DEPARTMENTS

BOOK REVIEWS

Introduction to Fourier Optics, Second Edition

Joseph W. Goodman, 441 pages including appendices, bibliography, and index. ISBN 0-07-024254-2. McGraw-Hill, Inc., 11 West 19th Street, New York, 10011 (1996) $89.38 hardbound.

Reviewed by Steven C. Gustafson, University of Dayton, 300 College Park, Dayton, OH 45469-0150.

The bottom line: If you are a research-oriented optics professional, buy this book. It is the long-awaited second edition of Goodman's classic 1968 text (reissued as a McGraw-Hill classic in 1988), but it is more than a typical second edition. It contains a wealth of new or updated material (441 pages in the new edition versus 287 pages in the original) characterized by an inspired selection of topics and the manner and depth of their treatment.

The first six (of nine) chapters are very similar in content to the classic first edition. They cover two-dimensional Fourier analysis and sampling theory, the Kirchhoff and Rayleigh-Sommerfeld formulations of diffraction, the Fresnel and Fraunhofer approximations, the Fourier transforming properties of lenses, and the spatial frequency analysis of coherent and incoherent imaging. Two notable additions are discussions of space-frequency localization and an operator approach for analyzing complex coherent systems.

The last three chapters (270 of the 392 total chapter pages) contain much new material. These chapters cover wavefront modulation (including photographic film, *spatial light modulators*, and *diffractive optical elements*), analog optical information processing (including the VanderLugt filter, the *joint transform correlator, invariant pattern recognition, image restoration*, SAR data processing, *acousto-optic processing*, and *discrete analog optical processing*), and holography (including Gabor, Leith-Upatnieks, thick, and *computer generated holograms* and discussions of *multiplex and embossed holograms, photopolymer and photorefractive recording materials*, and applications such as *holographic data storage* and *holographic weights for artificial neural networks*). The above topics in italics are largely new to the second edition and are a delight to study—the topics selected, the approach chosen in discussing them, and the level of detail employed are remarkably satisfying.

Each chapter is followed by problems that, as in the original edition, provide further instruction or insight (and not merely rote reinforcement). The new edition has 118 such problems versus 68 in the original. The appendices cover delta functions and derivations of Fourier transform theorems and include two new appendices that review paraxial geometrical optics and polarization and Jones matrices. The book concludes with a bibliography of 305 entries (some as recent as 1995) and a serviceable index.

I have used the new edition (in manuscript form and with permission) to teach a graduate engineering course on linear systems and Fourier optics, and the experience was gratifying. One caution, however, concerns a statement in the book's introduction: ''The readers of this book are assumed at the start to have a solid foundation in Fourier analysis and linear systems theory . . . .'' I suggest that this statement be taken seriously. In conclusion, I refer enthusiastically to the first sentence of this review.

Laser Communications in Space

Stephen G. Lambert and William L. Casey, 390 pages, illustrations, index, bibliographical references, and one appendix. ISBN 0-89006-722-8. Artech House, Inc., 685 Canton Street, Norwood, MA 02062 (1995) $99 hardbound.

Reviewed by James R. Lesh, Jet Propulsion Laboratory, California Institute of Technology, M/S 161-135, 4800 Oak Grove Drive, Pasadena, CA 91109.

Laser communications was one of the applications soon recognized when the laser was invented in 1960. During the past 36 years, much laser communications development and demonstration work has been carried out in government laboratories and in industry, both in the U.S. and abroad. A significant portion of that work was performed at the Saint Louis facility of the McDonnell Douglas corporation. The authors of this book spent a significant portion of their careers working on laser communications at that facility. Although the development road has been rocky, the technology has reached a state where it is ripe, and the applications are plentiful. These applications not only include the traditional high-data-rate government and lower-data-rate long-distance deep space links, but the newly emerging commercial communications satellite networks and the scientific and commercial Earth remote sensing missions as well. Accordingly a comprehensive treatise on this subject would be of great benefit to the community at large. In the preface the authors claim they have written a book ''. . . which provides the necessary depth for the technically pure . . . '' and which ''. . . provides the top level aspects in a manner understandable by the nontechnical manager . . . .'' In the opinion of this reviewer, they have accomplished neither.

