BOOK REVIEWS:

Dynamics of Complex Systems (Studies in Nonlinearity)

Variational Principles and the Numerical Solution of Scattering Problems

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Dynamics of Complex Systems (Studies in Nonlinearity)

Yaneer Bar-Yam

Addison-Wesley, New York, 1997; ISBN 0-201-55748-7; 800 pp., cloth, $56.00.

Reviewed by Susan R. McKay

The study of complex systems has expanded dramatically throughout the last decade and now involves researchers from many disciplines, including physics, biology, economics, engineering, mathematics, and psychology. Many educators would find it a challenging task to teach a multidisciplinary course on complex systems that would be appropriate for students in all these disciplines. Yaneer Bar-Yam's *Dynamics of Complex Systems*, an outgrowth of a graduate course that he has taught, provides the basis for such a course.

Bar-Yam avoids speaking only in generalities by focusing on four topics that exemplify complexity: neural networks, protein folding, evolutionary and developmental biology, and human civilization. Two chapters are included on each of these topics. The first of the two defines basic models and emphasizes analytical techniques, whereas the second usually focuses more on simulations and their results.

These eight chapters are preceded by an extensive (almost 280-page!) introductory chapter. The subjects of the subsections in this chapter—"Thermodynamics and Statistical Mechanics," "Computer Simulations," and "Cellular Automata"—could constitute courses in themselves. What Bar-Yam has done, very successfully, is to present essential background material for the study of complex systems in a variety of areas of physics, mathematics, and computer science. All any two subsections may have in common is that they are necessary to set the stage for the discussion in later chapters.

Most of the introductory material will be familiar to any physics student who has had courses in statistical mechanics and dynamical systems; in this case the first chapter of the book will serve as a useful review and reference. Even for those who are acquainted with these topics, the introductory section is worth reading because it is well illustrated and written in an unusually clear style. Coverage of material is complete, but the tone is informal; the author interrupts his exposition to pose questions and provide their solutions. These interspersed questions and answers make the book particularly well suited for independent study, although some readers may miss the end-of-chapter problems that are found in most physics texts. Bar-Yam suggests teaching this course with project assignments rather than traditional problem sets in order to accommodate students with different backgrounds.

For those from disciplines other than physics, the introduction may contain much new material that requires serious study. Bar-Yam has made an effort to define terminology as it is introduced, so that the introductory chapter is readable for those without previous experience. The presentation is self-contained and conveniently collects excellent background information for those who want to continue in the field of complex systems.

Bar-Yam acknowledges in his overview of the book that presenting the extensive introductory material could easily take a full semester even if the instructor moves quickly through the topics. In order to get to the complex systems themselves within a one-semester course, the instructor might follow an alternative syllabus proposed in Bar-Yam's overview, which begins with neural networks (Chap. 2) and draws on material from the introductory chapter as needed. For this type of course, the

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book offers two advantages: (1) It contains almost 300 pages of background material on complex systems, written clearly and in terms that students from a variety of disciplines can understand; and (2) it provides detailed treatments of four different types of complex systems, including discussions of basic models and important analytical and numerical results. The book closes with an 11-page section of additional readings arranged by chapter, which includes both key words (as provided by the Library of Congress for literature searches) and specific references.

Overall, this book fills a unique niche in the complex-systems literature by offering a unified picture of the entire field while providing a carefully chosen collection of technical information and insights. It can serve well either as a primary text or as a reference for students and researchers. Those who work on any complex system would benefit from reading the discussions of other systems here in order to gain a fresh perspective and to put their own system in a broader context.◆

Books Received

Bioinformatics: The Machine Learning Approach

Pierre Baldi and Soren Brunak

MIT Press, Cambridge, MA, 1998; ISBN 0-262-02442-X; 351 pp., cloth, $40.00.

Fields of Physics by Finite Element Analysis

Gunnar Backstrom

Studentlitteratur, Lund, Sweden, 1998; ISBN: 91-44-00655-1; 208 pp., paper, 326 SEK.

iWarp: Anatomy of a Parallel Computing System

Thomas Gross and David O'Hallaron

MIT Press, Cambridge, MA, 1998; ISBN 0-262-07183-5; 488 pp., cloth., $45.00.

Complexity: Hierarchical Structures and Scaling in Physics

Remo Badii and Antonio Politi

Cambridge University Press, Cambridge, England, 1997; ISBN 0-521-41890-9; 332 pp., cloth, $74.95.

Lattice-Gas Cellular Automata: Simple Models of Complex Hydrodynamics

Daniel H. Rothman and Stéphane Zaleski

Cambridge University Press, Cambridge, England, 1997; ISBN 0-521-55201-X; 304 pp., cloth, $69.95.

Solving Problems in Scientific Computing Using Maple and MATLAB, Third Edition

Walter Gander and Jiri Hrebicek

Springer-Verlag, Berlin, Heidelberg, and New York, 1997; ISBN 3-540-61793-0; 408 pp., paper, $49.95.

The Beginner's Guide to Mathematica Version 3

Jerry Glynn and Theodore Gray

Cambridge University Press, Cambridge, England, 1997; ISBN 0-521-62734-6; 347 pp., paper, $24.95. (Also available in cloth, ISBN 0-521-62202-6, $64.95.)

Variational Principles and the Numerical Solution of Scattering Problems

Sadhan K. Adhikari

John Wiley & Sons, New York, 1998; ISBN 0-471-18193-5; 323 pp., cloth, $84.95.

Reviewed by Roger G. Newton

Many of today's physics experiments are, in one way or another, based on the scattering of particles. Scattering plays a role in elastic or inelastic collisions, reactions, and rearrangements, as well as in captures of elementary particles, nuclei, atoms, molecules, and quasiparticles. We obtain most of the information we have about the forces and properties of particles at the microscopic level through particle-scattering experiments.

Theoretical predictions of scattering cross sections and resonances are always ultimately based on an underlying differential equation—more often than not, the Schrödinger equation. One of the tasks of scattering theory is to establish the mathematical tools necessary for the extraction of numerical results for comparison with experiment. Since a scattering experiment in effect compares the outcome of a collision between particles with a situation in which the collision partners have not interacted—the initial conditions being specified and the outcome observed at macroscopic distances—these mathematical procedures are not entirely straightforward. Understanding their use requires a certain amount of explanation and care.

The first chapter of Adhikari's book is devoted to explaining the theory of quantum-mechanical scattering and introducing the canonical tools—the S matrix, the t matrix, the K matrix, and phase shifts—for the various cases of interest. There is also a discussion of the most commonly used integral equation, the Lippmann-Schwinger equation, along with other integral equations needed for reactions involving more than two particles. Later chapters are devoted to the discussion of numerical methods for the solution of these equations, which can almost never be solved exactly. These chapters also cover the main focus of the book, namely the several specific variational principles that are useful for the calculation of results to be compared with experiments.

Because every numerical calculation is ultimately somewhat inexact, efficient methods for the construction of reliable approximations are of particular practical importance. Variational princi-

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