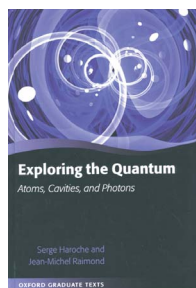


book. Haroche is a professor at the Collège de France, and Raimond is a professor at the University of Pierre and Marie Curie and at the University Institute of France. For many years the two have been at the forefront of the field of cavity quantum electrodynamics (QED), in which single photons and atoms are trapped and made to interact in intricate ways so that researchers can test and exploit some of the most puzzling aspects of quantum physics. What *Exploring the Quantum* shows is that the authors are also grand masters at telling us that story. Their monograph is a gem and a must-read for any student of quantum physics, from advanced undergraduate to expert.

Chapter 2 takes readers through a whirlwind pedagogical review of ideas and concepts. It covers considerable ground, from quantum interference to identical particles, from quantum entanglement to quantum teleportation, and from the quantum-classical boundary to quantum information. The chapter also teaches readers how to recast familiar two-state-system physics in terms of qubits manipulated by quantum gates and to represent that physics by quantum-circuit equivalents that become increasingly useful as the manipulation of atoms and fields becomes more elaborate. The authors' approach is indicative of the progression of quantum optics toward engineering applications and the increased influence of quantum information science on current developments in quantum optics. The old-timers among us optical physicists will be particularly fascinated by Haroche and Raimond's illustration of the quantum-circuit equivalent of a Mach-Zehnder interferometer (page 437).

The next two chapters, 3 and 4, discuss two-state systems, harmonic oscillators, and decoherence. The authors give much emphasis to the Jaynes-Cummings model of a two-state system coupled to a simple harmonic oscillator, and to the system's coupling to the environment. The problem is prominent in the rest of the book and is at the heart of quantum optics. Therefore, the chapters could easily form the basis of a short introductory course in quantum optics for advanced undergraduate or beginning graduate students.

In chapters 5 through 7, Haroche and Raimond guide us through a detailed tour of cavity QED—that area of atomic, molecular, and optical science that deals with the interaction between photons trapped in high- Q resonators



(photons in a box) and atoms, mostly the two-state variety. In about 200 pages, the authors take readers through topics ranging from superradiance and micromasers, to quantum gates, to multiparticle entanglement, to the life and death of Schrödinger cats. They also give many experimental details that emphasize the difficulty and elegance of the experimental work in the field and confirm the empirical law that the difficulty of an experiment is usually inversely related to the difficulty of the theory.

Not surprisingly, the book strongly reflects the personal interests and expertise of the authors; hence, the discussions of trapped ions, quantum degenerate atomic systems, and the potential applications of those systems in quantum information science are less detailed. Other emerging directions, such as circuit QED, are barely touched upon. Still, the close theoretical connections and comparisons between the various systems are clearly emphasized, and chapters 8 and 9 will certainly be useful as an introduction to students and researchers in those areas of quantum optics.

The authors state in their introduction that the text is intended for advanced undergraduate and graduate students. Although the material covered justifies their claim, the lack of problem sets may prevent the book from becoming a canonical text. Yet students at all levels, including advanced researchers, will certainly learn from it a great deal of exciting, modern physics, which the authors present in a way that builds clear bridges between quantum physics and quantum information science.

One criticism is that the index is not very detailed; it has the impression of having been added as an afterthought. I found it of little help in finding important key words and concepts in the text. But that flaw is essentially the only negative I have about this elegant and beautifully produced book. I have no doubt that Schrödinger would have loved *Exploring the Quantum*.

Pierre Meystre
University of Arizona
Tucson



materials science

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