checkered history and has previously appeared three times in translation, albeit not in this complete form. (For a history of this tome see *Science* of 9 April 1965, page 212, or PHYSICS TODAY of June 1965, page 52). According to Interscience, this is the only authorized and complete edition of *QED*. Also important, it is legible and is provided with a skeletal index. The print of the earlier incomplete editions is often difficult to read and, like most Russian books, they lack indexes.

Quantum electrodynamics, the theory of the interaction of light with matter, was the creation of Heisenberg, Pauli, Fermi and Dirac during the period 1928-1930. The new QED was the work of Feynman and Schwinger of the United States and Tomonaga of Japan during the late 1940's. At first it seemed that there were two radically different formulation of QED. The one due to Schwinger and Tomonaga stems from an action principle and is a quantum field theory. The other, due to Feynman, is a particle theory. This unsatisfactory state of affairs was resolved by Dyson, who showed that the two formulations, so different on the surface, are in fact mathematically equivalent. For this important work, Dyson was recently honored by APS (PHYSICS TODAY, June 1965, page 21), and the 1965 Nobel Prize in Physics was awarded jointly to Feynman, Schwinger and Tomonaga for their fundamental work in QED.

QED is written entirely in the Feynman formulation. The Schwinger-Tomonaga formulation is ignored. The authors take the extreme viewpoint that the set of all Feynman diagrams is QED. An advanced graduate textbook, it is the most exhaustive and detailed treatment of the subject known to the reviewer. About half of the book is devoted to exposition of the theory and the other half to the working out in minute detail of numerous problems. There are many graphs and tables, which are very useful for summarizing the results of vertiginous calculations. The translator, G. M. Volkoff, is a well known and experienced translator and is to be commended on an excellent job.

The faults of *QED* are mainly sins of omission. The notation is often gauche. For instance, the barbaric notation used for the decomposition of the operators A_μ, ψ and $\overline{\psi}$ into their positive and negative frequency parts, Eq. (16.13) and (18.18), is utterly ludicrous. But it is a moot point whether a translator should change the notation of an author to make it conform more closely to the notation used in English books or even to improve it, if necessary. The short index is an extra bonus and makes the book much more valuable than the previous incomplete, indexless editions. However, it is a limited index of only five pages. There are no entries for such important subjects as Wick's theorem, Noether's theorem, Dyson's equation, the adiabatic hypothesis, form factor, bound states, counter terms, causality condition, spin sums, transition probability, annihilation and creation operators, vacuum polarization, Hilbert space and the Lamb shift. The knowledgeable reader will find the book difficult to read at random, for no glossary is provided.

For such a brontosauric book, the scope of *QED* is too narrowly circumscribed. Since the late 1950's, QED has been viewed as a branch of quantum field theory, and a complete and accurate picture of it is not possible without venturing into quantum field theory. The work of Lehmann, Symanzik, Zimmermann and Nishijima, in which they formulate field theories based on a few postulates but not using a Lagrangian, a Hamiltonian or field equations, should have been included to provide the proper perspective. In this superformulation of QED, all unobservable divergent quantities are completely eliminated at the start and no divergences occur in the course of the entire calculation. This method is easily applied to QED, which has a parameter of smallness, the fine structure constant, and which results in convergent, unambiguous solutions, in complete agreement with the older, renormalized QED.

QED is obviously not for students who wish a quick survey of the subject. Such people will find F. Mandl's *Introduction to Quantum Field Theory* or R. Feynman's *Quantum Electrodynamics* very suitable. The only other book in English that is comparable to *QED* is *The Theory of Photon and Electrons* by F. Rohrlich and J. Jauch. Although somewhat dated, this important book can still be read with much profit.

Quantum theory and ionization

THE THEORY OF ELECTRON-ATOM COLLISIONS. By G. F. Drukarev. 161 pp. Academic Press, New York, 1965. 39s 6d.

by D. Elwyn Davies

Professor G. Drukarev of Leningrad University has presented in this small monograph six chapters, in each of which one of the following calculations is carried out in detail: elastic scattering of an electron by a hydrogen atom, excitation of the hydrogen atom by electron impact, the collision of an electron with a helium ion, with a helium atom, with a sodium atom, and the excitation of excited states of hydrogen, such as multicharged ions. The remaining four chapters deal with the general theory of the interaction of electrons with atoms.

Drukarev's success in this book comes from application of the following to the cases listed above: perturbation theory, distorted-wave calculations, variational-methods allowances for exchange and for coupling, together with improved computational techniques.

The monograph should be most useful to quantum theorists, and to the ionization physicists, for whom end products of the calculations have been compared with the experimental results available with considerable success. Thus, two distinct, and usually separated, sets of physicists are brought together by one monograph—a considerable achievement!

The text has been carefully prepared and clearly presented in the English translation, due to Mr. Chomet, and edited by Dr. J. B. Hasted of University College, London.

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The reviewer, who is reader in physics at the University of Keele in England, is interested in ionization phenomena in hydrogen and the inert gases, and has published several papers on this topic.