Generally, the book is poorly written, flits from topic to topic, repeats the same material many times (frequently in a very confusing manner), and often identifies the nouns for areas to which the reader must pay particular attention but does not describe the concept, what it means, or how the reader is supposed to handle it. Often times a concept is discussed without the use of any concept diagram to help the reader form a mental image. Their descriptions of systematic design procedures are presented in the form of ''watch me (based on my experience)'' without giving the reader any rationale for why certain design choices are made or what their implications will be in either similar, or different, applications. At a time when the applications base is explosively sprouting, it is very important that the users and the system designers become educated in the benefits and challenges of this important technology so they can embrace it more confidently. This book has been prepared in a style that sounds more like a proposal in response to a government solicitation, where the proposers (the authors in this case) are trying to show the reader that the field is so difficult that only they can make sense of it. This only serves to mystify the readers and clouds the real progress that has been made in the field.

The book is organized into 12 chapters and uses the ''peel the onion'' approach. The first chapter is a nine-page discussion

of the ''Past, Present and Future'' of laser satellite communications. The chapter rambles from topic to topic and often has vague, unsupported, and unreferenced statements like ''This study was conducted by one of the prime contractor teams.''

Chapter 2 is an 11-page discussion entitled ''Architecture and Applications.'' However, the first section is devoted to ''Why Lasercom.'' Generic and unsupported claims are made that will be hard for the novice to follow. The section on ''Architecture'' simply describes obvious tradespace procedures and adds nothing new. Section 2.3 then discusses satellite orbits around the Earth. The material is generic and provides nothing unique to the lasercom field. It does not calculate or even draw attention to important orbit parameters that impact the system designer such as link ranges, angular tracking rates, or point-ahead angle requirements. It even states (p.13) that an orbit must be inclined in order to be called geosynchronous. The final section on ''Applications'' simply brushes over the litany of LEO-LEO, LEO-GEO, etc. links, including links from space to air, ground, or submarine.

After two ''mini-chapters,'' the third chapter is an 83-page chapter entitled ''Systems Design Methodology.'' No design methodology is presented in this chapter! Instead, an entire set of descriptions of various aspects of lasercom systems is provided. A general top-level description of a lasercom transceiver is given in Sec. 3.1. A section entitled ''End-to-End Link Design,'' which is really an incomplete litany of the factors that must be considered when doing a link design is next, is followed by a section called ''Design Approaches.'' The design approaches section is simply an incomplete and often misleading discussion of different signal modulation types that can be employed.

A section on ''Design Trade Options'' is next. This section leads the reader to believe that one can trade acquisition for tracking, or communications for coalignment approaches. The next set of sections discusses lasers, detectors, isolation technology, beamsteering technology, acquisition, pointing and tracking, and communications technologies. The final section is on ''The Optical Link Equation'' but completely ignores the effects of noise, whether it be background, internal, or shot noise.

Chapter 4 covers ''Optical Design'' and discusses telescope gains, strehl ratios, telescope types, and the down-stream optics architectures for fine-beam acquisition and tracking. The chapter is generally better written than the previous ones. At times, however, material is presented in this chapter with no increased depth over that presented in Chap. 3. In the ''Receiver Gain'' section, the reader is referred to ''the equation in Chapter 3,'' but it is left to the reader to determine which of the 106 equations it is. The description of a Lyot stop is totally inadequate, defining it as ''. . . a stop that has the effect of rejecting light which may be reflected from portions of the tube, or edges of the primary mirror.'' Table 4.2 is not explained well. Also, this reviewer does not believe that common mounting structures or thermal control are ''imaging optics functions'' as is stated in Table 4.6. Section 4.6 (budget allocations and interfaces) does not appear to belong in this chapter.

Chapter 5 covers the communications receiver. It is totally inadequate from a communications point of view. It does not show the reader how to calculate the performance of any particular modulated signal set. All it does is calculate the required signal level needed to achieve some unspecified signal power level to noise power level for direct detection, amplified direct detection, and coherent reception. At two separate places in the chapter, ASE in an optical amplifier is defined as amplified ''stimulated'' emission, rather than amplified ''spontaneous'' emission.

