BOOK REVIEWS

Selection of books for review is based on the editor's opinions regarding possible reader interest and on the availability of the book to the editor. Occasional selections may include books on topics somewhat peripheral to the subject matter ordinarily considered acceptable.

The Theory of Coherent Atomic Excitation

Author	Bruce Shore
Publisher	John Wiley & Sons, New York (1990)
Pages	1689 (2 volumes)
Price	$123.00
Reviewer	Thomas Speziale

Progress toward understanding the nature of light and its interactions has a long history and has been particularly rapid over the past century. One may regard the publication by Christiaan Huygens of his *Treatise on Light* (1690) as the birth of optics as a science. Huygens used that immature science to improve lenses. Since then, we have acquired extensive knowledge and powerful tools that allow us to use photons to manipulate matter and energy in ways that were heretofore impossible. This book offers us a most thorough accounting of the theoretical tools needed to engineer atoms with light.

The monochromatic and coherent nature of laser light makes it possible to probe and manipulate atoms directly and precisely. Examples of such processes include laser isotope separation, laser-controlled chemical processing, and advanced spectroscopic techniques, each of which utilizes custom-crafted lasers finely tuned to specific atomic or molecular energy levels to produce a desired effect. This text is a by-product of the Laser Isotope Separation Project at the Lawrence Livermore National Laboratory, one of the most ambitious projects ever to employ modern (quantum) optics. Such projects signify a maturing science.

Shore's two-volume text is appropriately designed for those who wish to acquire an understanding of the physics of coherent excitation and for those who would apply advanced optical techniques to atomic and molecular engineering. In short, it represents a very complete exposition of the theory of resonant excitation of atoms by radiation. Following is a synopsis of the book's contents.

Volume I, "Simple Atoms and Fields," deals with the resonant excitation of two-level atoms. Much of the material covered here overlaps many of the more familiar texts, including, for example, that of Sargent, Scully, and Lamb and, particularly, that of Allen and Eberly. Naturally, the emphasis in Shore's text differs from those earlier works, which covered laser physics. Volume II, "Multilevel Atoms and Incoherence," is devoted to three- and N-level atoms and overlaps little with existing texts. Coverage of coherent excitation progresses in an orderly and logical manner. Each section begins with a brief overview of its contents and includes its own list of references resulting in some repetition, while making the text useful as a resource for researchers. References are pertinent and well chosen.

Part I covers basic principles and definitions including fundamental notions of quantization and atomic excitation and reviews concepts of radiation, polarization, spectral analysis, and coherence. The introductory material also includes an extensive review of the field/atom interaction and introduces the concept of the Rabi atom. The author also strives to place the material covered in the rest of the text into physical context by examining appropriate scales of length and time.

Most of the essential elements for understanding the physics of coherent excitation is contained in Part II, which discusses the two-level atom in detail. Shore's treatment of the two-level atom is thorough and intuitive. He introduces the two-level atom employing semiclassical analysis and the widely used rotating wave approximation (RWA). A view toward multilevel atoms is maintained throughout. For example, analytic solutions in the RWA with loss are developed with the interpretation that losses are to other, unspecified atomic states. Chapter 4 is particularly interesting because it deals with situations for which the RWA is not applicable, such as when the fields are strong. That chapter includes discussions of Floquet theory and broadband excitation.

Shore also covers pulse-shape effects. The well-known hyperbolic secant pulse solution is presented along with exponential and chirped pulses. Even though many applications of the theory are likely to rely on numerical simulation for their solution (which Shore also discusses), it is useful to have analytic checks to ensure that the numerical analysis is correct, as well as to provide insight into the physics.

Also in Part II, the Heisenberg picture of the atom is developed and compared with the Schrodinger atom. Throughout the remaining text, these two pictures are compared to the extent that shifting from one to the other becomes intuitive and easy.

The third part of the text, "Photons and Radiation," introduces the concept of field quantization. Most of the material covered is standard, but the presentation is unusually complete. Contact with the subject of the text, coherent excitation, is maintained in a smooth and natural way. Moreover, our understanding of coherent atomic excitation is enhanced. Two chapters are devoted to examining the self-consistent interaction between the field and atomic excitation, including wave propagation. Were Shore to conclude his work at this point, we would most certainly still have a useful and valuable text, but he is just getting started.

