

esses in nonabelian theory for which the calculations are closely analogous to the abelian case. Some topics one would expect to find, such as Noether's theorem, are omitted.

Brown calls his book "half a book on quantum field theory." We can hope for a later book on nonabelian gauge theory, written to the same high standard.

Michio Kaku's book is a polar opposite to Brown's. Kaku discusses a mind-boggling variety of topics: If

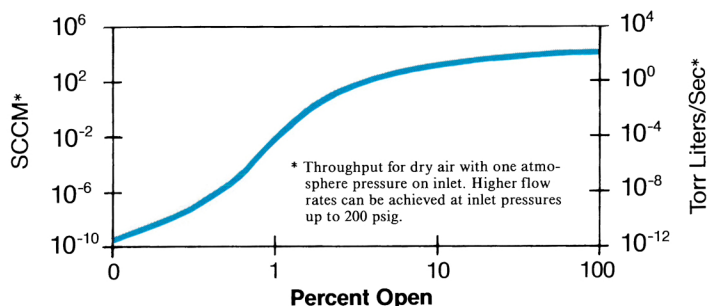
Brown's book is "half a book," Kaku's is three books. Part I discusses the basic ideas of quantum field theory through perturbation theory and renormalization in quantum electrodynamics. Part II introduces path integrals and uses them to discuss the standard model. Part III treats a collection of more advanced topics, such as lattice gauge theory, phase transitions and critical phenomena, quantum gravity and superstrings. The presentation in Parts I and II

follows standard lines and is remarkably concise. In Part III, the exposition is too sketchy. For example, two pages on the two-dimensional Ising model and one page on the heterotic superstring do little more than make the reader aware of the existence of these topics.

Both books are valuable references; I have already found them useful. Indeed, I have placed them on reserve in the library for a course on quantum field theory that I am teaching this coming spring.

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Quantum Theory of the Optical and Electronic Properties of Semiconductors

Hartmut Haug and
Stephen W. Koch

World Scientific, River Edge,
N. J., 1993. 473 pp. \$84.00 hc
ISBN 981-02-1341-7; \$42.00
pb ISBN 981-02-1347-6

Since the early 1950s, electrical engineers have been interested in band gaps, electrons and holes, quantum efficiency and other elements of the quantum theory of solids. But the language of electronics has remained predominantly classical, using concepts such as capacity, mobility, diffusion length, current-voltage characteristics and so on.

The next step in the technological revolution seems to involve the implementation of elements that are on a mesoscopic scale. Even the names of some of the building blocks of new electronic components refer to quantum mechanics: quantum wells, quantum wires and quantum dots. The widely used term *mesoscopic*, although sometimes differently understood, essentially means elements or specimens that are large on an atomic length scale but small in comparison with some quantum length scale, such as the de Broglie wavelength of electrons, localization length or the mean free path. So it is no accident that the proceedings of recent semiconductor conferences are full of material that reminds us of illustrations in elementary quantum mechanics textbooks—a rectangular potential well, tunneling through barriers of different forms, a double quantum well and so on. Electronic processes in such devices can hardly be considered in classical terms.

There is another important trend

that is specific to the physics of semiconductors. The successful application of semiconductors is closely connected with the wide-ranging possibilities for effectively and easily controlling electronic processes in semiconductor materials through spatial and temporal manipulation of carrier concentration and even type. Because concentrations are typically orders of magnitude smaller in semiconductors than in metals, the physics of semiconductors has been mainly that of single electrons plus a few collective phenomena that have mostly been accounted for by Poisson's equation. Truly quantum many-body phenomena were of interest only to theorists, especially those who were involved in calculating band structures from first principles.

New phenomena that are outside the framework of this simple perfect picture have gradually accumulated. Magnetic semiconductors, the Mott-Anderson transition, electron-hole liquid and the quantum Hall effect, are the best-known examples. An important event in this evolution was the invention of semiconductor lasers, which stimulated interest in the physics of highly excited semiconductors and later in ultrafast processes. For these processes the conventional description in terms of Boltzmann kinetics becomes inadequate.

Thus there is an urgent need for a textbook that can introduce the modern quantum theory of semiconductors to a broad range of students, researchers and engineers, to give them the possibility of speaking in a common language. In my opinion the authors of *Quantum Theory of the Optical and Electronic Properties of Semiconductors* succeeded in solving this far-from-trivial problem, at least with respect to the optical phenomena.

Both authors are well known in semiconductor physics. Hartmut Haug made important contributions to the theory of semiconductor lasers, optically excited semiconductors, including low-dimensional structures, and quantum kinetics in semiconductors. Stephen W. Koch and his colleagues used many-body theory for the self-consistent treatment of the optical nonlinearities in semiconductors, and they performed a number of interesting and important computer studies of ultrashort pulse propagation in semiconductor structures.

One of the remarkable successes of Haug and Koch's book is the selection and the presentation of the material. The authors extract a limited number of main physical points,

emphasize common features in the different phenomena and offer a unified approach and an adequately formal treatment, without overwhelming the reader with calculational details. The authors succeed in presenting the material in a rigorous but simple and elegant form, within the framework of a mathematically standard quantum mechanical approach. In this book of moderate length, the authors start with an ele-

mentary description of the response of classical oscillators and hydrogen-like atoms; they end up with recent theories of ultrafast coherent phenomena in a dense nonequilibrium electron-hole plasma and quantum kinetics on a femtosecond timescale. Mesoscopic semiconductor structures, excitons and polaritons, electro-optics and some magneto-optics in two-dimensional structures, optical bistability and semiconductor laser theory

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are also covered in several chapters.

An important feature of the monograph is the systematic presentation of collective excitations in terms of response functions. Green's functions are introduced in the book's first few pages as an alternative way to describe the response of classical oscillators and, a little later, for electronic processes. An introduction to the quantum nonequilibrium Green's function technique in appendix B closes the book. Here I would have

expected a broader use of Feynman diagrams as a way of representing the processes and, in some sense, as a way of thinking. A remarkable virtue of the book is that basically all the important results for bulk semiconductors and for mesoscopic structures of different dimensionality—quantum wells, wires and dots—are presented in parallel. The majority of the widely used approximation schemes for particular problems are briefly described and discussed.

Some relatively minor shortcomings seem to have resulted from squeezing so much material into one book. For example, the attempt to compress into Chapter 3 the whole introduction to the band theory of solids seems unsuccessful, and the selection of material here looks rather random. I think it would have been more tutorial to give a list of brief but exact formulations of the main results of band theory and crystallographic concepts as well as a few references to relevant books. A few sections are overloaded with unnecessarily thorough computations.

Notwithstanding the minor criticism above, I consider this book a useful and opportune monograph. Several problems are given at the end of each chapter, making this monograph a really effective textbook. I would like to recommend it as required reading for graduate students and researchers who intend to enter semiconductor physics and technology.

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Origin and Evolution of the Elements.