

authorial effort rules out any hope of communicating the science underlying Einstein's position on quantum mechanics. *Einstein's Greatest Mistake* devotes no time to explaining Einstein's seminal work on light quanta and the quantum theory of specific heat. According to Walther Nernst in 1910, Einstein's quantum hypothesis was "probably the strangest thing ever thought up. If correct, it opens entirely new roads ... for molecular theories."

Bodanis seems to have gone a step beyond the famous warning that one's readership is divided in half for each equation in the text. He has an aversion to terminology that *sounds* mathematical. Even the term "acceleration" appears to be a bit technical in his view. In presenting the famous thought experiment in which people in an elevator cannot distinguish undergoing uniform acceleration at g in empty space from being on Earth's surface weighed down by gravity, Bodanis describes the riders as having a "tug pulling them along ... of the right intensity." That kind of

vague language doesn't generate better understanding.

There are also outright problems with some of the book's physics. Here is one example likely to upset physicists: "If mass were simply magnified by the factor of the speed of light ... it would produce a tremendous amount of energy." No, it wouldn't; it would produce some amount of momentum (the units of mc), which will be "big" or "small" depending on what is a relevant momentum scale for comparison. A valid point can be made here about mass-energy conversion, but it has to be stated more carefully.

The purely biographical part of the book is pleasant in the main, but nothing stands out. Although *Einstein's Greatest Mistake* was never intended to be an Einstein biography for physicists or science geeks, neither can I recommend it to a humanist friend who wants to get a sense of the major concepts in Einstein's work.

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Introduction to Many-Body Physics

Piers Coleman

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The goal of quantum many-body physics is to understand the emergent properties—probed by thermodynamic, spectroscopic, and linear response functions—of a system of many interacting particles. As early as the 1950s, the methods of quantum field theory were applied to quantum fluids of fermions and bosons. Those efforts culminated in 1957 in the Bardeen-Cooper-Schrieffer (BCS) theory of superconductivity. In 1963 Alexei Abrikosov, Lev Gor'kov, and Igor Dzyaloshinskii wrote their classic book *Methods of Quantum Field Theory in Statistical Physics* (Prentice-Hall) on the use of Feynman diagrams to attack many-body problems at finite temperature. Terse but full of insights, the book had an enormous impact and is still used by practitioners.

However, the field has advanced tremendously since the 1960s. Subsequent decades saw great progress in ad-

ressing new many-body systems—such as those exhibiting the Kondo effect, disordered systems, superfluid helium-3, and unconventional superconductors—and the development of new tools, such as functional integrals and the renormalization group. Students and instructors of quantum many-body physics need an updated, modern textbook that covers those developments. *Introduction to Many-Body Physics*, a new book by Piers Coleman, successfully fills the need. Coleman, an eminent condensed-matter theorist at Rutgers University, covers his subject with pedagogical flair and attention to detail.

The book, which assumes the reader has no more than a knowledge of first-year graduate quantum mechanics, has two central aims. The first is to introduce a variety of techniques in many-body physics. The second is to illustrate

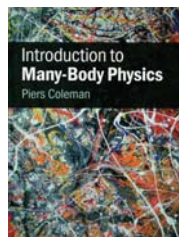
the power of these techniques using detailed examples from condensed-matter physics.

Coleman seems keenly aware of a common problem with many-body textbooks: Readers, especially newcomers to the field, tend to get overwhelmed by the mathematics and lose sight of important physical ideas. To ensure that does not happen, he discusses the phenomenology and experimental background for each topic and even includes a bit of history. He also includes plots of experimental data that serve to motivate the theory or illustrate tests of theoretical predictions. Coleman makes excellent use of color illustrations to illuminate qualitative ideas and, at regular intervals, emphasizes important results by highlighting them in boxes or tables. Experienced researchers might find some of the derivations overly lengthy, but beginning graduate students will benefit greatly from the level of detail. Students will also find the many solved examples and exercise problems useful.

Introduction to Many-Body Physics is more than 800 pages long and thus is able to provide wide-ranging coverage of topics central to the field. The book skillfully matches theoretical concepts with experimental probes. For example, the chapter on linear response successfully emphasizes the connection between theoretical correlation functions and observable consequences like photoemission, neutron scattering, and optical conductivity.

Two chapters in the middle of the book develop key phenomenological ideas. One of them focuses on Ginzburg-Landau theory and does a marvelous job of introducing the ideas of broken symmetry, phase rigidity, topological defects, and the Anderson-Higgs mechanism. The other carefully explains phenomenological aspects of Landau's Fermi liquid theory, but has little discussion of its microscopic formulation, which would have been of great value for students. Furthermore, the discussion of the T^2 resistivity arising from electron-electron interactions is somewhat misleading. The reader should have been warned that this mechanism by itself does not give rise to resistance, unless *umklapp* scattering or disorder degrades the momentum of electrons.

