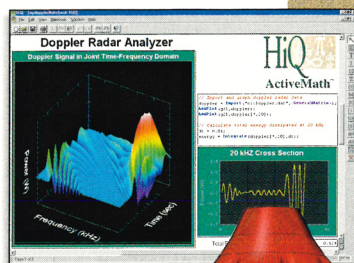


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mechanics and electrical science courses, will probably have to do extra study; an adequate bibliography is provided for this purpose.

Mechanics of solids is presented first, followed by two chapters on fluid mechanics and one each on mass transfer and heat transfer, the general material of mechanical and chemical engineering studies. Next come two chapters on systems and circuits from electrical engineering, which also include the application of mechanics principles. The two chapters dealing with biomaterials that follow also build on the mechanics chapters. Five chapters dealing with, respectively, locomotion and muscle biomechanics, electrophoresis, imaging, ionizing radiation and nonionizing electromagnetic fields, and an appendix dealing with linear transforms, complete the text.

The first nine chapters of underlying, basic material are very quantitative in both discussion and approach and contain worked examples of applications of the principles, many of which are a delight to read. These chapters also provide a reasonable number of homework-type problems, about half of which are supplied with answers. The last five chapters are decidedly less quantitative, with few if any worked examples. Some lack even homework problems for students to practice on.

Though the book should not be criticized too severely for not covering all aspects of an extremely broad topic, I feel compelled to remark that the field to which I devoted 45 years, bio-ultrasonics, receives very little attention, with no mention at all of contrast agents employed for imaging purposes or of physical interaction mechanisms for therapeutic purposes. No doubt there are other topics omitted. Nevertheless, the book can be recommended for those early mechanics-and-circuits and systems chapters, which may be sufficiently extensive to serve alone in rather specialized courses. Similarly, the book could be considered as a reference on how to approach certain biomechanics problems.

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Nonlinear Optics

▶ E. G. Sauter
Wiley, New York, 1996. 214 pp.
\$59.95 hc ISBN 0-471-14860-1

Nonlinear optics is now a well-established subdiscipline of physics having important extensions to other areas of both fundamental and technological interest. Its study, once concentrated in specialized graduate courses, is in-

creasingly being shifted to the undergraduate level, and it now constitutes an integral and indispensable part of any modern textbook in optics, optical engineering or laser applications. This development has created a need for an appropriate introduction to the subject to go along with the well-established advanced treatises being used by graduate students and practicing scientists.

E. G. Sauter's *Nonlinear Optics* is a simple and well-focused attempt to satisfy this need. It presents the subject in a way that can serve as an introduction for advanced engineering students or engineers who have minimal training in physics or optics but a good command of electromagnetic propagation. The book's presentation of the interaction of light and matter is entirely classical, occasionally illustrated by reference to the classical forced anharmonic oscillator but devoid of any quantum mechanical considerations. The focus of the book is the presentation of some key nonlinear effects in propagation; the generation of the corresponding nonlinear polarization terms is taken for granted.

The book contains eleven chapters. Nonlinear polarization is disposed of in the first, where the main macroscopic characteristics of nonlinear susceptibilities are stated. In chapter 2, a much simplified version of the slow varying envelope approximation is presented and used to derive the nonlinear propagation equation in an anisotropic medium.

In the following three chapters, the essentials of the second-order (quadratic) propagation effects are discussed; these include the effects—Pockels, optical rectification and Faraday effects—arising from modification of the linear optical properties by static fields (chapter 3), second harmonic generation in the weak regime in some specific beam configurations (chapter 4), and a summary of the parametric quadratic effects, including frequency mixing, amplification and oscillation (chapter 5).

In chapters 6 through 8, a few third-order (cubic) optical effects are briefly discussed, with an attempt to include as well their resonant behavior, but this is reduced to its minimal form because of the inadequacy of classical models, on which the presentation relies, to account properly for the resonances. Also mentioned pell-mell are the Raman and Brillouin effects (chapter 6); effects such as optical bistability and self-focusing, which are related to the optical Kerr modification of the refractive index, (chapter 7); and degenerate four-wave mixing (chapter 8).

