

Statistical Mechanics: A Short Treatise

▶ Giovanni Gallavotti
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Statistical mechanics is a little more than a hundred years old. The foundational work was done by James Clerk Maxwell, Ludwig Boltzmann, and Josiah Willard Gibbs. The development of the field since then has been phenomenal. Statistical mechanics played an essential role in the beginnings of quantum theory (with Max Planck and Albert Einstein), and its entropy concept has been central to the creation of information theory by Claude Shannon. In fact, the ideas of statistical mechanics appear unexpectedly in many areas of physics and pure mathematics. So writing a comprehensive treatise of statistical mechanics seems at present to be a superhuman enterprise. What, then, does Giovanni Gallavotti mean when he proposes to us his "short treatise"?

The prospective reader should first be told what this book is not. It is not application oriented. It does not display rules and techniques for the solution of problems that occur in practice. It does not, for instance, have a list of definitions of critical exponents. In fact, it has basically nothing about renormalization group or critical points. While Gallavotti himself has done important work using the renormalization group, this is not what he chooses to discuss here. Then what?

The "short treatise" is a conceptual (one might almost say ideological) presentation of statistical mechanics. It is not very mathematical, stresses ideas rather than proofs, and is ideally suited to learning rapidly the difficult principles of the subject. I would see it most useful as a second book after a basic introduction.

Equilibrium and nonequilibrium are discussed, and the historical dimension is not forgotten. (Gallavotti shows that he has studied the writings of Boltzmann and others in depth.) The reader thus gets a competent evaluation of what is known and what is not known. For example Gallavotti explains (p. 108) that "very important phenomena, such as the liquid-gas transition or the crystal-liquid transition, are not really understood." Apparently, the thermodynamic functions have essential singularities at phase transitions, and one has to give up the theory of "metastable states" for short-range interactions, although metastability occurs as a

dynamical phenomenon (p. 206). These facts are known to the experts, but it is good to have them plainly stated in an accessible text.

Part of the charm and interest of Gallavotti's book is in the way he relates Boltzmann's ideas to modern concepts. Boltzmann's ideology was discrete rather than continuous, and Gallavotti quotes Boltzmann, for example: "The concepts of differential and integral calculus separated from any atomistic idea are truly metaphysical, if by this we mean, following an appropriate definition of Mach, that we have forgotten how we acquired them." (See p. 140 for further Boltzmann quotations.) Thus, phase space should be a finite set, and time evolution should give rise to periodic orbits. One can see how such ideas could (and did) infuriate some mathematicians. But Gallavotti shows (for instance in appendix 9.A3) how Boltzmann got the physics right.

Most of this "short treatise" deals with equilibrium statistical mechanics and allows the reader with a reasonable background to see what is currently known about phase transitions and coexistence of phases. The last chapter, however, is on nonequilibrium and puts this subject in a very modern perspective. Stated succinctly, the modern view is that chaotic microscopic dynamics is essential for nonequilibrium. In more mathematical words, positivity of the entropy production requires "hyperbolicity" of the underlying dynamics. Therefore, the older approaches to nonequilibrium, which did not take into account the chaotic dynamics, missed an essential fact. This may explain why the study of nonequilibrium has progressed so slowly compared with that of equilibrium. The "chaotic hypothesis" developed by Gallavotti and his colleague Ezekiel Cohen has been central to the new developments. As in the rest of the book, this last chapter insists on the ideas, basic formalism, and history, and leaves out most of the mathematics.

Gallavotti has written a somewhat ideological and quite personal book. Certainly one may disagree with him on some issues. But he has expert knowledge of what he discusses and also of many things he chooses not to discuss. And since he also knows the history of the subject, his opinion must be taken seriously. We may thus thank Gallavotti for giving us a fresh, authoritative, and readable introduction to a fundamental area of conceptual physics.

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Modern Introductory Physics

▶ C. H. Holbrow, J. N. Lloyd,
and J. C. Amato
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Some time ago, I came across a set of notes on approximation techniques useful in physics. They were so clear, well-motivated, and literate, I wanted permission to give copies to my students. In tracing them to Colgate University, I learned that they were part of the relativity chapter in a textbook being developed there for an innovative, one-semester, introductory physics course. I remember hoping that the book would be completed quickly, because it looked like such a welcome change of pace. It is now out as *Modern Introductory Physics* by Charles H. Holbrow, James N. Lloyd, and Joseph C. Amato. Recalling that earlier brush, I happily agreed to review it. In brief, the book is a delight and, for the correct audience, it will be very successful.

I wish that I could reproduce the authors' preface; it is hard to summarize the thinking that went into this effort. I recommend that teachers of introductory physics read it or the authors' more extended description (with E. Jose Galvez) in the *American Journal of Physics* volume 63, 1078, 1995. Although this is a book for likely physics majors (and other students you'd like to lure into the major), it represents somewhat of a return to the liberal arts tradition in that it is written to be read, and it respects the student's intelligence. And by avoiding simply repeating high-school material at a higher level, it offers a more enticing entrée to the college-level curriculum.

The book follows a single story line: the physics of the atom and how it was discovered. This allows coverage of much material included in the typical year-long introductory course and more 20th-century physics than usually fits in even a two-semester course. And there are nice applications, telling, for example, how ink-jet printers steer blobs of ink or how scanning tunneling microscopes work. While the book is not explicitly part of the IUPP (Introductory University Physics Project), the authors have done a fine job of implementing the project's principles.

Many of the book's stylistic features stimulate engagement and comprehension. First, a sense of intelligent inquiry permeates the book.