The acquisition receiver is discussed in Chap. 6, and the tracking receiver is covered in Chap. 7. By segmenting Chaps. 5, 6, and 7 this way, the reader could easily conclude that separate receivers are needed for each of these functions, whereas in practice, the three are very intertwined. What the authors call ''pulse detection acquisition'' is really beacon detection when a CW beacon is either on all the time, or off all the time. The tone acquisition detection equations are repeated from Chap. 3, but no effort is made to connect them to thesystem parameters. The system configuration for the tone acquisition PLL is not specified. In the tracking receiver chapter, only the received signal and noise levels are calculated. No analysis of the design and performance of the tracking loop or its jitter suppression characteristics is presented.

Chapter 8 covers ''Key Technologies.'' The chapter makes for interesting reading but is of limited value. It mainly describes technologies that McDonnell Douglas used in the LCS system, a system that is not very practical by today's standards. Much of the chapter is covered very superficially. For example, the laser subsystem for the LCS is shown (Fig. 8.20) but its operation is not explained.

Chapter 9 is an attempt to walk the reader through a design example. The authors start off by stating that the trade space is so large that only the experienced designer can really do well. Next, they stress the importance of keeping the option tradespace open so as to not prematurely preclude a better solution. After saying this, they then proceed to make specific system choices, closing out those options, without any discussion of why those choices were made or what their implications would be. Performance results are frequently quoted without any justification. No block diagram is presented for the resulting system, and the required signal level analysis is extremely confusing (at one point discussing the tracking channel, then jumping to the communications channel, etc.). The discussion in Sec. 9.8.5 doesn't match the data in Fig 9.7.

Chapter 10, ''Trading RF and Laser Communications for Your System,'' was a delightful surprise in the book. It is not the usual ''my glimpse of the realities, or wishes, of the comparison trades,'' but is instead a very good description of a methodology for making such trades.

Size, weight, and power trends are covered in Chap. 11. The chapter is reasonably well written, although the authors seem to repeat themselves in the technology assumptions area. The trend information is well done and useful in a qualitative sense. However, the weight and power results of system 4 are misleading due to a formatting problem in Table 11.2, and the double curves in Figs. 11.4 to 11.9 are not explained.

The final chapter is yet another one entitled ''Laser Communications Applications.'' It is a reasonably good review of past lasercom applications, particularly the ones with which McDonnell Douglas has been involved. However, as the authors begin to discuss space-to-ground links, they begin (for the first time) to discuss the technical aspects of atmospheric effects on laser beams. This section is totally inad-

equate! Relevant atmospheric parameters are given by name, but the reader is referred to references listed at the end of the chapter to find out what the items are, and why they are significant. The chapter introduces the important parameter Cn^2, but does not adequately define what it is. Plots of Cn^2 are then given in Fig. 12.15, but there is no mention of how those curves should be interpreted or used by the reader.

Following the final chapter there is an appendix entitled ''Useful Formulas.'' Most of the first three pages are instead tables of physical constants. There are then two pages of optical formulas, although the explanations are often incomplete. Finally, there is a section called ''Useful Mathematical Expressions'' that is simply a brief summary of some high school level items from plane and solid geometry and contains such simple formulae as the area of a triangle and the circumference of a circle.

In summary, the authors have tried to produce a book that would address a disparate pair of users and have produced something that will be of little or no use to either. The book is poorly organized, poorly written, omits extremely relevant material, and duplicates (repeatedly) a number of others. Many of the claims are unsupported and the text is often confusing and contradictory. This book will not enlighten the uninformed, provide the perspective needed by management, or be a useful reference to the technically pure.

Laser Beam Mode Selection by Computer Generated Holograms

Victor Soifer and Mikhail Golub, 221 pages, illustrations, index, references, and four appendices. ISBN 0-8493-2476-9. CRC Press, Inc., 2000 Corporate Blvd. NW, Boca Raton, FL 33431 (1994) $66.95 hardbound.

Reviewed by Joseph N. Mait, U.S. Army Research Laboratory, AMSRL-SE-EO, 2800 Powder Mill Road, Adelphi, MD 20783-1145.

Over the past three decades computer-generated diffractive elements have advanced considerably from Adolf Lohmann's initial hand-drawn and photoreduced binary-amplitude elements to phase elements etched in glass with submicron features. As fabrication technology has improved, interest in the application of diffractive elements has increased and new applications are constantly being considered. Applications of thin diffractive elements can be broadly classified into analysis (gratings), aberration correction and beam shaping (Fresnel zone plates and their relatives), and arbitrary pattern generation (modulated gratings and diffuser-like structures).

