Journal of Statistical Physics, Vol. 126, No. 2, January 2007 (© 2006)
DOI: 10.1007/s10955-006-9263-z

Book Review: *Statistical Mechanics: Entropy, Order Parameters, and Complexity*

Published Online: January 5, 2007

Statistical Mechanics: Entropy, Order Parameters, and Complexity. James P. Sethna, 349 pp, Oxford University Press, 2006.

Statistical mechanics, while having originated as a field of physics, has had significant impact on other disciplines, both related to physics and remote from it, such as mathematics, chemistry, biology, engineering, information theory and social sciences. This book is the author's distillation of the key ideas of statistical mechanics in the light of the concepts and applications developed in all these fields during the last fifty years.

The text of the first half of the book covers standard topics such as random walks, temperature, phase-space dynamics, entropy, free energy, and quantum statistical mechanics, while exercises illustrate various new applications of statistical mechanics: random matrix theory, single-molecule experiments, stock-market volatility, the KAM theorem, Shannon's entropy in information theory, and Dyson's concepts of life at the end of the universe. The second half of the book incorporates calculation and computational aspects (Monte Carlo simulation methods and perturbation theory), order parameters, correlations and linear response, and abrupt and continuous phase transitions.

The book contains extensive tutorial material including examples, figures and an excellent collection of graded exercises (many of them are computational problems) with hints to guide the reader. Available are the lists of exercises conveniently sorted by difficulty (from level 1—doable by inspection, up to level 5—advanced) and by subject (with enough diversity to cover astrophysics, biology, chemistry, computer sciences, finance, statistics, and so forth).

Intended to appeal to an audience from different fields, this book treats traditional topics of statistical mechanics with an interdisciplinary slant. It stays close to the real world measurements and to experimental techniques currently used by researchers in several fields in the physical and biological sciences and beyond. Such an interdisciplinary approach, though, inevitably leaves out of the main text some of the traditional textbook concepts, such as Maxwell relations in thermodynamics, transition state theory and Kramers' problem, and a few other topics as being not of a significant influence, in the author's view, in areas remote from physics and chemistry; instead, these topics are incorporated into exercises.

The author's style, although quite concentrated, is simple to understand, and has many lovely visual examples to accompany formal ideas and concepts, which makes the exposition live and intuitively appealing. A carefully distilled selection of ideas and concepts will undoubtedly make this book helpful to upper-level undergraduate and beginning graduate students-physicists looking for fundamental problems in the diversity of today's research world where the interdiffusion of once remote subjects is apparently a sign of the times. A substantial part of the book is accessible to sophisticated students in other fields. Since the book treats intersections of mathematics, biology, engineering, computer science and social sciences, it will be of a great help to researchers in these fields in making statistical mechanics useful and comprehensible. At the same time, the book will enrich the subject for researchers-physicists who'd like to apply their skills in other disciplines.

Olga K. Dudko
Mathematical & Statistical Computing Laboratory,
Center for Information Technology,
National Institutes of Health,
Bethesda, MD 20892
E-mail: dudko@mail.nih.gov