DEPARTMENTS

BOOK REVIEWS

Practical Volume Holography

R. R. A. Syms, 399 pages, illus., index, references, and two appendixes. Number 24 in the Oxford Engineering Science Series. ISBN 0-19-856191-1 Oxford University Press, Walton Street, Oxford OX2 6DP, U.K. (1990) $98 hardbound.

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Since the earliest days, holographers have blamed many of the limitations of the technology on the characteristics of the materials used for recording and reconstruction. In fact, it has not often been clear whether those limitations were in the material characteristics or in the physics of the diffraction of light in thick or volume media (thick enough that Bragg selection effects must be considered). When I first met Dr. Laszlo Solymar in the late 1970s he described an ambitious plan to account for the fate of "every photon that enters a thick hologram." Over the following years, and with the help of a talented group of graduate students, a succession of elegant experiments and mathematical analyses has more or less accomplished this goal, at least for some important basic cases. This progress has been chronicled in a series of papers from the Holography Group at Oxford University and in two books, of which R. R. A. Syms's *Practical Volume Holography* is the latest and most comprehensive.

Although the term "volume holography" is meant to distinguish this subject from thin, especially embossed, holograms, much holographic work involves layers thick enough to have to be considered as "volume holograms," so the topic is of very general interest within the field. The book is clearly and appropriately organized, with good introductory content, an overview of mathematical theories of diffraction by thick holograms, descriptions of the diagnostic experiments for the verification of those theories, a discussion of recording materials and how they modify the theories, a very good section on self-induced "noise gratings," an overview of applications, and a chapter on the application of these ideas to guided waves. Syms's own work emphasizes the theories of volume diffraction, the effects of noise gratings and his recent guided wave work (at Imperial College), and those chapters could serve as stand-alone monographs. But much of the value of the book is in its synopsis of the "lore" of the Oxford group, as many connections are drawn and references cited that are not often seen in U.S. discussions.

As an overview, it is a bit thin and uncritical in places (in some of the materials and processing discussion, for example). To laud such a bleach component as para-benzoquinone without mention of its extreme hazards (it has caused more harm to holographers than any other chemical in my experience) is no longer acceptable. The very important and worrisome issue of the stability of processed volume holograms is not addressed beyond a few remarks about printout (not the prime concern). The most important recent developments in commercial holography have had as much to do with the technology of mass production (the subject of Chapter 12) as with new materials, but many key issues are neglected. Also, the treatment of aberrations, which are very important in considering the reduction to practice of many of the ideas invoked, is very limited. The quality of these peripheral sections becomes a concern only because of the very high price per page of the volume.

The scientific core of the book, on the other hand, is clearly presented with a view toward the practical issues, as promised by the title. It is in this sense more accessible than the otherwise similar 1981 *Volume Holography and Volume Gratings* by Solymar and Cooke. The complications of the simple "Kogelnik-style" approach when one considers diffraction efficiencies and complex grating structures of practical importance occasion many pages of analysis. The author guides the reader through the conflicting claims of several analytical approaches and arrives at methods that correlate well with the data generated by the Oxford group. But this approach, although rich in insight, is only a beginning. Over the next few years, these elegant analytical methods will be complemented by more brute-force numerical simulation methods made possible by the inexorable progress of digital computing, and made necessary by the departure of grating structures of interest from the idealized models that are tractable by analytical methods, the classic dilemma of mathematical physics!

The treatment is extended to multiple gratings in a single hologram, probably the key step from simple theories to working holograms. The emphasis is on the resulting diffraction efficiency of any component grating, but in most cases a more pressing question is the degree of cross-diffraction, which produces a haze of "intermodulation noise" in pictorial holograms. It is often the signal-to-noise ratio that is more limiting than the signal level itself. This remains a current topic in holography research, and Syms's treatment provides a useful background for further progress.

Chapter 8, on noise gratings, should be especially widely read because, left to themselves, these parasitic holograms would scatter most of the light from desired diffraction orders in many applications.

The book is amply and clearly illustrated with diagrams and data plots. There is an attractive silver-halide hologram on the cover, although it is not correlated with the discussion inside, and its clarity is compromised by the rough texture of the surface to which it has been laminated. There is a wealth of references that are nicely cited in the text. Two hundred and twenty-three of them have appeared since January 1984; that is, within five years of manuscript completion. In that sense, it serves as a useful update to Hariharan's 1984 *Optical Holography,* the previous "important book" in holography.

Practical Volume Holography will be an important addition to every scientific and engineering holographer's bookshelf. The mathematical level will discourage the journeyman holographer, although there is much to be gleaned in the way of practical notes. It seems to be intended for those who need a quantitative sense of what is going on or a deepened physical insight into diffraction that can provide a foundation for further research. Like a careful audit of our own bank balances, it provides a reassuring account of where the photons do indeed go, even if we don't much like the answer.

The Elements of Nonlinear Optics

P. N. Butcher and D. Cotter, 344 pages, illus., index, bibliography and ten appendixes. ISBN 0-521-34183-3. University of Cambridge, 40 West 20th Street, New York, NY 10011 (1990) $49.50 hardbound.

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At last, the contents of P. N. Butcher's excellent monograph *Nonlinear Optical Phenomena*[1] have become available again. That monograph was the only place I could find comprehensible explanations of symmetry in nonlinear optics and of the repeated use of commutators of the interaction Hamiltonian to derive nonlinear optical susceptibilities. Other sorely needed contributions represented in this new monograph are a careful accounting of the integer multiplicative factors that go with the susceptibilities and how these factors differ in degenerate and nondegenerate processes and an explanation of the relationship between the hated (by me) cgs units and the SI units used throughout the book. I do wish, however, that the back cover did not claim that the book could be the basis of a master's level course. The treatment is quite abstract and, to a beginning student, maybe a little dry; there is very little discussion of experiments until the end of the book where semiconductor nonlinearities are described. As a supplement to a more straightforward treatment, it would be very valuable. The points that are often glossed over in more elementary texts are explained carefully here.

