

Particle physics is a difficult subject to cover in a textbook. It has a long history, and as is true throughout physics, new discoveries are still being made. Furthermore, that particle physics is based on rich mathematics makes it impossible to describe without, for example, group theory. The discipline is grounded in quantum field theory, which students seldom take before encountering a particle-physics course. The author must develop an abridged version so as to convey the science.

I would recommend Thomson's text to any physicist interested in learning the subject. It contains excellent physical explanations that help make it useful as a self-study guide or for a year-long course. The excellent mix of theory and phenomenology requires that the chapters be consumed in sequence. That makes the book less suitable for a one-semester undergraduate physics course with time for only a few selected topics. However, it would still be a very useful companion text for such a course.

Many authors start with a historical treatment, beginning with J. J. Thomson's discovery of the electron in 1897. But author Mark Thomson forgoes the historical route to present the material more coherently. After a short overview of the standard model of particle physics, he delves into how particles interact with matter and provides a short description of the different detector technologies used in modern experiments. The nod to detectors is a nice addition, given that many similar texts do not discuss experimental issues at all. But I would have liked to see it expanded to include a discussion of how experimentalists use triggers, collect data, and re-create tracks to enable physics analyses. The book goes on to cover aspects of the standard model, based almost exclusively on tree-level (lowest perturbative order) properties. Only in a few places where higher-order loop effects are crucial are they discussed, which is perfectly reasonable for a book at the level the author is shooting for.

Throughout the text, just enough mathematics is introduced to facilitate the presentation of theory and phenomenology. Thomson has an excellent ability to explain physics and pull it out of the math. For instance, starting with perturbation theory he motivates the use of Feynman diagrams, usually derived from path integrals. Later, he uses helicity amplitudes to evaluate matrix elements. A practitioner would usually not do the calculation in that way, but

Thomson uses it to elucidate some of the physical aspects that would be hidden in the standard trace formalism (which he introduces in an optional section). A less successful explanation is given for the Higgs mechanism, in which the Lagrangians that suddenly appear increase the complexity and cloud the physics for the initiate.

Thomson has experience in different experimental collaborations, including the ATLAS experiment at CERN's Large Hadron Collider and the Long-Baseline Neutrino Facility. Clearly his professional interests influenced the text, which focuses on the important topics of weak interactions, *CP* (charge conjugation plus parity) violation, and neutrino oscillations. He dedicates a short section to the Higgs discovery and also includes a discussion of the theoretical necessity for the Higgs mechanism to break electroweak symmetry.

It is surprising that *Modern Particle Physics* provides no substantive discussion of precision electroweak physics, rare B decays, or top-quark physics—topics in Thomson's research portfolio. The author devotes a section to open questions in particle physics, but it's too short. I understand the pedagogical reasoning behind those choices, but given the current state of particle physics, I think it is particularly important for texts to develop physics beyond the standard model. All of the model's particle content has now been found, and yet mysteries remain. Given Thomson's excellent presentation of the material he covered, I would have liked to see his exposition of those puzzles as well.

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Wizards, Aliens, and Starships Physics and Math in Fantasy and Science Fiction

Charles L. Adler
Princeton U. Press, 2014. \$29.95
(378 pp.). ISBN 978-0-691-14715-4

Wizards, Aliens, and Starships: Physics and Math in Fantasy and Science Fiction is a fascinating book. As I started to read it, what immediately caught my attention was the passion and excitement that author Charles Adler instills in the text. I couldn't put it down.

Adler's goal is to explain the feasibility of some physics underlying popular works of science fiction and fantasy, in books and in films. His enthusiasm for

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the genre is evident from the start, where he dedicates his book to the celebrated science fiction author Poul Anderson.

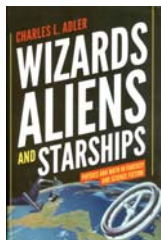
The book sets itself apart in the first few chapters with its discussion of the physics of the *Harry Potter* series. One of the first concepts he considers is the power of “disapparation,” the ability to vanish from one location and then reappear almost immediately someplace else. Adler compares that to the action of a transporter machine in the *Star Trek* series. He discusses how disapparation may violate various conservation laws. In addition, he points out, it requires the person to be killed then brought back to life elsewhere, which is “implausible.” He also considers the feasibility of that power in terms of the physics of quantum teleportation, superconductivity, and Bose–Einstein condensation.

A significant portion of *Wizards, Aliens, and Starships* is devoted to space travel and the question of whether it will be commonplace. To start the discussion, Adler reminds the reader of the many works on the theme, including the movie *2001: A Space Odyssey* and Ray Bradbury’s classic book, *The Martian Chronicles*. Adler confronts the reader with the realities of the high cost of space travel by alluding to the fundamentals of orbit mechanics and the rocket equation. In short, conventional space travel is extremely expensive—and it’s dangerous, too.

Adler also discusses how exploiting gravity slingshots or chaotic orbits can help conserve fuel during manned interplanetary space travel by conventional rockets. For the chaotic-orbits approach, he mentioned my work for Japan’s *Hiten* mission showing that harnessing chaotic orbits can save fuel, but at the cost of much slower travel.

Alternative space-travel methods are discussed, including the space elevator and exotic yet-to-be-developed propulsion systems. Adler goes even further, considering interstellar travel in the context of Albert Einstein’s theory of relativity. For a real mind bender, he even takes a look at faster-than-light travel and the weird realm of time travel, whose “grandfather paradox” has been studied by Kip Thorne and others.

The remainder of the book takes the reader on a wild ride, starting with the search for habitable planets and moving on to how we would communicate with aliens if we discovered they exist. To test the likelihood that advanced



alien civilizations are out there, Adler applies the Drake equation, based on a probabilistic argument used to estimate the number of active extraterrestrial civilizations in the Milky Way.

Adler brings some incredible concepts to life in his discussion of building artificial worlds, such as the one in Larry Niven’s classic *Ringworld*, about an enormous ring-like structure surrounding a star. Also discussed is Freeman Dyson’s “Dyson sphere,” which would surround the Sun or another star and capture energy. And Adler explores the feasibility of huge space colonies, such as those envisioned by Princeton University high-energy physicist Gerard O’Neill. The cost would be out of this world.

Accessible to anyone with knowledge of high school algebra and physics, *Wizards, Aliens, and Starships* is spellbinding and offers a totally unconventional way to study basic concepts in modern physics.

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atomic and molecular physics

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