

facts from a variety of fields were united to create a new science.

Gleick, a science writer for *The New York Times*, understands his subject and has a gift for simple, nonmathematical explanations that are accurate and insightful. *Chaos* is a scholarly book. Gleick's explanations of phase space and Poincaré sections should be read by all physicists. He has interviewed essentially everyone in the US who contributed to the development of the field, and he switches from discipline to discipline with apparent effortlessness. Even specialists may find that he has extended their knowledge of the boundaries of their fields.

Chaos is also a lively book, and one that is beautifully written. In fact, like any good novel, it is almost impossible to put down. Each chapter focuses on one or a few researchers and discusses their work as part of their lives. Some are fine musicians, some writers, some polymaths, some mountain-climbers. They all seem to share a love for art and culture that has allowed them to escape the restrictive patterns of thought that characterize their disciplines. Among this great range of personalities, as expected, some are attractive and some not. Gleick presents them fairly, without romanticization but always with respect. The portraits will ring true to those who know the subjects. The book is full of vignettes and stories that make both the scientists and the process of science come alive. The frustrations and setbacks are presented in as much detail as the triumphs. Particularly attractive is the chapter devoted to Edward Lorenz, the significance of whose work was not recognized for 15 years because of its extraordinary novelty.

To write a history of current events is a difficult task. It calls for evaluating the importance of individual pieces of research when their long-term significance is still unclear. This sort of judgment is very personal, and we agree with most of Gleick's choices. But we do have a few reservations. We would have liked to see a chapter on Hamiltonian chaos and on the contributions of the great Russian theorists Vladimir I. Arnol'd, Andrei N. Kolmogorov and R. L. Stratonovich. Though Gleick continually refers to the importance of Russian research, a sketch of one of these men and his work, even at second hand, would have rounded out the presentation. Neither the discoverers of fractals—Georg Cantor, Felix Hausdorff, Gaston Julia and Pierre Fatou—nor the important topic of pattern formation are sufficiently discussed. An

experimentalist will search in vain for a mention of Geoffrey Taylor, whose work inspired much of the current experimental research on hydrodynamic chaos. Overall, however, these are minor quibbles and it is the breadth and evenhandedness of Gleick's presentation that make a lasting impression.

Science books that are accurate, nontechnical and exciting are extremely rare. Gleick's book is worthwhile reading for every physicist, chaos specialist or not. It cogently addresses many of the problems, both scientific and philosophical, that face contemporary physics. Since it is eminently readable and uses no mathematics it would be an excellent text to use in a history or philosophy of science class to introduce nonspecialists to the excitement of physics. The illustrations are familiar but well chosen, and Gleick provides information allowing one to duplicate many of the basic computations on a home computer. One could scarcely ask for a better popularization of contemporary research. It will be interesting to look back in ten years to see how Gleick's judgments have fared.

Nonlinear Optics and Quantum Electronics

Max Schubert and
Bernd Wilhelmi

Wiley, New York, 1986. 726 pp.
\$59.95 hc ISBN 0-471-08807-2

From the early 1960s lasers have established a firm presence in science curricula. With the parallel development of nonlinear optics as an independent field of research, the need for a broad coverage of modern optical principles and techniques has become a major concern for both physics and engineering programs. Many of us can attest from experience that the selection of a balanced sequence of topics in a modern optics course can be a significant challenge. Many excellent textbooks tend to focus on selected subjects, so one often needs to meet the instructional goals with supplementary information derived from a variety of different sources. This is both time consuming for the teacher and a notable source of discomfort for students, who find themselves forced to integrate different books with different approaches, notations and methodologies.

Nonlinear Optics and Quantum Electronics by Max Schubert and Bernd Wilhelmi meets this well-defined need in optics curricula by spanning a wide range of modern

subjects systematically and authoritatively. This book is an outgrowth of lectures for advanced students at the Friedrich Schiller University in Jena, DDR. It is organized in two main sections, the first dealing with the formulation of the physical principles and mathematical techniques for describing the interaction of light and matter, the second devoted to numerous applications of current scientific and technological interest.

The subjects discussed in this book include phenomena for which the traditional classical or semiclassical techniques provide satisfactory approximations, but also topics for which nothing short of a fully quantum mechanical approach would be appropriate. One of the major strengths of this book is that the authors have succeeded in blending these techniques while stressing their relative merits and ranges of applicability. In fact some basic phenomena are described according to both semiclassical and quantum theories; while this strategy introduces a certain amount of redundancy, the repetition is in my opinion very valuable from a pedagogical point of view.

Nonlinear optics, by its very nature, requires consideration of vector and tensor quantities, among many other mathematical symbols. Some of the notations employed in this volume are somewhat unusual; however, they are not difficult to master, although I found myself consulting the table of notation and symbols more than a few times before reaching the end of the first chapter.

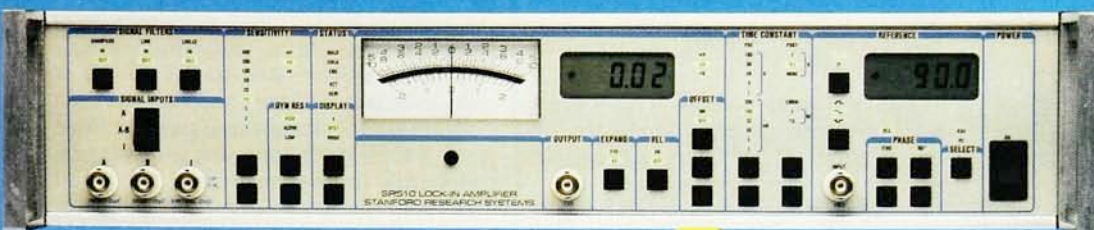
The section devoted to general concepts begins with a detailed description of classical electromagnetic fields in vacuum and in the presence of sources. The introduction of the susceptibilities for linear and nonlinear systems and the description of their symmetry properties follow traditional lines. The same can be said about the classical description of wave propagation in nonlinear optical media. What is most valuable in this chapter is its wealth of details and its completeness in providing the groundwork for much of the material developed in the following sections.

