books

Condensed-matter physics: new field, new text

States of Matter

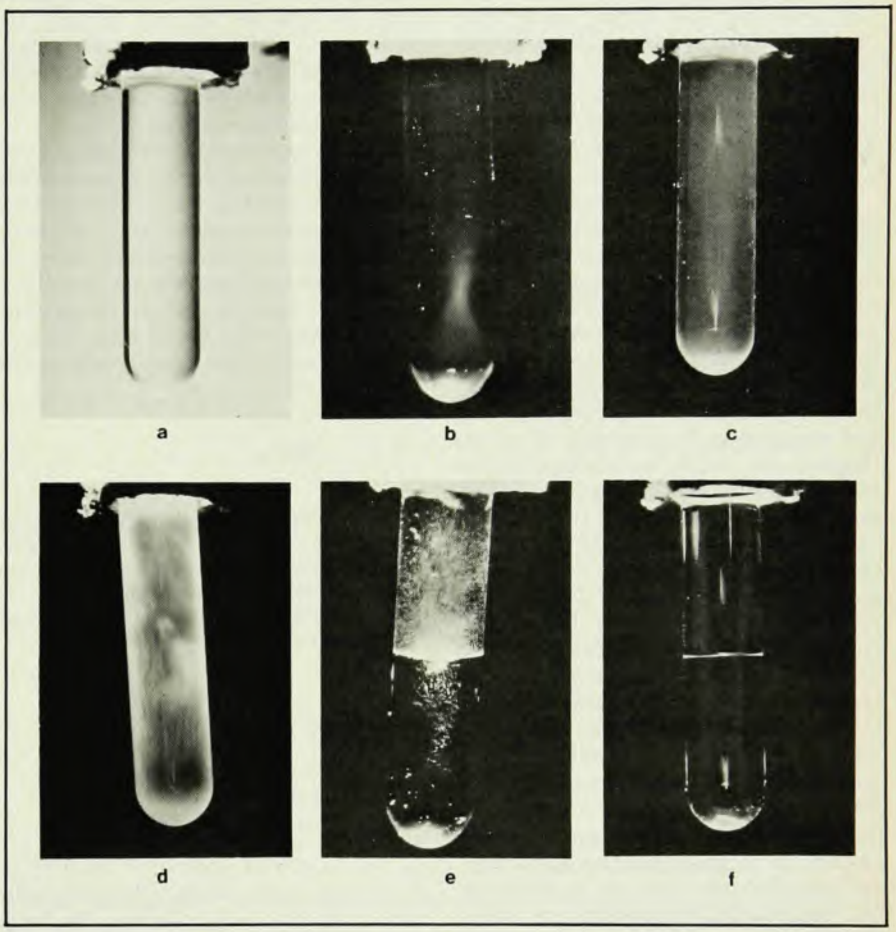
D. L. Goodstein
500 pp. Prentice-Hall, Englewood Cliffs, N.J., 1975. $23.95

Reviewed by H. Eugene Stanley

The opening lines of this book are a Dantesque admonition to all who enter: "Ludwig Boltzmann, who spent much of his life studying statistical mechanics, died in 1906, by his own hand. Paul Ehrenfest, carrying on the work, died similarly in 1933. Now it is our turn to study statistical mechanics."

David L. Goodstein's text is based on lectures given by the author in a first-year graduate course required of all students in applied physics at Cal Tech. Goodstein presumes that the students have a wide variety of undergraduate backgrounds, with only the rudiments of thermodynamics, electricity and magnetism, and quantum mechanics in common. Although care is given to conceptual foundations, the main emphasis is on providing the student with an appreciation for some of the recently solved problems in condensed matter physics. If Goodstein's goal were to provide an introduction to condensed-matter physics for nonspecialists, he could hardly have written a more readable text.

