

approach is similar to that of Mladen Pavičić's *Quantum Computation and Quantum Communication: Theory and Experiments* (Springer, 2006); Pavičić's book, however, does not include exercises.

As a senior particle theorist at the Nonlinear Institute of Nice in France, Le Bellac has written several books, which appears to have helped him immensely in providing an accessible and physical primer to the subject, particularly for students and nonspecialists. *A Short Introduction to Quantum Information and Quantum Computation* is a laudable textbook by an author who has much experience writing about physics. It outperforms other similar texts that contain more pages but fail to communicate the essence of the subject to anyone not working in the field. The only small disappointment is the brevity of its bibliography, which includes fewer than 50 citations. On the other hand, Le Bellac's book is designed as a self-contained, short introduction rather than a comprehensive overview of the subject. It fully succeeds in its mission.

Gregg Jaeger
Boston University
Boston, Massachusetts

Statistical Mechanics

Entropy, Order Parameters, and Complexity

James P. Sethna

Oxford U. Press, New York, 2006.

\$99.50, \$44.50 paper (349 pp.).

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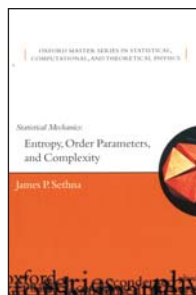
One compelling reason to study statistical mechanics is the substantial insight it yields into an amazing variety of phenomena—from the properties of black holes, to the organization of material inside human cells, to the behavior of financial markets. Another is its importance and centrality in many fields of physics: Statistical mechanics is typically a prerequisite to such courses as condensed-matter physics, astrophysics, and cosmology. Thus an important goal for an instructor teaching a course on the subject is to convey the range of applicability while presenting a fairly standardized curriculum.

James P. Sethna's *Statistical Mechanics: Entropy, Order Parameters, and Complexity* does an admirable job of covering the fundamentals while also highlighting nontraditional areas to which statistical mechanics provides useful insights. Examples of applications in nontraditional areas are also

presented throughout the text. Although the ordering of the material is nonstandard, in that random walks and diffusion are introduced before thermodynamics and partition functions, the choice of arrangement could be changed by the instructor, if desired. The material on random walks is used to good effect in the presentations on dynamical correlation functions and the concept of scale invariance. Thermodynamics is treated in parallel with partition functions, a choice that tends to

mask the distinction between the properties that follow as a consequence of entropy being a state function and those that rely on how entropy is defined. The distinction, however, is not important in practical situations.

Sethna has made a series of thoughtful choices; the book is well organized and varied, yet not too long. It covers an appropriate selection of topics, and the amount of detail presented is suitable for an introductory course. The author has worked



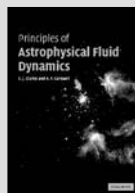
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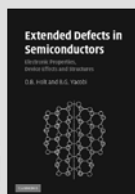


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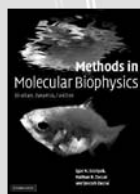
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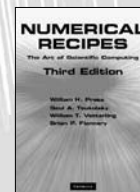
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on many of the topics in the text; his experience is reflected in the interesting and cohesive perspectives related to the different subjects discussed and in the adaptation of calculations from his own work to new, substantial, and intriguing problems.

Each chapter has two short introductions: one to outline its contents and the other to discuss the exercises at the end of the chapter. The introductions are most useful for providing context, and they help the flow of the presentation. The one choice made by the author with which I disagree is that he did not provide literature recommendations when he did not cover a topic in depth.

A highlight of the book is the broad array of thoughtful exercises; an answer key to most of them is available to instructors on request. That sensible policy is a tremendous boon to time-crunched instructors who want to make up problem sets that take an appropriate amount of time for students to complete. Sethna asks that instructors do not post the answers to the exercises on the Web or distribute them electronically. The exercises include a substantial number of computational problems; software for several of them can be downloaded from the author's website. Some of the software is prewritten so that students can easily download and run simulations. When I was writing this review, some of the canned exercises did not work on Macintosh OS X. I hope the problem is remedied by the time this review is published.

Some of the exercises in the book guide students to write their own simulations. They are encouraged to program in Python, a computer language that runs on all standard platforms and is relatively easy to learn. Some of the exercises would take a long time to grade, so it is best to assign them in a course only when the class is small or considerable grading assistance is available.

