*numerical solution to Duncan–Mortensen–Zakai equation*, S.-T. Yau and S. S.-T. Yau.

LARS B. WAHLBIN

**3[65-02, 65F15]**—*Templates for the solution of algebraic eigenvalue problems, a practical guide*, Zhaojun Bai, James Demmel, Jack Dongarra, Axel Ruhe, and Henk van der Vorst (Editors), SIAM, Philadelphia, PA, 2000, xxix+401 pp., 25 cm, softcover $62.00

Algebraic eigenvalue problems are ubiquitous in scientific computing. Many excellent methods for computing the eigenvalues and corresponding eigenvectors of dense matrices are available in programming environments like Matlab and in libraries like LAPACK. For such problems it is rather straightforward to select the "best" method, as the choice depends on parameters that are easy to formulate and check, e.g., symmetry and band structure. Often it is the default (and fastest) operation to compute all the eigenvalues.

For very large, structured, and/or sparse problems, no single best method exists. There are several competing methods to choose between, depending on the properties of the problem. Apart from the parameters mentioned above for dense problems, the choice of algorithm is influenced by the desired spectral information, and the available operations and their cost: Can similarity transformations be performed on the matrix? Can the matrix be factorized? Can we only multiply a vector by the matrix or perhaps by its transpose? This book gives an overview of the state of the art in algorithms for large, sparse eigenvalue problems.

Based on the desired spectral information and the available operations and their cost, recommendations are given on choosing one of the algorithms. The recommendations are summarized in the form of a decision tree. The complexity of the decision problem is illustrated by the fact that the decision table for the Hermitian eigenvalue problem has six classes of methods, each with two or three variants, the choice of which depends on six parameters.

Each algorithm is presented in the form of a *template*, which is a high-level description. Apart from the algorithmic structure, information is given about when the algorithm is effective as well as estimates about the time and space required. Available refinements and user-tunable parameters are described, and ways to assess the accuracy are given. Finally, numerical examples illustrate both easy and difficult cases for each algorithm.

There is a website for the book, which describes how to access software discussed in the book (the home page was not available when this review was written).

The table of contents demonstrates the scope of the book. To give an idea of how the book is organized, we give also the section headings for a typical chapter, namely that on Hermitian eigenvalue problems.

1. Introduction
2. A brief tour of eigenproblems (30 pp.)
3. An introduction to iterative projection methods (8 pp.)
4. Hermitian eigenvalue problems (54 pp.)
   (a) Single- and multiple-vector iterations (M. Gu)
   (b) Lanczos method (A. Ruhe)
   (c) Implicitly restarted Lanczos method (R. Lehoucq and D. Sorensen)

   (d) Band Lanczos method (R. Freund)
   (e) Jacobi-Davidson methods (G. Sleijpen and H. van der Vorst)
   (f) Stability and accuracy assessments (Z. Bai and R. Li)
5. Generalized Hermitian eigenvalue problems (26 pp.)
6. Singular value decomposition (14 pp.)
7. Non-Hermitian eigenvalue problems (82 pp.)
8. Generalized non-Hermitian eigenvalue problems (48 pp.)
9. Nonlinear eigenvalue problems (34 pp.)
10. Common issues (22 pp.)
11. Preconditioning techniques (32 pp.)
12. Appendix: Of things not treated (8 pp.)
13. Bibliography (473 references)

Most of the algorithms presented have been developed over a reasonable period of time and it is likely that they are quite close to their ultimate version. So from this point of view it is appropriate that this book is published now. The book also contains one or two sections on nonstandard material, which is not yet ready to be made into numerical software. In view of the preliminary state of the work, it might have been better to omit the section on preconditioned eigensolvers (Knyazev), and consider it for possible inclusion in a second edition of the book.

The intended readership is stated to be both students and teachers, a general audience of scientists and engineers, and experts in high performance computing who want to solve the most difficult applied problems. In my opinion the book is very useful for all categories mentioned. However, it should be noted that the presentation presupposes that the reader already has a good background in numerical linear algebra.

Most of the algorithms are well known, at least for researchers in numerical analysis, and have been developed and made into numerical software during the last decade. Even if the main part of this material is already available in the literature, it has not been presented in a common framework and it has been difficult to compare different alternative methods. This book, written by some of the best experts in the field, is invaluable for anyone who wants to know the state-of-the-art algorithms for large, sparse eigenvalue problems. The availability of codes at the website of the book will make it possible for many more people to quickly take advantage of the latest research in the area (provided that the website is well maintained). I consider the book as a very important source in this field of scientific computing.

Lars Eldén
Institute of Mathematics
University of Linköping
S-581 83 Linköping
Sweden

**4[35Q80, 49-01, 53-01, 65D99, 68U10]**—*Geometric partial differential equations and image analysis*, by Guillermo Sapiro, Cambridge University Press, New York, NY, 2001, xxv+385 pp., 23 1/2 cm, hardcover $64.95

**Introduction.** Image analysis is now present and necessary in many different areas and aspects in the sciences, such as internet, compression and transmission, medical imaging, satellite imaging, video surveillance, and many others.