The final three chapters concern pulse propagation in optical Kerr me-

dia, starting with modulation and modulation instability (chapter 9), proceeding to solitons (chapter 10) and concluding with a quick survey of some additional effects that may complicate the pulse propagation in glass fibers and are of technological interest (chapter 11).

The presentation is fluid and coherent, but it suffers somewhat by the near absence of physical considerations. The material is actually a collection of different examples that may be found scattered throughout several well-established books in nonlinear optics, examples that are frequently used to illustrate in classical terms different aspects of the subject. The principal merit of this book is its arrangement of these examples in a coherent and self-contained way and adapted for readers who have a good background in electromagnetism but have no background in quantum mechanics. This treatment allows the reader to get a quick glimpse of the topic and its potential applications before approaching more advanced treatments of the subject. The drawbacks of such a presentation are evident when nonlinear effects close to resonances are discussed or problems related to quantum noise or relaxation become relevant.

Despite such evident limitations, *Nonlinear Optics* has definite merits, one being that it renders the topic accessible to engineering students and engineers who are interested in applications, and it will help with further reading. The notations and definitions are also geared to such a readership, as are the exercises that accompany the chapters.

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Black Holes: Gravitational Interactions

▶ Peter D. D'Eath
Oxford U. P., New York, 1996.
286 pp. \$80.00 hc
ISBN 0-19-851479-4

There has been a considerable revival of interest in recent years in the study of a number of phenomena involving black holes. Much of the impetus for this renewed interest has arisen from the construction of the Laser Interferometer Gravitational Wave Observatory (LIGO), which should be able to detect gravitational radiation from the mergers of black holes. Further impetus has been provided by the efforts of several research groups that aim to calculate numerically the de-

tails of the process of black-hole collisions. Finally, recent developments in string theory—which successfully reproduced the Bekenstein–Hawking formula for black-hole entropy for certain classes of black holes—have led to renewed interest in the theory of scattering by black holes.

The theory of linear waves propagating in a black-hole background was developed to a highly advanced state in the 1970s, but the theory of nonlinear interactions between black holes remains in a relatively rudimentary state. One analytical technique that has been successfully applied to study certain nonlinear phenomena involving black holes is the method of matched asymptotic expansions. The basic idea of this approach is to develop two (or more) different perturbation approximations, valid in different local regions of spacetime. When these local domains of validity have a non-empty intersection, the results can be matched in the overlap region, and a great deal of information often can be extracted. However, it is quite difficult to obtain any rigorous results from this approach, since it is very difficult to establish rigorously the domain of validity and convergence properties of the various perturbation approximations.

Peter D'Eath's *Black Holes* is mainly devoted to the application of matched asymptotic expansions to two problems: the motion of a (small) black hole in a background spacetime and the collision of two Schwarzschild black holes at (nearly) the speed of light. Most of the research described in the book was carried out by D'Eath and his students, but comprehensive references to other work are provided.

The book is written in a clear style, and I encountered no obvious errors or misstatements. Some general introductory material on black holes is provided, but in a form that is much too terse for a novice to follow. The organization of the book is generally good, although there is some noticeable repetition of material from chapter to chapter.

The calculations presented are quite complex—particularly in the chapters analyzing the high-speed collisions of black holes—and it would take enormous effort by the reader to work through the details of these calculations. Furthermore, the focus of the book is much more on results than on methods, so the reader who is interested in learning the methods in order to apply them to other problems will not have an easy time extracting the necessary information. Finally, near the end of the book, it is found that this method produces an unphysical answer for the mass of a black hole

resulting from the collision of two black holes at the speed of light: This final mass is greater than the initial energy, thus contradicting conservation of energy. D'Eath believes that the explanation of this contradiction lies in the failure of a certain uniformity condition to hold, thus invalidating the calculation. However, this leaves the reader to wonder whether any of the other (physically reasonable) results presented earlier in the book might also be invalid, for similar reasons.

In summary, this book makes a useful contribution to the literature by presenting an impressive series of calculations and results relating to the motion of a black hole and the collision of two black holes. However, for the reasons given in the previous paragraph, interest in the book will probably be limited to a small number of specialists.

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