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Fundamentals of Condensed Matter and Crystalline Physics: An Introduction for Students of Physics and Materials Science FREE

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An introduction that blends hard and soft condensed matter

Fundamentals of Condensed Matter and Crystalline Physics

An Introduction for Students of Physics and Materials Science

David L. Sidebottom
Cambridge U. Press, New York, 2012.
$75.00 (398 pp.).
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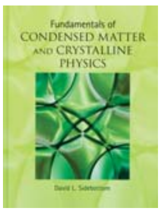
Reviewed by Ivan Smalyukh

A number of advanced condensed-matter textbooks give adequate coverage to soft-matter physics, in recognition of the prominent role that subfield has played in recent decades. The most notable of those is Paul Chaikin and Tom Lubensky's *Principles of Condensed Matter Physics* (Cambridge University Press, 1995; reviewed in PHYSICS TODAY, November 1995, page 82). Along with other textbooks, it provides a fantastic resource for graduate students, who can nowadays take a balanced course that covers soft and hard condensed matter.



At the undergraduate level, however, most textbooks focus on the solid state. The few that do address soft matter at the appropriate level focus exclusively on it—they include Ian Hamley's *Introduction to Soft Matter: Synthetic and Biological Self-Assembling Materials* (Wiley, 2007) and Linda Hirst's *Fundamentals of Soft Matter Science* (CRC Press, 2013). And unfortunately, only a few large universities offer separate undergraduate solid-state and soft-matter courses on a regular basis. As a result, introductory condensed-matter courses, especially in small schools, typically lack a soft-matter component.

That may change with David Sidebottom's *Fundamentals of Condensed Matter and Crystalline Physics: An Introduction for Students of Physics and Materials Science*. Largely inspired by Charles Kittel's classic *Introduction to Solid State Physics* (8th edition, Wiley, 2005), Sidebottom's text combines two seemingly different condensed-matter subjects into a single, coherent, one-semester course. The author, a professor at Creighton University in Nebraska, blends the condensed-matter topics in a manner that blurs the distinction between soft and hard parts.

That's a novel idea. Potentially, this book will modernize the undergraduate condensed-matter physics course by introducing more of the soft-matter component. Moreover, it might inspire lecturers to teach the subject from a perspective of unifying physical concepts rather than following historical developments. It remains to be seen how successful such an approach will be at facilitating students' understanding of the material.

The book's organization clearly shows that the same concepts and experimental techniques are relevant for crystalline, mesophasic, and amorphous materials. Part 1 of the book—the first four chapters—focuses on the structure of matter, including crystal lattices and Bravais lattices; amorphous matter; van der Waals forces; covalent and ionic bonds; and dia-, para-, and ferromagnetic materials. Part 2 focuses on scattering; its four chapters cover general theory and scattering by crystals, by amorphous matter, and by polymers and liquid crystals. Part 3 addresses physical concepts of dynamics, with six chapters describing density fluctuations in liquid, crystal vibrations and phonons, thermal properties, the free-electron model, electron band theory and Mott transitions, and the response of matter to deformations. The four chapters of part 4, the final section, discuss conventional phase transitions and critical phenomena, percolation, mean-field theory, and superconductivity. Each chapter in the book provides 5–10 exercises that are intended to help students digest the material and develop problem-solving skills.

It would have been extremely instructive if, in the structure section, the author had systematically discussed ordering by going from hard condensed matter to soft condensed matter. He could have begun with solid crystals and their perfect three-dimensional positional and orientational ordering. He then could have introduced various forms of liquid crystalline ordering and explained how various degrees of positional ordering are lost as one goes from crystal perfection, to columnar phases, to smectics, and finally to nematic phases.

Also, since the book covers such a wide variety of topics, the level of detail suffers a bit. For example, the discussion of polymers makes no reference to the important concepts of persistence or Kuhn lengths. It also does not discuss in any depth plastic crystals, in which orientational ordering is lost but positional ordering survives. Those concepts, and corrections to some minor errors, will hopefully be considered for subsequent editions.

Overall, though, *Fundamentals of Condensed Matter and Crystalline Physics* succeeds at covering many fundamental concepts of solid-state and soft-matter physics and at combining them in an approachable manner. If only one undergraduate elective course slot is available for solid-state and soft matter, this text is clearly the best available option. It will also serve another important purpose: as a starting point for people who do not take such an undergraduate course.

Ivan Smalyukh is an assistant professor of physics at the University of Colorado Boulder. He is a soft-condensed-matter researcher and lecturer. His PhD student, Julian Evans, provided helpful feedback on the book under review.

Atoms in Intense Laser Fields

C. J. Joachain, N. J. Kylstra, and R. M. Potvliege
Cambridge U. Press, New York, 2012.
$135.00 (568 pp.).
ISBN 978-0-521-79301-8

Research on intense laser interactions in atoms owes its growth primarily to three breakthroughs: the development of short-pulse, high-energy lasers; the discovery of extreme nonlinear ionization; and the discovery of the vacuum ultraviolet (VUV) light production that occurs when the magnitude of an optical field approaches that of the fields that bind electrons in atoms. The past