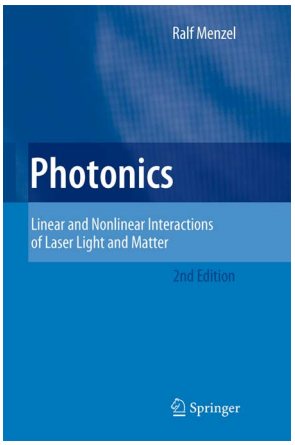
Book Review

Photonics: Linear and Nonlinear Interactions of Laser Light and Matter, 2nd Edition

Ralf Menzel, 1024 pages +xxiii, ISBN: 978–3–540–23160–8, illus., index, Springer, Berlin (2007), $119.00, hardcover.

Reviewed by Barry R. Masters, Visiting Scientist, Department of Biological Engineering, Massachusetts Institute of Technology, Fellow of SPIE and OSA. E-mail: bmasters@mit.edu



Photonics: Linear and Nonlinear Interactions of Laser Light and Matter is a concise handbook that contains the equations of linear and nonlinear interactions of light and matter. While these equations are described they are not derived as would occur in a textbook. The text presents the equations and qualitatively discusses the physical phenomena at an elementary level. The text is divided into the following sections: properties of light, linear interactions, nonlinear interactions without absorption, nonlinear interactions with absorption, lasers, and nonlinear spectroscopy. The latter half of the book is a 400-page listing of further readings and a bibliography that is keyed to each chapter. These selected references are cited with the names of all authors, the full title, and the page numbers. The text is amply supplemented with well-designed figures that illustrate the physics. In addition, the text provides a large number of tables that contain useful experimental data. Unfortunately the author did not provide the citation and the primary source for the data contained in the tables so that the values can be checked.

The integrative theme of *Photonics* may be instrumentation and the techniques for the measurement of linear and nonlinear phenomena related to light interactions with atoms and molecules. For the experimentalist working in the laboratory the question often arises: how do I measure a particular property or phenomenon? I think this book is a reference that may prove useful in such cases. The author admits that the wide range of topics in *Photonics* (the table of contents comprises 13 pages) can present difficulties for the reader to locate a topic, and the author has attempted to ameliorate this problem by greatly expanding the index. This solution is partly successful. I would suggest that the inclusion of a table that lists experimental techniques and the relevant papers, in contrast to the current list of all the tables, would increase the utility of this reference book.

The projected audience for this book is intended to be graduate students; predominately they majored in the fields of physics, chemistry, or electrical engineering. While *Photonics* is definitely not a textbook due to its wide scope of topics and its lack of detailed derivations and explanations, it can serve as a useful reference book for the researcher investigating light-matter interactions. I state this with the caveat that the cited monographs and original peer-reviewed publications are studied. The intended audience can include those individuals who have not studied advanced mathematics and quantum mechanics. Since many clinicians and biologists may not be sufficiently prepared to study a more advanced book on photonics, the relaxation of the above requirements may fulfill the need for a reference book at an elementary or intermediate level and thus explain the lack of advanced treatments of the topics.

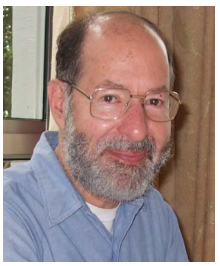
To test the usefulness of the index, I looked up the following terms: Kramers-Kronig relation, Kaska's rule, coherent anti-Stokes Raman scattering (CARS), surface-enhanced Raman spectroscopy (SERS), and mode-locking. One page was listed in the index for the Kramers-Kronig relation. Unfortunately, the sentences on that page do not explain the Kramers-Kronig relation, but instead the text cites two books. One sentence states that in linear optics if the real part or the imaginary part of the complex susceptibility is known for all frequencies, then the corresponding part can be determined. When I looked up the term Kasha's rule I was more successful. Not only did the text state that usually the fluorescence from a molecule occurs from the first excited singlet state (S1); but more importantly it cited the exceptions to the rule. The rule is not observed with short pulses in the subnanosecond or femtosecond range. The text also gives the interesting case of azulene molecules that emit from the second excited singlet state (S2). The index entry for CARS was more problematic. Two-and-a-half pages are devoted to CARS and BOX CARS; there is a state energy diagram, a diagram of CARS phase matching, and a diagram of phase matching in BOX CARS. The author places all of the CARS references (30) within a single bracket without any discussion. Therefore it is impossible for the reader to obtain any sense of either priority in the development of CARS, nor of the connections among these publications. The recent important developments in CARS microscopy together with that entire field of publications are not contained in *Photonics*. In fact, perusal of the index and the complete table of contents indicates an absence of the applications of photonics to microscopy. *Photonics* devotes two short paragraphs to the topics of SERS. This cursory treatment is totally inadequate in a reference book with the title *Photonics*, since SERS is a very active area of photonics research as evidenced by the growing number of publications and citations on SERS.