Chapters 2 and 3 deal with the quantum theory of the electromagnetic field and with the basic theory of the interaction of light and matter. These chapters form the basis for the microscopic derivation of the susceptibilities and for the introduction of the Bloch equations for the two-level atomic model in chapter 4.

Chapter 5 concerns the statistical properties of the electromagnetic field and the notion of coherence in

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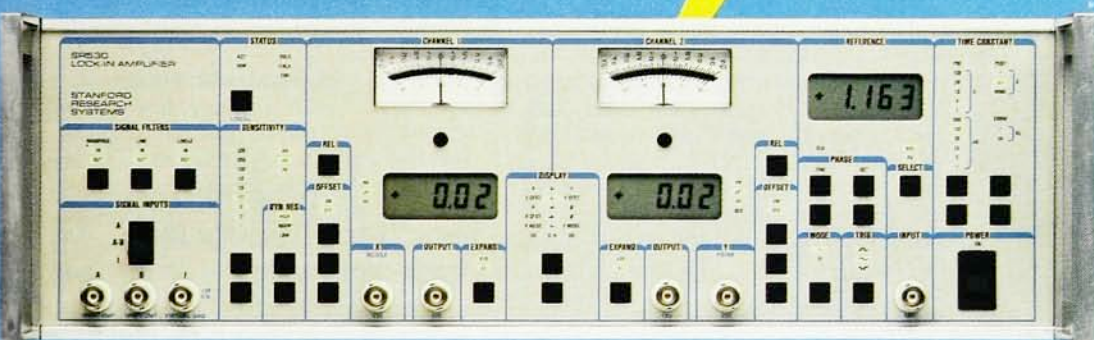
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both classical and quantum terms. The review of some of the classic measurements of photoelectron counting distributions forms a nice complement to the theoretical background.

The first section closes with a short survey of pulse propagation in nonlinear media. This includes resonant and nonresonant propagation and a brief mention of solitary pulses—too little to do justice to this growing subfield, but enough to provide the interested student with a launching pad.

The most successful part of the book, and the most interesting one from the point of view of applications, is the second. This is devoted to the development of the semiclassical and quantum mechanical models of the laser, including descriptions of noise, linewidth and fluctuations (chapter 7), to nonlinear propagation phenomena involving one-photon processes, coherent interactions and transient effects (chapter 8), and to a number of atom-field interaction processes that are more easily described in quantum mechanical terms, including resonance fluorescence, photon antibunching and superfluorescence (chapter 9).

Nonlinear optics in its traditional sense is taken up again in chapter 10, which contains a description of multiphoton absorption and emission, and in chapters 11 and 12 with discussions of the generation of harmonic, sum and difference frequencies; parametric amplification and oscillation; and stimulated Raman scattering. Optical bistability and phase conjugation are the subjects of the final two short chapters. An appendix with a compendium of quantum mechanical definitions and equations completes this impressive survey. The emphasis is mainly on the theoretical side, but the book contains in addition a number of useful illustrations of the main experimental facts.

In reviewing a volume of this size and scope it is appropriate to comment on the selection of topics and the unity of the presentation. I grant at the outset that the matter of selection is subjective to some extent: What may please one reader may displease another. I rank the selection of topics as outstanding and quite in line with the stated purpose of creating a useful teaching tool. In fact, many active researchers in modern optics also are likely to find this work a useful reference source. The treatment in the various chapters should also receive high marks, although some sections, understandably, are more successful and complete than others.

(For example, I find the discussion of optical bistability and phase conjugation quite sketchy, in spite of the wealth of background material assembled in previous chapters, which could have been used to deepen the presentation of these subjects.)

Numerous references appear at the end of each chapter; some important landmark papers have been left out (for example, the well-known theory of the laser amplifier by F. Tito Arecchi and Rodolfo Bonifacio, which appeared in 1965 in the *Journal of Quantum Electronics*, is not mentioned), but this is unavoidable and even understandable. The book is singularly devoid of misprints and awkward sentences; the authors and the publishers should be commended for their efforts.

A course in modern optics based on this book should be designed as a year-long sequence for American students with a traditional graduate background. A more advanced audience, however, may benefit also from exposure to selected topics from the second half of the book during a one-semester course, after an accelerated review of some introductory material. In either case this volume should be quite successful as a teaching tool and as a reference source for a number of years to come.

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Fearful Symmetry: The Search for Beauty in Modern Physics

Anthony Zee
Macmillan, New York, 1986.
322 pp. \$25.00 hc
ISBN 0-02-633430-5

This is a really lovely book. It is the story of how the idea of symmetry has led physicists in the 20th century to an ever clearer understanding of nature. The book is very well written—a rare feat for a popular science book. Its special feature is the obvious excitement Anthony Zee feels and communicates to the reader about advances in elementary-particle physics. With enthusiasm and much hindsight, he pictures an essentially straight road (though acknowledging some turnoffs) leading from Albert Einstein to Emmy Noether to Chen Ning Yang and Robert Mills to Steven Weinberg and Abdus Salam. The road passes through such territory as Lorentz invariance, parity, group theory, the “eightfold way,” gauge theory, the electroweak unification, GUTs and cosmology.