Centre for Computational Mathematics, Manchester, UK, February 2000.
- [437] F. Tisseur and N. J. Higham. Structured pseudospectra for polynomial eigenvalue problems, with applications. Numerical Analysis Report No. 359, Manchester Centre for Computational Mathematics, Manchester, UK, 2000.
- [438] S. Toledo. Improving instruction-level parallelism in sparse matrix-vector multiplication using reordering, blocking, and prefetching. In *Proceedings of the Eighth SIAM Conference on Parallel Processing for Scientific Computing*. SIAM, Philadelphia, 1997.
- [439] S. Toledo. Improving the memory-system performance of sparse-matrix vector multiplication. *IBM J. Res. Develop.*, 41(6):711–726, 1997.
- [440] L. N. Trefethen. Computation of pseudospectra. In A. Iserles, editor, *Acta Numerica*, Volume 8, pages 247–295. Cambridge University Press, Cambridge, MA, 1999.
- [441] L. N. Trefethen. Spectra and pseudospectra: The behavior of non-normal matrices and operators. In J. Levesley, M. Ainsworth, and M. Marletta, editors, *The Graduate Student's Guide to Numerical Analysis*, Volume 26. Springer-Verlag, Berlin, 2000.

- [442] C. Trefftz, C. C. Huang, P. K. McKinley, T.-Y. Li, and Z. Zeng. A scalable eigenvalue solver for symmetric tridiagonal matrices. *Parallel Computing*, 21:1213–1240, 1995.
- [443] H. van der Veen and C. Vuik. Bi-Lanczos with partial orthogonalization. *Computers and Structures*, 56:605–613, 1995.
- [444] H. A. van der Vorst. A generalized Lanczos scheme. *Math. Comp.*, 39:559–561, 1982.
- [445] H. A. van der Vorst. Bi-CGSTAB: A fast and smoothly converging variant of Bi-CG for the solution of non-symmetric linear systems. *SIAM J. Sci. Statist. Comput.*, 13:631–644, 1992.
- [446] P. Van Dooren. The computation of Kronecker’s canonical form of a singular pencil. *Linear Algebra Appl.*, 27:103–141, 1979.
- [447] P. Van Dooren. The generalized eigenstructure problem in linear system theory. *IEEE Trans. Automat. Control*, AC-26(1):111–129, 1981.
- [448] P. Van Dooren. A generalized eigenvalue approach for solving Ricatti equations. *SIAM J. Sci. Comput.*, 2:121–135, 1981.
- [449] P. Van Dooren. Algorithm 590, DUSBSP and EXCHQZ: FORTRAN subroutines for computing deflating subspaces with specified spectrum. *ACM Trans. Math. Software*, 8:376–382, 1982.
- [450] P. Van Dooren. Reducing subspaces: Computational aspects and applications in linear systems theory. In *Proceedings of the 5th Int. Conf. on Analysis and Optimization of Systems*, 1982, Lecture Notes on Control and Information Sciences. Volume 44. Springer-Verlag, New York, 1983.
- [451] P. Van Dooren. Reducing subspaces: Definitions, properties and algorithms. In B. Kågström and A. Ruhe, editors, *Matrix Pencils*, Lecture Notes in Mathematics, Volume 973, pages 58–73. Springer-Verlag, Berlin, 1983.
- [452] C. F. Van Loan. A symplectic method for approximating all the eigenvalues of a Hamiltonian matrix. *Linear Algebra Appl.*, 61:233–251, 1984.
- [453] C. F. Van Loan. *Computational Frameworks for the Fast Fourier Transform*. SIAM, Philadelphia, 1992.
- [454] E. L. Wachspress. *Iterative solution of elliptic systems, and applications to the neutron diffusion equations of reactor physics*. Prentice-Hall, Englewood Cliffs, NJ, 1966.