After the introductory chapter, a general classical treatment of the constitutive relations is given. The third chapter is a bare bones, Schrodinger-equationless introduction to quantum mechanics for nonlinear optics with the density matrix. It is adequate for the purpose at hand—the derivation of susceptibilities from dipole matrix elements—but no more. On the one hand, it is good that the authors have resisted the temptation to do too much, but on the other hand the book suffers for basically ignoring some of the flashier applications such as nonlinear laser spectroscopy and squeezed states. The next chapter deals with the susceptibility tensors in the dipole approximation, using the famous trace method and introducing overall permutation symmetry. There are good treatments of local field corrections, two-photon resonant nonlinearities, and derivation of susceptibilities in terms of the current operators. Unfortunately, the incorrect single-sided Feynman diagrams are used. The fifth chapter repeats the treatment of symmetry from the original Ohio State University monograph. It is excellent. The sixth chapter deals with resonant two-level systems: the Feynman Vernon Hellwarth theory (without, alas, more than a mere mention of photon echoes), saturation of susceptibilities, optical Stark effect (done very beautifully), and reduction of multiphoton processes to equivalent two-level systems. The chapter on wave propagation and phase matching is standard (frequency doubling, etc.) except that it introduces group velocity dispersion right away to make the treatment of solitons at the end of the chapter easier. It includes a good discussion of phase matching in higher order processes such as third harmonic generation with Gaussian beams.

Semiconductor nonlinearity is chosen as the one physical system treated in any depth because, as explained in the preface, "first, semiconductors provide useful illustrations of many aspects from earlier chapters; second, in recent years there have been very significant advances in semiconductor materials and these are likely to remain of the greatest technological importance; and lastly, this reflects the current research interests of the authors." There are two chapters devoted to this topic. They start with a lightning fast introduction to solid state physics—probably too fast for a beginning student—and then follow up with a succinct discussion of most of the important features of absorption and the various nonlinearities, mostly interband and exciton effects. Finally, there is a short discussion of quantum wells and quantum dots.

In summary, this book cannot stand alone as an introductory text. There are important topics missing, and the complexity of the treatment is quite uneven and at times too much for a beginning student. Even so, because it fills a previously gaping void in the literature in the areas of symmetry, susceptibility derivation, and term counting, this book will make a very valuable addition to the library of anyone in the nonlinear optics field.

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[1]*Nonlinear Optical Phenomena,* P. N. Butcher, Bulletin 200, Engineering Experiment Station, Ohio State University (1965).

BOOKS RECEIVED

Experiments in the Machine Interpretation of Visual Motion, by David W. Murray and Bernard F. Buxton, 236 pp., illus., subject index, references. ISBN 0-262-13263-X. The MIT Press, 55 Hayward Street, Cambridge, MA 02142 (1990). $37.50 hardbound. Covers image scene and motion, computing image motion, structure and motion of edges, edges and surfaces, structure and motion of planes, visual motion segmentation, matching to edge models, and matching to planar surfaces.

Fundamentals of Optical Fiber Communication, by Wim van Etten and Jan van der Plaats, 407 pp., illus., subject index, references, appendix. ISBN 0-130-717513-2. Prentice Hall International Ltd, Englewood Cliffs, NJ 07632 (1991). $44.00 hardbound. Covers dispersion in the step index fiber, monomode fibers, propagation of light rays in multimode graded index fibers, dispersion in graded index fibers, modulation of semiconductor light sources, transfer characteristic and impulse responses of a fiber communication system, power launching coupling efficiency, receiver principles and signal-to-noise ratio in analog receivers, receivers for digital optical fiber communication systems, system noise, system components and design, and coherent optical fiber communication.

Fiber Optics, Communication, and other Applications, by Henry Zanger and Cynthia Zanger, 326 pp., illus., subject index, appendix. ISBN 0-675-20944-7. Macmillan Publishing Company, 445 Hutchinson Avenue, Columbus, OH 43235 (1991). Covers physics of light, principles of optics, fiber characteristics, principles of fiber optic communication, modulation, multiplexing, fiber optic components, optical sources for communication, optical detectors, and fiber optic communication systems.

Handbook of Laser Science and Technology; Supplement 1: Lasers, by Marvin J. Weber, 595 pp., illus., subject index, references. ISBN 0-8493-3506-X. CRC Press Inc., Lewis Publishers, 2000 Corporate Blvd. Boca Raton, FL 33431 (1991). $249.95 hardbound. Covers solid state lasers, liquid lasers, masers, laser safety, neutral gas lasers, ionized gas lasers, molecular gas lasers, nonlinear optical properties, radiation damage, special properties, thin films and coatings, and optical materials fabrication.

Wave Mechanics Applied to Semiconductor Heterostructures, by Gerald Bastard, 357 pp., illus., references, appendix following each chapter, ISBN 0-470-21708-1. Halsted Press, 605 Third Avenue, New York, NY 10158 (1988). $44.95 softbound. Covers idealized quantum wells and superlattices, band structure of bulk III-V compounds, envelope function description of heterostructure electronic states, coulombic bound states and interface defects in heterostructures, energy levels in modulation-doped heterostructures, electrical conductivity of quasi-bidimensional electron gases, optical properties of quasi-bidimensional systems, effect of static external electric and magnetic fields on the energy levels of quasi-bidimensional electron gases.