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book reviews

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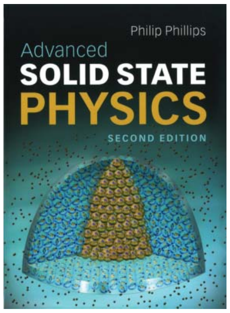

Advanced Solid State Physics. By Philip Phillips. Pp. 402. 2nd ed. Cambridge University Press, 2012. Price (hardcover) GBP 45.00. ISBN 978-0-521-19490-7.

There are many excellent books giving an introduction to solid state physics. This book on advanced topics is in many ways different from traditional books within this field. It has an excellent mixture between modern and traditional topics, with emphasis on strongly correlated phenomena. The topics range from interacting electron gases, local magnetic moments, the Kondo effect and plasmons, through topics like bosonization, electron-lattice interaction, superconductivity and disordered phenomena, to quantum phase transitions, the quantum Hall effect, topological insulators and 'Mottness', a term introduced by the author for the non-rigidity of Mott bands.

The presentation of the material is fresh and modern, always with a look at overarching phenomena and concepts. It was an excellent idea to start the book with an introductory chapter (Chapter 1, 9 pages) about general concepts in condensed matter physics. The student is made aware from the very outset of the importance of symmetry and the fundamental process of spontaneous symmetry breaking. Such a start is not standard for solid state physics textbooks, and it sets the tone right from the beginning: this textbook is more about physical concepts than about mathematical rigor. The introductory sections on symmetry breaking are matched with a brief, in fact a bit too brief, discussion of the phenomenon of emergence, which will feature so prominently later in the book. Modern understanding of the phenomenon of emergent symmetries is formulated in terms of effective low-energy theories, which are determined by the symmetry and topology of zero modes of the quantum vacuum. It would be very exciting to see in future editions parts of section 1.3, *Beyond broken symmetry*, upgraded into an additional section, *Emergence*, introducing the student at this point to the new components emerging at low energy: bosonic collective modes of the quantum vacuum, fermionic excitations forming quasiparticles and topological excitations. The antipodal concepts of spontaneous symmetry breaking and of emergent symmetry should really be presented on the same footing.

Chapters 2–6 (40 pages) deal with an introduction to traditional solid state physics in a nutshell. This includes chapters about non-interacting and interacting electron gases, the Born–Oppenheimer approximation, second quantization, and the Hartree–Fock approximation. Given the advanced nature of the textbook, these chapters are brief and sketchy, and assume that the student is already familiar with these topics. A short digression on Wigner solids fits well into the scope of the book, stressing local physics.

The main part of the textbook (Chapters 7–16, 348 pages) deals with advanced topics in solid state physics. The strength of the book lies in those subjects that typically are only briefly touched upon in traditional condensed matter textbooks. Chapters 7 and 8 (64 pages) introduce local magnetic moments and Kondo physics in metals. Here a healthy balance has been found that presents all the basic methods and concepts in a compact and not too technical form. Green's functions are introduced (even the correct grammatical construction 'the Green function' is explained), complemented with the Lehmann representation (here the name is incorrectly written 'Lehman'), Friedel's sum rule, Luttinger's theorem, the Anderson model and poor man's scaling, and the relation between the Anderson model and the Kondo model is elucidated.

In Chapters 9 and 10 (54 pages), screening of charges, plasmons and Luttinger liquids are discussed in detail (with a short surprising digression into the stopping power of a plasma). Methods like the use of collective coordinates, bosonization and linear response are introduced in a compact form, which is of great teaching value.

There follows a presentation of electron–phonon interactions in solids, Fermi liquid theory and the BCS theory of superconductivity in Chapters 11 and 12 (89 pages). These two chapters are rather conventional in presentation and content, leaving out newer developments, and do not touch upon the question of electronic correlations. Polarons are skipped over in the same way as unconventional pairing, or strong coupling superconductivity, which would have fitted well with the rest of the book, which stresses interactions and correlated electron states. A short discourse on Ginzburg–Landau theory (interestingly, the book chooses the German transliteration 'Ginsburg') is followed by coverage of BCS theory, following largely the classical treatment in Schrieffer's book.

In the next chapters follow theories on localization (Chapter 13, 30 pages), quantum phase transitions (Chapter 14, 26 pages), topological matter (Chapter 15, 34 pages) and Mott–Hubbard physics (Chapter 16, 46 pages). These are similarly exciting presentations to Chapters 7–10 and are exemplary for a short and concise introduction to these modern branches of physics. In particular the last two chapters make the textbook a valuable choice, as they are presenting topics at the forefront of current research, not covered yet in other textbooks.

The presentation of the subjects is very pleasing, with important formulas in gray boxes, simple illustrations and instructive tables. Numerous exercises help to deepen the understanding and give additional background on modern developments like, for example, graphene. There are pleasantly short lists of references after each chapter, such that the student is not lost in a plethora of literature.

At places the elegant and intuitive presentation is slightly at the cost of precise statements and clarity. Selected examples are the discussion of Goldstone modes in the introduction, where a bit more rigor in the formulation would be to the benefit of students (the theorem holds in the non-relativistic case only for sufficiently short-ranged interactions); an unfortunate typo in equation (3.5) and Fig. 3.1 (the order of magnitude should read $10^{-1}a$ instead of $10^{-4}a$); the paragraph after equation (3.30), which is not particularly enlightening; the introductory paragraph of Chapter 9, which is also not tremendously elucidating; and the statement that non-interacting quasiparticles with infinite lifetime in the normal state are a crucial assumption for BCS theory, which makes it sound like an obstacle for having superconductivity in diffusive metals. However, it should be clear from the beginning that this is not a textbook that one chooses to learn condensed matter theory for the first time. The emphasis is on the broad picture, not on the detail. Thus, the lack of clarity here and there is outweighed by the inspiring presentation of the subjects using simple model calculations and intuitive arguments. For the reader who looks for inspiration rather than formal rigor this is the right choice.

The targeted audience is the graduate student who has already pre-knowledge in elementary solid state physics and many-body physics. It is an ideal textbook for getting acquainted with the most important methods and concepts in modern condensed matter physics, and an excellent basis for getting an overview before moving on to deeper studies using more specialized books.

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