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A practical guide to pseudospectral methods. (English) [Zbl 0844.65084](#)

Cambridge Monographs on Applied and Computational Mathematics 1. Cambridge: Cambridge Univ. Press (ISBN 0-521-49582-2). x, 231 p. (1996).

The connection between pseudospectral and finite difference methods is investigated. A key theme of this book is to exploit this connection and to obtain powerful and flexible spectral methods. Finite difference schemes are local whereas spectral schemes are global. Usually the approximation is performed by very smooth functions, for example by Chebyshev polynomials or trigonometric functions. For analytical functions, errors typically decay at exponential rate. Further, the method is virtually free of both dissipative and dispersive errors. On the other hand, there are difficulties when using spectral methods: certain boundary conditions, irregular domains, strong shocks.

At present, spectral methods are highly successful in several areas: turbulence, weather prediction, nonlinear waves, seismic modeling. The efficiency of spectral methods benefited greatly from the fast Fourier transform (FFT) algorithm of *J. W. Cooley* and *J. W. Tukey* [*Math. Comput.* 19, 297-301 (1965; [Zbl 0127.09002](#))].

It is shown that pseudospectral methods can be seen as limiting cases of increasing-order finite difference methods. The basic idea goes back to *H.-O. Kreiss* and *J. Olinger* [*Tellus* 24, 199-215 (1972; MR 47.7926)], and was developed by *B. Fornberg* [*SIAM J. Numer. Analysis* 12, 509-528 (1975; [Zbl 0349.35003](#)) and *ibid.* 27, No. 4, 904-918 (1990; [Zbl 0705.65076](#))]. In chapter 3 advantages of the finite difference methods are listed. In the remaining chapters, key properties of spectral methods and applications are discussed.

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MSC:

- [65N35](#) Spectral, collocation and related methods for boundary value problems involving PDEs
- [65-02](#) Research exposition (monographs, survey articles) pertaining to numerical analysis
- [35L65](#) Hyperbolic conservation laws
- [35J65](#) Nonlinear boundary value problems for linear elliptic equations
- [65N06](#) Finite difference methods for boundary value problems involving PDEs
- [65M70](#) Spectral, collocation and related methods for initial value and initial-boundary value problems involving PDEs
- [65M06](#) Finite difference methods for initial value and initial-boundary value problems involving PDEs

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[pseudospectral methods](#); [practical guide](#); [finite difference methods](#); [fast Fourier transform](#)

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