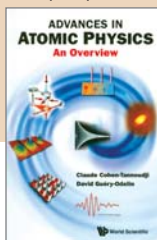


Atomic interactions in colorful detail

Advances in Atomic Physics

An Overview

Claude Cohen-Tannoudji and David Guéry-Odelin
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Reviewed by
Gordon Berry

French Nobel Prize-winning physicist Claude Cohen-Tannoudji is second to none in his understanding of the modern theory and application of atom-photon interactions. He is also known for his lucid and accessible writing style, as demonstrated by his lectures at the University of Paris and in such books as *Atom-Photon Interactions: Basic Processes and Applications* (Wiley, 1992), with his coauthors Jacques Dupont-Roc and Gilbert Grynberg. His technical mastery shines through in his most recent work, *Advances in Atomic Physics: An Overview*, which he co-wrote with his colleague, atomic physicist David Guéry-Odelin. And despite a few “Frenchisms” that show up here and there, the book is an otherwise excellent translation, which showcases the authors’ pedagogical skills.

The authors start by introducing the theory needed to describe the interactions of a few-level—typically 2 to 3—atom with a radiation field in semiclassical and quantum treatments. Their elegant presentation, which focuses on the linear and angular momentum conservation laws, sets the stage for the scenarios described in later chapters, which generally proceed chronologically. The book first explains the useful-

ness of lasers and other atom-photon interactions as sources of atomic information and then brings the reader up to date with some of the most fascinating and initially unexpected experimental results and detailed theoretical interpretations in cooled and very cold laser-trap physics. Cohen-Tannoudji has been a leader in those topics, and his expert hand is clearly seen in the book.

The sections on the physics of quantum correlations in entangled states and the many variants of Bose-Einstein condensation are thorough, and for me are the highlights of the text. Those presentations, especially, are helped by color diagrams, which appear throughout the book. After all, atomic and laser physicists are naturally attuned to using color in thinking about their research! For taking that approach, World Scientific deserves praise.

A few negative points about the book. Besides the aforementioned Frenchisms, I am a little surprised that the authors did not provide a detailed discussion or even a separate chapter on the exciting new links to quantum computing through entangled states. Perhaps that will be the topic of their next book. But my main objection with the book is that it does not, as its title suggests, fully cover the advances in atomic physics, particularly the ones made in the past 50 years or so.

In their introduction, the authors admit that the book “is necessarily biased by our better knowledge of the fields within which we have worked.” Indeed, it comes closer to an effective development on Cohen-Tannoudji’s earlier texts cowritten with Dupont-Roc and Grynberg, *Atom-Photon Interactions* and *Photons and Atoms: Introduction to Quantum Electrodynamics* (Wiley, 1989). Thus, this latest work should be more appropriately called *Atom-Photon Interactions: An Overview and Recent Advances*, making its limited scope clear.

For example, the book’s treatment of quantum beats and density operator descriptions of atomic coherence is limited to photon-atom interactions even though Ugo Fano and Joseph Macek, in a 1973 *Reviews of Modern Physics* article, developed a physical understanding of

atomic orientation, alignment, and higher-order atomic multipoles that has been applied fruitfully to other areas of atomic physics. Another example is the abbreviated discussion of our theoretical understanding of relativistic many-electron atoms; the corresponding calculations, which have tremendously advanced that understanding, are mentioned only peripherally when the authors describe atomic experiments to test parity violation and the measurement of nuclear anapole moments.

Who should read this book? Certainly researchers in the fields of atom-photon interactions and atom traps will want it as a reference on their bookshelves. At 700 pages, this mammoth book is too detailed for use in a US graduate course. However, a selection of chapters may be of benefit to students: the early chapters for those entering the field, the later chapters for those already doing atom-laser PhD thesis work.

For a course text, I recommend Dmitry Budker’s *Atomic Physics: An Exploration Through Problems and Solutions* (2nd edition, Oxford University Press, 2008); it explores more varied areas of atomic physics than does *Advances in Atomic Physics*. A text with a modern approach and good discussions of recent developments in condensed-matter theory is Walter Johnson’s *Atomic Structure Theory: Lectures on Atomic Physics* (Springer, 2007). Other important advances in atomic physics are presented in two texts published by Cambridge University Press: Lorenzo J. Curtis’s *Atomic Structure and Lifetimes: A Conceptual Approach* (2005) and Andrew Ellis, Miklos Feher, and Timothy Wright’s *Electronic and Photoelectron Spectroscopy: Fundamentals and Case Studies* (2011).

Despite some relatively minor drawbacks, *Advances in Atomic Physics* is an impressive and wonderful-to-read reference text. Readers will marvel at the recent progress in atom-photon physics, and I look forward to new miracles to come in this effervescent field. Atomic physicists have won the Nobel Prize in Physics every fourth year since Cohen-Tannoudji, Steven Chu, and William Phillips won it in 1997. Could 2013 be another atomic year?

Gordon Berry is a professor of physics at the University of Notre Dame in Notre Dame, Indiana. He has been an atomic spectroscopist since the late 1960s, mainly studying relativistic effects in few-electron heavy ions and using laser interactions to study fine, hyperfine, and quantum electrodynamic interactions in light atoms and ions.