- [455] H. F. Walker. Implementation of the GMRES method using Householder transformations. *SIAM J. Sci. Statist. Comput.*, 9:152–163, 1988.
- [456] W. Waterhouse. The codimension of singular matrix pairs. *Linear Algebra Appl.*, 57:227–245, 1984.
- [457] J. H. Wilkinson. *The Algebraic Eigenvalue Problem*. Clarendon Press, Oxford, UK, 1965.
- [458] J. H. Wilkinson and C. Reinsch. *Handbook for Automatic Computation. Vol. II, Linear Algebra*. Springer-Verlag, New York, 1971.
- [459] Y.-C. Wong. Differential geometry of Grassmann manifolds. *Proc. Nat. Acad. Sci. USA*, 57:589–594, 1967.

- [460] M. Wonham. *Linear Multivariable Control Theory: A Geometric Approach*. Springer-Verlag, New York, second edition, 1979.
- [461] K. Wu, Y. Saad, and A. Stathopoulos. Inexact Newton preconditioning techniques for eigenvalue problems. Technical Report LBNL-41382, Lawrence Berkeley National Laboratory, Berkeley, CA, 1998. Also published as Minnesota Super Computer Centre report number UMSI 98-10, Minneapolis.
- [462] K. Wu and H. D. Simon. A parallel Lanczos method for symmetric generalized eigenvalue problems. Technical Report LBNL-41284, National Energy Research Scientific Computing Division, Lawrence Berkeley National Laboratory, Berkeley, CA, 1997. Software available at <http://www.nersc.gov/research/SIMON/planso.html>.
- [463] K. Wu and H. D. Simon. Dynamic restarting schemes for eigenvalue problems. Technical Report LBNL-42982, National Energy Research Scientific Computing Division, Lawrence Berkeley National Laboratory, Berkeley, CA, 1999.
- [464] H. Yang. Conjugate gradient methods for the Rayleigh quotient minimization of generalized eigenvalue problems. *Computing*, 51(1):79–94, 1993.
- [465] Q. Ye. A breakdown-free variation of the nonsymmetric Lanczos algorithms. *Math. Comp.*, 62:179–207, 1994.
- [466] H. Zha and H. Simon. On updating problems in latent semantic indexing. *SIAM J. Sci. Comput.*, 21:782–791, 1999.
- [467] H. Zha and Z. Zhang. On matrices with low-rank-plus-shift structures: partial SVD and latent semantic indexing. *SIAM J. Matrix Anal. Appl.*, 21:522–280, 1999.
- [468] T. Zhang, G. H. Golub, and K. H. Law. Subspace iterative methods for eigenvalue problems. *Linear Algebra Appl.*, 294(1-3):239–258, 1999.
- [469] T. Zhang, K. H. Law, and G. H. Golub. On the homotopy method for perturbed symmetric generalized eigenvalue problems. *SIAM J. Sci. Comput.*, 19(5):1625–1645, 1998.
- [470] S. Zhou and H. Dai. *Dai Shu Te Zheng Zhi Fan Wen Ti (The Algebraic Inverse Eigenvalue Problems)*. Henan Science and Technology Press, Zhengzhou, China, 1991. (In Chinese.)
- [471] Z. Zlatev, J. Waśniewski, P. C. Hansen, and Tz. Ostromsky. PARASPAR: A package for the solution of large linear algebraic equations on parallel computers with shared memory. Technical Report 95-10, Technical University of Denmark, Lyngby, September 1995.
- [472] P. I. Davies, N. J. Higham, and F. Tisseur. Analysis of the Cholesky Method with Iterative Refinement for Solving the Symmetric Definite Generalized Eigenproblem. Manchester Centre for Computational Mathematics, Manchester, England, Numerical Analysis Report 360, 2000.
- [473] D. J. Higham and N. J. Higham. Structured backward error and condition of generalized eigenvalue problems. *SIAM J. Matrix Anal. Appl.*, 20:493–512, 1998.