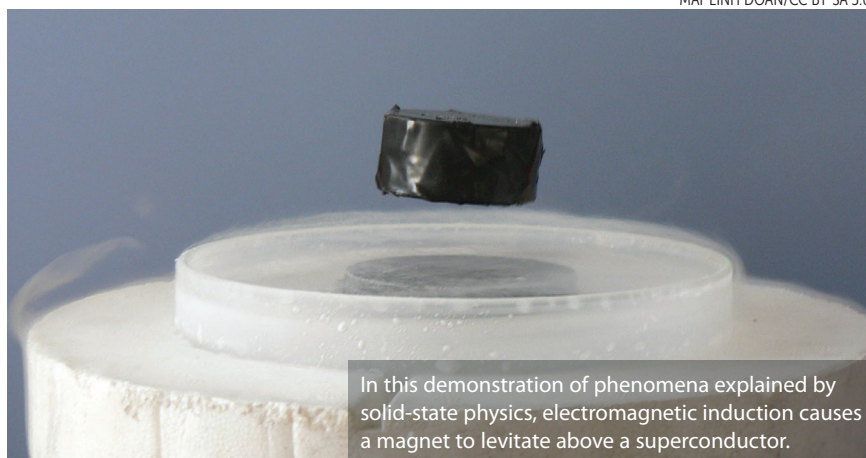




In this demonstration of phenomena explained by solid-state physics, electromagnetic induction causes a magnet to levitate above a superconductor.

An interdisciplinary approach to solid-state physics

Although solid-state physics has evolved into a highly interdisciplinary field, it is typically taught differently by physicists, chemists, and engineers. *Quantum Theory of Materials*, a new graduate-level textbook on the physics of crystalline solids, attempts to bridge varying approaches and provide a comprehensive picture for that broad audience.

Written by two leaders in the field, Efthimios Kaxiras and John Joannopoulos, the book features a clear exposition of solid-state physics' fundamental theoretical principles, an excellent account of modern computational approaches and applications, and a first-rate introduction to modern topological concepts and their role in shaping the dynamics of Bloch electrons. Because of the authors' clarity, focus on basic principles, and thoughtful choice of examples, *Quantum Theory of Materials* serves as a top-notch introduction to solid-state physics not only for physicists but also for chemists, engineers, and materials scientists.

Solids are complex many-body systems, but their properties are often explained by single-particle or quasiparticle models. In *Quantum Theory of Materials*, the authors discuss with pedagogical clarity the physical principles behind that major simplification without going into complicated technical details. They then describe the emergence of collective excitations, such as excitons, phonons, plasmons, and magnons, and explore the essential effects of the interactions between those collective

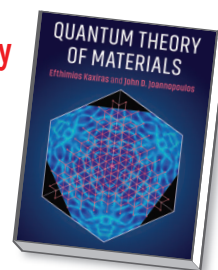
excitations and quasiparticles. One of those effects—superconductivity—is outlined elegantly in the text.

The chapter on electron dynamics and topological constraints differentiates the book from most existing textbooks because the most important developments in those subfields occurred in the past three decades. It gives a nice pedagogical introduction to the important role played in condensed-matter physics by Berry phases and such related concepts as curvature, connection, and Chern numbers. Similarly, it discusses the role of those concepts in the quantum Hall effect, the microscopic theory of dielectric polarization, and the emerging field of Dirac materials.

Quantum Theory of Materials is a welcome addition to the current crop of solid-state physics textbooks. It has a slightly more advanced mathematical level than the classic *Solid State Physics* (1976) by Neil Ashcroft and N. David Mermin, and it includes significant new material that was not available when that text was written. Modern concepts such as Berry phases and related notions are included in some recent graduate-level textbooks, such as *Fundamentals of Condensed Matter Physics* (2016) by Marvin Cohen and Steven Louie and *Solid State Physics* (2nd ed., 2013) by Giuseppe Grosso and Giuseppe Pastori Parravicini, but those two excellent textbooks require knowledge of more advanced mathematics and are specifically tailored for physicists.

Quantum Theory of Materials

Efthimios Kaxiras
and John D.
Joannopoulos
Cambridge U. Press,
2019. \$89.99



Unlike the aforementioned books, *Quantum Theory of Materials* provides a comprehensive treatment of the subject that is appropriate for a wide interdisciplinary audience. For example, it covers group theory and symmetry in more detail than most solid-state-physics textbooks. Those topics are usually presented in more specialized physics classes, but they are often ignored in engineering and chemistry.

At the same time, the text includes a useful introductory chapter explaining how chemical bonds relate to atomic properties and how vastly different materials result from various bonding interactions. That is a popular subject in chemistry but often receives little attention in physics. Similarly, physicists often use the more abstract formulation of electronic structure theory in reciprocal space, whereas chemists use the more intuitive orbital formulation in real space. The close interrelation of the two approaches is stressed throughout the book.

Every chapter is supplemented by well-chosen problems to help readers better understand the subject. The appendices include concise overviews of basic background material, including mathematical tools and essential concepts from classical electrodynamics, quantum mechanics, thermodynamics, and statistical mechanics.

It is impossible to cover all the important facets of a discipline as diverse as condensed-matter physics in a single textbook. Notably, Kaxiras and Joannopoulos chose not to discuss the effects of disorder on material properties or include an introduction to the physics of liquids and glasses. Those topics would be of interest to the book's audience, and the authors should think about adding such a chapter in a future edition. Nevertheless, *Quantum Theory of Materials* will likely be widely adopted at many universities.

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