Sethna's book provides an important service to students who want to learn modern statistical mechanics. The text teaches students how to work out problems by guiding them through the exercises rather than by presenting them with worked-out examples. Overall, *Statistical Mechanics* is probably more appropriate as a textbook than a self-study guide. Instructors can point out to students which material is core and central to understanding following chapters, and which is cultural and not required to comprehend later topics.

Susan Coppersmith
University of Wisconsin–Madison

Many Worlds in One

The Search for Other Universes

Alex Vilenkin
Hill and Wang, New York, 2006.
\$24.00 (235 pp.).
ISBN 978-0-8090-9523-0

Alexander Vilenkin's *Many Worlds in One: The Search for Other Universes* is a beautifully written story of a new worldview that has developed during the past 25 years. Cosmologists associate this view with the concept of an eternally inflating multiverse. String theorists, who joined in on the discussions a few years ago, call it the string theory landscape. The new paradigm replaces the idea of a single uniform universe with that of a multiverse consisting of many different universes with different properties.

Another recently published book on multiverse theory is *The Cosmic Landscape: String Theory and the Illusion of Intelligent Design* by Leonard Susskind (Little, Brown and Co, 2006). If you are interested in the string theory perspective, the best introduction can be found in *The Cosmic Landscape* (see the review of Susskind's book by Paul Langacker in *PHYSICS TODAY*, June 2006, page 61). If you are interested in the theory of the inflationary multiverse, Vilenkin's book should be your first choice. But why not read both?

Susskind is a brilliant and prolific scientist, an expert on string theory and cosmology who coined the term string theory landscape. Vilenkin is one of the world's leading theoretical cosmologists. He is the inventor of the theory of cosmic strings, the author of several influential works on quantum creation of the universe, and one of the architects of the theory of eternal inflation. Both Susskind's and Vilenkin's books are wonderful.

Cosmological observations tell us that the universe looks the same everywhere and that the physical laws in all of its parts are the same as they are in the vicinity of our solar system. In the early 1980s when inflationary cosmology was first proposed, one of its main goals was to explain the uniformity of the universe. Inflation is a stage of an exponentially fast expansion of the early universe. Inflation stretches all previously existing inhomogeneities and makes our part of the universe perfectly uniform, except for the small

quantum fluctuations amplified during inflation. Those quantum fluctuations later give rise to galaxies.

However, a few years after the invention of inflationary theory, cosmologists realized that the theory may have some unforeseen consequences. Like water, which can be either solid or liquid in different parts of the ocean, vacuum may have different properties in different parts of the universe. Inflation makes each of those parts uniform and exponentially large, so by looking at any of those parts, one would think, incorrectly, that the whole universe looks the same everywhere.

The next important step was made in the mid-1980s with the discovery of the eternal chaotic inflation scenario. The scenario emphasized that even if the universe began its evolution in one particular vacuum state, quantum fluctuations produced during inflation would exponentially divide the universe into many large parts corresponding to

all possible vacuum states. From a local observer's point of view, this means the universe would divide into many universes with different laws of low-energy physics operating in each (see my article in *PHYSICS TODAY*, September 1987, page 61).

But why would any theory have many different vacua? A possible answer is found in the context of string theory. According to the theory, our space has many dimensions, but some of them are extremely small, or "compactified"; therefore, we perceive our spacetime as four dimensional. The first commonly accepted solution to ensure the stability of compactified dimensions was the KKLT (Kallosh-Kachru-Linde-Trivedi) mechanism, proposed in 2003. Researchers soon realized that this mechanism allows an enormously large number of ways to stabilize the vacuum. String theory admits 10^{100} , or maybe even 10^{1000} , different vacuum solutions. Each solution appears in the context of the same fundamental theory, but the laws of interaction of elementary particles in each of these vacua look completely different. Combining this scenario with the theory of eternal inflation leads to a picture of an inflationary multiverse consisting of 10^{1000} different types of exponentially large universes, the string-theory landscape.

If that picture is correct, then it is insufficient to find the fundamental theory. One must also determine in which of the 10^{1000} possible universes we live. Some people like this newly revealed