When I looked up the term mode-locking in the index there were several subentries that spanned several pages of the book with a detailed discussion of a variety of techniques. The latter example is consistent with the page allocation in the book; the topic of lasers is given one-third of the text, which may reflect the interest of the author. These examples are illustrative of the cursory treatment of many of the topics that are listed in the extensive index and lead the reviewer to question the value of such brief treatments of specific topics. Perhaps it would be more helpful to reduce the number of topics that are cited in the reference book and to treat those topics in a more comprehensive manner.

A strength of *Photonics* is its use as a reference book for theoretical and experimental aspects of lasers with an emphasis on experimental laser spectroscopy. Anyone using lasers should be familiar with transverse and longitudinal modes, resonators, mode-locking, and the generation of picosecond and femtosecond pulses, and *Photonics* is an excellent reference for these topics. Additionally, there are extensive tables of the typical properties of commercial lasers. However, there are very brief sections on pulse compression that do not adequately cover the experimental techniques; typically the exposition is very abbreviated and references are cited.

A major problem exists with a reference book that contains the key equations that are related to many topics contained in *Photonics*. In the absence of the detailed mathematical derivations of the equations, and a clear citing of the approximations and physical assumptions that are used in the derivations, the reader cannot accurately assess the physical limitations of the equations.

I examined the other sections of this reference book for ease of use, depth of explanation, and utility, and here are my conclusions. The author, a highly experienced researcher and educator in the fields of lasers and laser spectroscopy, made a decision in the design of this reference book: in order to keep the book to a reasonable size, the emphasis is placed on a wide range of theoretical and experimental topics, with a minimal amount of rigorous mathematical treatment and qualitative physical assessment of the fundamental physics. The net result is that the book would not be suitable for teaching a course on the topic of photonics, but it serves as a useful reference for the key formulas, experimental setups, important references, and experimental data. The fact that the reader must refer to the original papers cited in the bibliography is a major limitation; nevertheless, for those readers who are familiar with the fundamental physics of lasers and laser-light interactions, *Photonics* provides a practical summary of the field. Potential readers who are interested in the subject of photonics, yet do not have the skills of advanced mathematics and quantum mechanics, will find *Photonics* to be a good introduction to the subject at the elementary level.



Professor Barry R. Masters is a visiting scientist, in the Department of Biological Engineering at the Massachusetts Institute of Technology, and was formerly a professor in anatomy at the Uniformed Services University of the Health Sciences. He is a fellow of both the Optical Society of America and SPIE. Professor Masters has published 80 refereed research papers and 110 book chapters. He is the editor or author of: *Noninvasive Diagnostic Techniques in Ophthalmology; Medical Optical Tomography: Functional Imaging and Monitoring; Selected Papers on Confocal Microscopy; Selected Papers on Optical Low-Coherence Reflectometry and Tomography; Selected Papers on Multiphoton Excitation Microscopy; Confocal Microscopy and Multiphoton Excitation Microscopy: the Genesis of Live Cell Imaging;* and (with Peter So) *Handbook of Biomedical Nonlinear Optical Microscopy*. Professor Masters is a member of the editorial board of three journals: *Computerized Medical Imaging and Graphics; Graefes Archive for Clinical and Experimental Ophthalmology*, and *Ophthalmic Research*. His research interests include the development of *in vivo* microscopy of the human eye and skin and the fractal analysis of branching vascular patterns.