The novel application of mode selection presented in the book *Laser Beam Mode Selection by Computer Generated Holograms* is a combination of the first two; that is, it combines beam shaping with analysis. The authors, Soifer and Golub, and their coworkers coin the term ''modan'' to describe the diffractive element that achieves mode selection and the book is a complete summary of their work on the modan.

In its most basic operation, a modan is a mode analyzer that generates a discrete array of spots, the complex wave-amplitude of which corresponds to the wave-amplitudes of the modes present in the illuminating beam. The modan can also be used as a mode synthesizer to generate a beam as the sum of weighted modes or as a mode filter to remove unwanted modes from a beam.

The first two chapters of the book lay the groundwork for modan design through a discussion of modes, modal decomposition, and diffractive design. However, the presentation of the material would be enhanced if the authors reversed Chaps. 1 and 2. Chapter 1 is a mathematical discussion of modes with little motivation or context. The authors first provide this perspective in Chap. 2. Chapter 3 is a discussion of the modan's operation as mode analyzer, mode selector, and mode filter. Performance and sensitivity analyses of the modan are presented in Chap. 4. Chapter 5 is a presentation of experimental results, and Chap. 6 is a discussion of the modan's application to fiber optic sensors and fiber optic communications.

By design, the intended audience of the book is small. The authors state in the preface that they hope to reach those interested in diffractive optics and those interested in fiber and laser systems. Unfortunately, the authors narrow the audience further through their presentation, which is lacking in explanation or clarification. Thus, the book cannot be recommended for the uninitiated graduate student and serves best the needs of the active researcher.

Nonetheless, due to the terseness of the presentation, the book is still difficult to read. This is further compounded by the fact that grammatical errors abound. Even a cursory proofreading of the manuscript by the publisher would have corrected the majority of these errors. Mathematical terms are not always defined and meaning is often unclear. Reading this book was like plowing 40 acres with a single mule and hitting a stone every linear foot.

However, the work is original and complete in its presentation from theory to experiment to practical application. The appearance of the book is also timely. It behooves any researcher in diffractive optics, laser design, fiber sensors, and fiber communications to be aware of this work by Soifer and Golub.

BOOKS RECEIVED

Automatic Extraction of Man-Made Objects from Aerial and Space Images, edited by Armin Gruen, Olaf Kuebler, and Peggy Agouris. 321 pp., illus., author index, references following each paper, list of workshop participants. Proceedings of the Centro Stefano Franciscini, Monte Verit, Ascona. ISBN 3-7643-5264-7. Birkhauser Verlag, P. O. Box 133, CH-4010, Basel, Switzerland (1995) hardbound. One of the objectives of this project was to combine the expertise of photogrammetry and computer vision groups, which in essence translates to supporting computer vision activities with the quantitative approaches of photogrammetry, including precise calibration methods and camera models and a general 3-D world and analysis concept.

Applications of Photonic Technology, edited by George A. Lampropoulos, Jacek Chrostowski, and Raymond M. Measures. xiv + 566 pp., illus., subject index, references following each paper. Proceedings of the International Conference on Applications of Photonic Technology, Sensing, Signal Processing, and Communications, Toronto, Ontario, Canada, June 21, 1994. ISBN 0-306-45011-9. Plenum Publishing Corp., 233 Spring Street, New York, NY 10013 (1995) $129.50 hardbound. Part I covers telecommunications. Part II discusses optical routing, computing, and processing. Part III is dedicated to optical measurements from space to industrial applications and electro-optical signal processing. Part IV reveals the broad potential for fiber optic sensing ranging from medical to structural monitoring. Part V shows various photonic components such as lasers, detectors, and integrated optics, including current research and development.

Semiconducting Transparent Thin Films, by H. L. Hartnagel, A. L. Dawar, A. K. Jain, C. Jagadish. x + 358 pp., illus., subject index, references following each chapter. ISBN 0-7503-0322-0. Institute of Physics Publishing, The Public Ledger Building, Suite 1035, Independence Square, Philadelphia, PA 19106 (1995) $180 hardbound. Deals with the properties, growth, and applications of semiconducting transparent thin films. Chapters cover: transparent conducting oxides, basic properties and growth techniques; electrical properties; optical properties; applications of transparent conducting oxide films.