Later chapters of the book describe several topics in condensed-matter



physics. The first is itinerant magnetism, which Coleman uses to illustrate an application of functional integrals. Next come two chapters on superconductivity that cover weak coupling BCS theory, retardation effects, p -wave pairing in ^3He , and d -wave pairing in lattice models.

The final three chapters focus on the problems of local moments in metals and of heavy-fermion physics. Coleman has made pioneering contributions to those topics, and readers can gain much insight here. He even discusses the hotly debated possibility of topological Kondo insulator behavior in samarium hexaboride. However, the discussion of topological insulators is much too brief and readers will have to turn elsewhere for a deeper understanding of topological states of quantum matter.

Despite its length, *Introduction to Many-Body Physics* does not cover several topics that could be included in a modern many-body physics course. Among them are the Bogolyubov Bose gas, the superfluid-to-Mott insulator transition

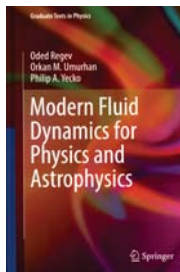
in the Bose–Hubbard model, and the BCS-to-BEC (Bose–Einstein condensation) crossover—all problems of great relevance to ultracold-atom experiments. Nor does Coleman discuss one-dimensional systems, the fractional quantum Hall effect, or numerical methods for many-body problems, all of which rightly deserve books of their own.

Coleman concludes *Introduction to Many-Body Physics* with a short but insightful epilogue in which he summarizes challenges for the future, including many-body problems that cannot be understood within the Landau paradigms of broken symmetry and well-defined quasiparticles with conventional quantum numbers. A reader who has mastered the material in this excellent book should be in a strong position to take on problems that have resisted conventional solutions.

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Modern Fluid Dynamics for Physics and Astrophysics

Oded Regev, Orkan M. Umurhan, and Philip A. Yecko
Springer, 2016. \$119.00 (680 pp.). ISBN 978-1-4939-3163-7



It is hard to disagree with the authors of *Modern Fluid Dynamics for Physics and Astrophysics* when they write in their preface that fluid dynamics is a topic often neglected in undergraduate and even graduate physics courses. However, for many physicists—astrophysicists in particular—the Navier–Stokes equations are as fundamental for their daily work as quantum mechanics. In my experience, it is the students themselves who often ask for fluid dynamics courses in their curriculum.

Unfortunately, there seems to be a widespread and incorrect impression that hydrodynamics is a subject with little ongoing research. But as authors Oded Regev, Orkan Umurhan, and Philip Yecko point out, turbulence and nonlinear fluid instabilities are very much active areas of contemporary research, ones that physicists have often delegated to engineers. As a consequence, the courses in which fluid dynamics is taught tend to rely on classic

textbooks such as *Fluid Mechanics* by Lev Landau and Evgeny Lifshitz (Pergamon Press, 1959) and *An Introduction to Fluid Dynamics* by George Batchelor (Cambridge University Press, 1967), which were first published more than half a century ago.

The textbook situation is a bit better in astronomy courses, in which fluid dynamics plays a fundamental role. Students and instructors can consult *Principles of Astrophysical Fluid Dynamics* by Cathie Clarke and Bob Carswell (Cambridge University Press, 2007) for a basic introduction aimed at undergraduates, and *Astrophysical Flows* by Jim Pringle and Andrew King (Cambridge University Press, 2007) for a more advanced approach that skips some fundamental concepts. When teaching fluid dynamics to undergraduates, I myself have often used the Clarke and Carswell book but always had to complement it with more

advanced material to provide a broader view of the subject.

Modern Fluid Dynamics for Physics and Astrophysics is a welcome addition that helps fill the gap between introductory and advanced books. It covers important basic concepts that Clarke and Carswell omit, such as the Reynolds transport theorem, and exciting advanced topics, such as nonlinear instabilities.

The textbook includes several examples of astrophysical and geophysical applications of fluid dynamics that help the reader to put the theoretical concepts into specific contexts. Accretion disks and gravity waves on water surfaces, for example, are discussed extensively. Simple polytropic models for stellar structure are also covered, although not as thoroughly; the teacher who is interested in that specific topic might want to consult additional resources. The book includes an extensive and useful discussion of turbulence. The final chapter on magnetohydrodynamics is also particularly valuable, especially for astronomy students.

I did feel that numerical methods deserved a more comprehensive treatment than they received. Although the authors acknowledge that numerical methods are an important area of research in modern fluid dynamics, they only discuss them in a small, six-page appendix. That appendix concentrates on grid-based methods and neglects particle-based methods such as smoothed particle hydrodynamics, which are common in astrophysics.

The textbook is especially suited for graduate courses, but I believe that it can also be easily used for senior undergraduate courses. Given the breadth of the material covered, however, a typical one-semester undergraduate course might do well to concentrate on a few selected topics from the book.

In general, I find *Modern Fluid Dynamics for Physics and Astrophysics* to be a very good resource, not just for astrophysics and geophysics courses but for any physics course that covers the fundamental topic of fluid dynamics. Hopefully, this valuable book will help inspire physics departments to give fluid dynamics the role it deserves in the education of young physicists.

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