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Book Review: *Convection and Chaos in Fluids*

Convection and Chaos in Fluids. J. K. Bhattacharjee. World Scientific, Singapore, 1987.

Over the past decade it has become increasingly clear that various hydrodynamic instabilities can be understood through the analysis of relatively simple nonlinear models that manifest complicated dynamical behavior. These models usually consist of a set of coupled nonlinear differential equations or a set of coupled nonlinear maps. Both these types of models are discussed in the present book. The author adeptly picks his way through the snarled equations of continuous hydrodynamic systems involving fluid flow, temperature fields, density differences, and magnetic fields, pointing out the types of bifurcations here and the similarities in structure there. He begins with a treatment of the Navier–Stokes equations coupled to an inhomogeneous temperature field, i.e., the Rayleigh–Bénard problem, introduces linear stability theory, and discusses the properties of the linear eigenvalues characterizing the onset of convection. A multiple-scale analysis in both space and time is used to describe the fluid behavior near the point of onset, and the instabilities of the convection state are discussed.

The truncated description of the convection rolls in the Rayleigh–Bénard problem given by Lorenz is presented and the ideas of a strange attractor and chaos are introduced. The mathematical properties of chaos are briefly reviewed and such concepts as the Lyapunov number, fractal dimension, Cantor sets, and so on are briefly discussed.

The various routes that a dynamical system can take to arrive at a chaotic state are discussed in some detail. The routes include period-doubling bifurcations, intermittency (tangent bifurcations), and quasi-periodicity. The various types of experiments in which each of these mechanisms have been observed are described, clarifying the physical interpretation of some of the mathematical results.

There is then a sequence of chapters, each devoted to the discussion of a single phenomenon: (1) convection in a magnetic field, (2) thermohaline convection, (3) more general doubly diffusive fluid systems, and (4)

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Couette–Taylor flow. The book ends with a discussion of the effect on each of these phenomena of modulating the control parameter with a harmonic perturbation that is adjusted in both amplitude and phase.

This work has the feeling of a set of lecture notes in that the perspective of each chapter is quite tightly focused and one never loses sight of the hydrodynamics. This book is for the senior scientist in hydrodynamics who wants to learn what these new techniques have done to the field while he or she was not looking, as well as for the novitiate who wishes to learn hydrodynamics through the analysis of classic problems from a modern point of view.

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