The first chapter summarizes essentials in thermodynamics and statistical mechanics relevant to an awareness of current work in condensed-matter physics. The style here is practical and down to earth, both in the treatment of fundamental ideas and in the emphasis on development of the student's facility with the manipulations necessary for calculations. For example, the chapter concludes with an appendix on the less than widely known mnemonic device known as the "thermodynamic square" (the author quips "You may find it necessary to make up your own mnemonic to remember the mnemonic."). One knows from the outset that this book is written by an experimentalist rather than a theorist. Goodstein proves, for instance, the positivity of the specific heat and susceptibility by consideration of a physical system with a movable partition; a theorist might instead have demonstrated that the two response functions were proportional to the squares of energy and magnetization fluctuations, respectively.



Critical opalescence in binary fluid mixture of cyclohexane–aniline at the critical temperature. Beginning at relatively high temperature (figures a and b), the mixture passes the critical stage in the middle of the sequence, when the opalescence phenomenon appears, after which the temperature drops to far below critical (figures e and f). Photos by H. E. Stanley, after R. A. Ferrell.

The essential meat of the book is in the following three chapters, each on one of three principal states of matter. Chapter 2 treats Bose–Einstein and Fermi–Dirac statistics in 50 pages and includes extensive discussions on such applications as Bose condensation and electrons in metals (the "very degenerate Fermi gas"). In the third chapter, Goodstein covers as much solid-state physics as most students can be expected to appreciate at an early stage of their training. There is essentially no discussion of space groups, semiconductors and most of the topics that make the typical solid-state physics text seem rather like an organic chemistry treatise. Rather, Goodstein's approach is to present first the general concepts, followed by a specific example worked out in detail, and finally some well chosen problems at the end of the chapter. Goodstein's style is also occasionally to interject light-hearted remarks, which keep the reader awake while studying rather tedious material. Thus in introducing the term "phonon," the author observes that this terminology "follows the convention of giving quantized entities names ending in -ons: photons, electrons, protons and so on. Even human populations have quantized units called persons."

Chapter 4, on liquids and interacting gases, represents the best attempt this reviewer has seen in *any* elementary textbook at extracting at least partial order from the chaos that comprises our current understanding of this primordial state of matter. The author, though not himself a theorist, does not shrink from using the full panoply of graph-theoretic expansions. Thus Goodstein does fair justice to the Yvon–Born–Green, hypernetted chain, and Percus–Yevich equations—topics about which most workers in condensed-matter physics are all too ignorant. At the end of each chapter appears a bibliography, annotated in the same breezy style as the text; in this fourth chapter, the author leaves little doubt concerning his opinions of the "reasonably simple but seriously flawed" monograph by P. A. Egelstaff and the monograph *Statistical Mechanics of Simple Liquids* "about which nothing is as simple as the title seems to imply."

The two concluding chapters are more specialized in scope and perhaps will be omitted by those instructors who adopt this book for a one-quarter rather than a one-year course, or by those who wish to pursue the topics of the first four chapters somewhat more leisurely or in greater depth. Chapter 5, "Some Special States," treats superfluidity, superconductivity, and magnetism; the concepts of earlier chapters are nicely exemplified in the discussion here. The fine sense of history remains omnipresent, and the reader is even led to speculate what was on the mind of Heike Kamerlingh–Onnes when he carried out his famous 1911 experiment that resulted in the discovery of superconductivity. The Curie constant and the Langevin function are both introduced in the same paragraph, and the author cannot resist noting that "Madame Curie was named correspondent in a celebrated divorce action taken against Paul Langevin." Perhaps a second edition will include a few pages on liquid crystals, or at least those aspects of liquid-crystal physics that can be treated in the framework of magnetism and superconductivity.

