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Book reviews

Spectral Methods for Incompressible Viscous Flow
by Roger Peyret

The present book is concerned with Fourier and Chebyshev spectral methods for the simulation of incompressible viscous The book consists of nine chapters divided over three parts. The first part contains the fundamentals of the Fourier and Chebyshev methods for the solution of differential equations. The second part focusses on the solution of the Navier–Stokes equations, and the third part on special topics like stiff and singular problems, and domain decomposition methods. These chapters, together with appendices containing formulas for Chebyshev polynomials and the solution method of a quasi-tridiagonal system, provide a rather complete introduction to the field of spectral methods for incompressible viscous This book, and in particular chapters five to nine, can be considered as a well-documented review for the specialists in this field.

The first part of the book gives an overview of the basics of spectral methods, and serves as an introduction to the field. In a good tradition, Chapter 1 starts with the method of weighted residuals and an introduction to the various formulations of the solution of a differential equation: the Galerkin method, the tau method and the collocation method. In Chapter 2 the Fourier method is discussed and in Chapter 3 a comprehensive overview of the Chebyshev method is given. Issues as differential equations with constant or nonconstant coefficients are discussed for either the Fourier or the Chebyshev method. Several important issues are addressed in Chapter 3: direct and iterative methods for multidimensional problems, and the principles of the in matrix method. Finally, in Chapter 4, time-discretization schemes are analysed for problems where Fourier or Chebyshev methods are applied in various situations.

The second part of the book, and in my opinion the central part for many dynamicists and engineers involved in CFD, contains the material that addresses the application of spectral methods to the Navier–Stokes equations for incompressible Besides a general introduction to the Navier–Stokes equations and the Boussinesq approximation (Chapter 5) this part is primarily devoted to the application of Fourier and Chebyshev methods to the vorticity–streamfunction (Chapter 6) and the velocity–pressure (Chapter 7) formulation of the Navier–Stokes equations. Three different cases are discussed in both chapters: fully periodic in two dimensions (vorticity–streamfunction equations) or three dimensions (velocity–pressure equations), two-dimensional with one periodic direction and two-dimensional without periodicity. A minor point of criticism is the lack of any discussion of the application of spectral methods to the vorticity–velocity formulation of the Navier–Stokes equations. Although the author acknowledges successful efforts in this direction no chapter is devoted to this formulation. For a complete overview of spectral methods for incompressible viscous it should be included in a second edition.

The third part concerns two special topics. In Chapter 8 attention has been paid to various approaches for the solution of stiff and singular problems. The application of Chebyshev domain decomposition methods for elliptic problems (in matrix, iterative, and spectral-element methods) is addressed in Chapter 9 and illustrated with a few typical examples for the Stokes problem and the Navier–Stokes equations.

In general, this monograph is well-structured, contains many illustrating examples and can be used as a guide to program (parts of) a computer code to simulate satisfying the Navier–Stokes equations for incompressible flows. I strongly recommend this book to researchers involved in this field and the book should be available in dynamics laboratories.

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