

Quantum electronics gets a successful, interesting text

Principles of Quantum Electronics

D. Marcuse

507 pp., Academic, New York, 1980 (first published 1970). \$35.00

Reviewed by Melvin Lax

Principles of Quantum Electronics by Dietrich Marcuse is an excellent introduction to quantum electronics. The author has achieved the objectives of writing both a highly readable text, useful for graduate students in physics and electrical engineering and for professionals who prefer detailed explanations and a review of the underlying principles of quantum mechanics. Indeed the book could be used as a text in a quantum mechanics course in which all the applications are quantum electronic.

The strength and weakness of this book stem from the same source: that it is designed to be an introductory text. Thus it comes replete with the necessary problems expected of an adequate text. It also comes with a review of quantum mechanics from the Dirac point of view. While the latter might be boring to a professional or to a physics student who has just completed an appropriate course in quantum mechanics, it is probably necessary for many readers.

Marcuse begins with a detailed review of the Schrödinger, Heisenberg and interaction representations. He then applies field quantization to photons and phonons. Here Marcuse's tendency to simplify, which makes this book (and his earlier book on light transmission optics) so readable, has occasionally gone too far. For example, although he states on page 40 that "variables whose operators do not commute cannot be measured simultaneously," in section 6.3 he points out the equivalence between simultaneous measurement of q and p and a heterodyne detector. In this discussion he fails to refer to the work of his colleagues E. Arthurs and J. L. Kelly Jr., and James P. Gordon and William H. Louisell, who have provided the modern discussion of simultaneous mea-

surement of noncommuting observables. Similarly, he recommends the quantization of electrical and mechanical waves "from the need to replace all observable quantities (variables) of physics by operators..." without indicating that the quantization of the electromagnetic field is based on the proof of Bohr and Rosenfeld that electric and magnetic fields cannot be measured simultaneously with complete precision.

Another oversimplification is Marcuse's derivation of $-e\mathbf{E}\cdot\mathbf{r}$ from $-e\mathbf{p}\cdot\mathbf{A}/m$ by a procedure that he states is "not much more than a memory aid." The reader, however, is not told that the $\mathbf{r}\cdot\mathbf{E}$ interaction is superior to that of the $\mathbf{p}\cdot\mathbf{A}$ interaction because the latter leads to precursors that travel faster than the speed of light and must be canceled by the instantaneous Coulomb interaction, as pointed out in 1957 by B. Power and S. Zienau.

These occasional lapses into oversim-

plicity can be forgiven because of the author's highly readable and provocative style. While the book is full of formulas, the emphasis is on ideas, and provocative ones at that. For example, Marcuse states on page 54 that a classical theory (of the electromagnetic field) cannot account for the photoelectric effect, photon counting statistics, spontaneous emission of radiation and its relation to the fluorescence of lasers, quantum noise and precise measurement of field variables. Later he discusses these points in detail.

Marcuse gives a thorough and clear discussion of electromagnetic response to a classical current source in both the Schrödinger and Heisenberg pictures. He applies this procedure to the interaction of an electron with an L - C oscillator. He calculates stimulated emission both classically and quantum mechanically and extends this application to the transit-time oscillator. He clearly makes the point that quantum

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mechanical procedures perform phase averaging that must be done explicitly in a classical treatment.

Marcuse exploits the idea that a quantum field can be expressed as a classical field plus the quantized vacuum field and shows in amplifier calculations that the zero-point energy is not amplified. He demonstrates that the photocount statistics of thermal noise filtered to a narrow bandwidth do not equal the photocurrent statistics of a coherent laser beam.

Marcuse introduces density operators, which he applies to laser amplifiers and oscillators as well as to second harmonic generation, parametric up conversion, Raman scattering, Rayleigh scattering and modes in a lossy waveguide.

His book is provocative, readable and an excellent text, but slightly dated since nine of the chapters stem from an earlier book, *Engineering Quantum Electronics*, that should not have been allowed to go out of print.

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Atomic Structure

E. U. Condon, H. Odabasi.

674 pp. Cambridge U. P., New York, 1980.
\$49.95 cloth, \$18.95 paper

Together with spectroscopic data of ever-increasing precision, the theory of atomic structure provides sensitive probes not only for atomic physics but also for a wide range of topics, such as interstellar matter, parity violation, plasma diagnostics and exotic atoms. Substantial progress has been made in the study of atomic structure in the past few decades, particularly in Racah algebra, application of group theory and the use of digital computers. One of the classic texts on this subject is *The Theory of Atomic Structure* by Edward U. Condon and George H. Shortley, frequently cited by specialists as TAS.

Although the subject of this review started out as a revised edition of TAS, Condon passed away in 1974 before he and Halis Odabasi could finish their task. As Odabasi states in the Preface, "the present book is not a new Condon and Shortley," but it "is intended to be a text for seniors or first-year graduate students." Even with this less ambitious goal, it is a difficult, if not impossible, task to put everything into a text compact enough to be of a manageable size, and still explain enough details for students to follow. The authors originally decided to write two volumes, the second to include such topics as the relativistic theory of atomic structure, radiative transition, electron correlation, and the Zeeman and Stark ef-