The sixth chapter provides an introduction to phase transitions between different states of matter and to phenomena that occur near "critical points," where the distinction between phases ceases to exist. Goodstein opens by whetting our appetites for simplicity: he presents the story of how G.I. Taylor was able, using dimensional analysis, to deduce the yield of the first nuclear explosion from a series of "Life" magazine photographs of the expanding fireball. He then proceeds to take us through standard material on mean-field theory, van der Waals theory, and Landau theory, before going on to a discussion of critical-point exponents and scaling laws. There is no mention of "universality" or of renormalization-group concepts, and in fact the entire chapter could probably have been written almost a decade ago. Nevertheless, it is welcome that a text on condensed-matter physics for first-year graduate students should include a coherent and highly readable introduction to the topic of phase transitions and critical phenomena.

States of Matter, then, is a unique book. It is unique in that it represents perhaps the first introductory text to paint—in broad brush strokes—a picture of what much of the current excitement in condensed-matter physics is all about. It is unique in that substantial historical perspective is woven into the text, courtesy of Judith Goodstein. It is unique in that the author has not resisted the temptation to allow in print the sort of light-hearted remarks that characterize most lectures but that usually are edited out of published material.

It is my opinion that every serious student of condensed-matter physics would do well to read this book. For the time being, however, students may have to do this on their own, because most universities, unlike Cal Tech, are not so enlightened as to have recognized the need to structure curricula along lines recognizably different from those of one or two decades ago.

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Nuclear Structure

W. F. Hornyak
605 pp. Academic, New York, 1975.
$49.50

For some years, Morris Preston's *Nuclear Physics* was probably the most widely used general nuclear-physics textbook in the United States. Suddenly, in the last few years, a number of new and comprehensive textbooks on nuclear physics have proliferated, including three multi-volume sets by Walter Greiner and Judah Eisenberg, Aage Bohr and Ben Mottelson, and Amos de Shalit and Herman Feshbach. This situation accurately reflects the significant progress made in the field in the 1960's and early 1970's (the correlation between the publication rate and the decline in financial support of nuclear physics is noteworthy). Now another addition to the list of nuclear textbooks has appeared, *Nuclear Structure* by William F. Hornyak. Hornyak, a member of the physics faculty of the University of Maryland, has pursued his research interests primarily in experimental nuclear spectroscopy in light nuclei, in particular in p-shell nuclei.

As the title implies, Hornyak's book deals only with nuclear-structure physics, whereas the sets listed above include both nuclear structure and nuclear reactions. The organization of *Nuclear Structure* is quite conventional. We inspect, in order, the nucleon–nucleon force, bulk nuclear properties (shapes, moments, total binding energies), microscopic models of nuclear structure, collective models, and finally electromagnetic and weak interactions in nuclei. Hornyak's approach is to treat a few basic topics in considerable detail; he tries to avoid the "it can be shown . . ." route.

The volume is in some sense a workbook: there are numerous exercises interspersed with the text, and Hornyak deals with simple models which have analytic solutions. This makes good pedagogical sense, and as a result there are a number of sections of the book that will be particularly useful to those who must, for the first time, plow through Slater determinants, exchange operators, vector spherical harmonics and so forth.

In the preface, Hornyak acknowledges that his approach may appear old-fashioned, with some of the "newer techniques" omitted. Several such omitted topics are second quantization, Brueckner–Hartree–Fock theory, the theory of effective residual operators and pairing theory. I would think that when a student has taken a graduate-level course in nuclear structure, he should have some possibility of being able to understand the current literature in nuclear-structure physics and some facility with the common tools of the field. These omitted topics are essential to this end.

The most significant drawback to *Nuclear Structure* is its price, almost twice that of the volume on nuclear structure in the de Shalit and Feshbach series. For this reason alone, *Nuclear Structure* seems destined for the library reference shelf.

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Computers for Spectroscopists

R. A. G. Carrington, ed.
275 pp. Halsted, New York, 1974. $35.00

In *Computers for Spectroscopists*, twelve different articles by various authors deal with the problems of computer usage. All the authors are members of the Ultraviolet Spectrometry Group, an organization of long standing that includes most of the experimental spectroscopists active in electronic spectroscopy in British laboratories.