Much of the material in the second volume has never before appeared in book form. Part IV, "Multistate Atoms," introduces three-level atoms building on results from the discussion of two-level atoms and includes population trapping and quantum beat effects. The global RWA is introduced along with other methods for solving the three- and N-level atom equations such as long-time averaging and the Laplace transform method.

Part IV also covers N-state ladders with solutions derived for special cases and particular kinds of state linkage patterns. Solutions for bounded and unbounded N are obtained for special cases. Discussions of multiphoton excitation, anharmonicity, and atomic beam deflection are noteworthy. Extension of the formalism is made to continuum processes for those situations involving ionization. Part IV concludes with coverage of radiative transitions and rate equations applicable to N-level atoms.

In order to deal effectively with more complicated structures, Part V, "Angular Momentum and Complex Atoms," offers an extensive review of the required quantum theory of angular momentum operators. With this foundation, Shore covers the excitation of degenerate systems and of fine and hyperfine states including branched excitation and Zeeman splitting.

The text concludes with Part VI, "Incoherence," aimed at determining when it is necessary to employ rate equations. Coverage includes discussion of the sources of incoherence including Doppler broadening, orientation effects, and collisions. The rate equation limit of the Schrödinger equation is derived, and various methods of dealing with fluctuations and interruptions are treated.

Finally, several appendixes are included covering mathematical topics, numerical analysis, classical Lagrangian mechanics, probability theory, and electromagnetism. A thorough index is provided at the end of Vol. II, although it would be desirable to have a copy of the index included in Volume I also.

In addition to the comments made in this necessarily brief overview, I offer the following observations. Overall, I am quite impressed with the completeness of coverage, both in the selection of topics and in their exposition. I am equally impressed with the author's skill in presenting the material in lucid terms and in his ability to keep the reader's attention focused on the main themes of the text.

The designated audience of the text is "physicists, optical scientists, spectroscopists, and physical chemists." I have no doubt that the book will prove an invaluable work for this group. The level of presentation is suitable for a graduate course, and I would recommend the book for such a course. The text covers much material in its nearly 1700 pages so that the instructor may need to exercise some selectivity in the topics to be covered. In terms of classroom use, the text would be enhanced by the inclusion of worked examples and exercises. All students will benefit from Shore's pedagogic style.

The author has succeeded in his endeavor to make the various parts of the book self-contained, including references. Many points are repeated when needed so that cross-referencing to previously covered material is minimized, but at the expense of somewhat greater bulk. This makes for more efficient and pleasurable reading while adding to the utility of the book for researchers.

We are entering a new era in applied optics, and Bruce Shore has succeeded admirably in presenting to us the tools of the trade that will be employed in that era. He tempts us with exciting possibilities. Laser isotope separation is one such application and receives coverage in the book, although this is done in only a few pages of fairly general discussion. I would like to have seen specific applications discussed in some detail, but I appreciate the constraints of time and space. Bruce Shore is to be congratulated for his fine work, and I recommend his book without reservation.

Thomas Speziale is a scientific specialist at the Idaho National Engineering Laboratory and directs the Advanced Concepts Program for the Department of Energy Office of Arms Control. He received his PhD from the University of Rochester, specializing in resonant laser-plasma interaction in support of the Laboratory for Laser Energetics. He taught and did research at the University of Arizona in the nuclear engineering department before joining the Theory Division at KMS Fusion, where he performed research in support of the fusion and SDI programs. He served as a technical leader upon joining the Physics Group at EG&G Idaho, conducted research in nuclear pumped lasers, and managed the Applied Physics and Analysis Section before moving into his present position in the Special Programs Group.

The Physics of Ionized Gases

Author	L. Tanovic
Publisher	Nova Science Publishers, Commack, New York (1989)
Pages	728
Price	$145.00
Reviewer	E. Bickford Hooper, Jr.

This book contains the Proceedings of the 14th Yugoslav Summer School and International Symposium on Physics of Ionized Gases (SPIG '88), held in Sarajevo, Yugoslavia, August 15–19, 1988. The meeting was attended by 172 participants from 25 countries. The editors separated the book into four sections. Space is lacking to fully describe the articles; perhaps a few that caught the attention of this reviewer can typify the collection for the reader.

1. *Atomic Collision Processes* (12 papers)—Smith has provided an excellent description of recent advances in the paper entitled, "Electron Impact Ionization of Ions Relevant to Fusion." Following a brief discussion identifying important impurities and their roles, data are presented comparing measurements of selected single ionization cross sections with Born and semiempirical formulas. Among the other papers