Reformulating quantum mechanics

QUANTUM MECHANICS AND PATH INTEGRALS. By R. P. Feynman and A. R. Hibbs. 365 pp. McGraw-Hill, New York, 1965. $12.50.

by George H. Weiss

Some years ago, when Feynman first introduced the path-integral formulation of quantum mechanics it was hoped that the new technique held the answer to many of the outstanding problems in that field. Since then, this hope has slowly diminished as it became evident that the solution of problems by path integrals was considerably more difficult than by the usual differential-operator techniques. In fact, most of the soluble problems are those in which the path integrals can be shown to be equivalent to a Schrödinger equation. It is with this background in mind that we must evaluate the book by Feynman and Hibbs.

In essence this monograph is an expanded version of Feynman's earliest papers on the subject. It is shown that a quantum-mechanical "action" can be defined and the laws of quantum mechanics set forth in terms of a path integral over a function of this "action." Next it is demonstrated that in many cases the detailed evaluation of the path integral can be reduced to the solution of a Schrödinger equation. The following chapter on perturbation methods is just about the same as one would expect in a more orthodox treatment of quantum mechanics. Other topics covered in the book include the theory of harmonic oscillators (the only physical system for which the evaluation of path integrals is relatively easy), elementary quantum electrodynamics, statistical mechanics, and selected topics in the theory of probability.

Even though a considerable portion of the theories of quantum mechanics and statistical mechanics can be reformulated in terms of path integrals, a complete translation would be difficult to make. There is, for example, no satisfactory treatment of systems with spin. Furthermore, the intuitive picture provided by forty years of the development of quantum mechanics has provided an insight into many applications that would be difficult to translate into path-integral terms. For this reason Feynman and Hibbs' book seems to be more of an extended proof of the possibility of reformulating quantum mechanics rather than a demonstration of the desirability of doing so. It would make interesting supplementary reading in a course in quantum mechanics, but could not be used as a main text.

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RICHARD P. FEYNMAN

Nonrelativistic two-body problem

POTENTIAL SCATTERING. By V. de Alfaro and T. Regge. 205 pp. (North Holland, Amsterdam) Interscience, New York, 1965. $8.00.

by Geoffrey Chew

It might seem late in the history of quantum mechanics for a book to be appearing on the nonrelativistic two-body problem, a dynamical system presumed for more than thirty years to be completely understood. In 1958, however, Tullio Regge uncovered a major aspect of this familiar problem that had eluded earlier investigators. Regge's discovery has since had enormous influence on thinking about the general (relativistic) strong interaction problem—giving powerful impetus to the concept described sometimes as the "bootstrap" and sometimes as "nuclear democracy." In collaboration with V. de Alfaro, Regge has now written a monograph entitled *Potential Scattering*, giving a detailed mathematical description not only of his personal contribution to the nonrelativistic model but of nearly all other related contributions.

TULLIO REGGE

The two-body, short-range potential model is the most realistic model of strong interactions that at the same time is mathematically well defined. Questions asked here have definite answers, a situation not always true for relativistic models, and the book by Alfaro and Regge presents the definitive answers available to them at the time of publication. The emphasis throughout is on the scattering (S) matrix, the concept through which it is hoped that a link with relativisitic theory eventually will be established. Exhaustively discussed are the analytic structure and asymptotic behavior of the S-matrix generated by a potential, those aspects with a chance of relativistic application being underlined.

Analytic properties in the complex angular-momentum plane naturally play a key role, Regge's original work having centered on analytic interpolation in angular momentum. To the best of the reviewer's knowledge, the only significant published results not covered by Alfaro and Regge are those pertaining to the left half of the angular-momentum complex plane. Recent developments in relativistic theory and experiment indicate that this region, largely ignored by Alfaro and Regge, is of substantial interest.

For a physics book there is a high level of mathematical precision, and the reading cannot be described as easy. By the same token, however, this monograph will represent for some time to come the standard reference on nonrelativistic potential scattering.

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Professor Chew, who is a member of the Berkeley faculty, is well known for his "bootstrap" theory of particle dynamics.

Classical optics and extensions to current research

OPTICAL PHYSICS. By Max Garbuny. 466 pp. Academic Press, New York, 1965. $14.50.

by Joseph G. Hoffman

The preface says this work was intended as a textbook. It is an exceptionally good one, even though it has no problem sets at the end of each chapter or in an appendix. It is a highly readable account of recent basic work in optics. The author has extensive practical experience and is experimentally oriented. He gives the material in terms of the barest essential mathematics, with emphasis on facts and concepts which are developed with a superb clarity. The point of view will appeal to all students.

Chapter 2 deals with emission and absorption of heat radiation in a unique sequence. Following a discussion of black-body theory and quantum statistics, among other pertinent topics, there is a section on actual sources of heat radiation continua which leads into an exposition of thermal plasmas. Chapter 3, on monochromatic radiation, develops radiation theory to the matrix element of the dipole moment, and then to quadrupole transitions, a subject further elaborated in chapter 4 with a section on multipole radiation and its transition rules. Standard phenomena of propagation, such as reflection, refraction, and polarization, are supplemented with interesting descriptions of liquid crystal properties in chapter 5. Chapter 6, on interactions of coherent radiation with matter, includes the theory of photon correlation and the Hanbury Brown—Twiss experiment, and a thorough summary of maser phenomena in theory and experiment.

Chapter 7 is entitled "Secondary effect of light and processes of detection," and illustrates the applications of theoretical concepts to practical means for detection of light. An example of the author's range is his discussion of the vectorial photoelectric effect discovered in 1894 by Elster and Geitel and not yet satisfactorily explained.

The format is inviting; the author and subject indices adequate; and the generous references given after each of the seven chapters support the rapidly moving text. This is a highly commendable presentation of classical physical optics and its extensions into current optics research.

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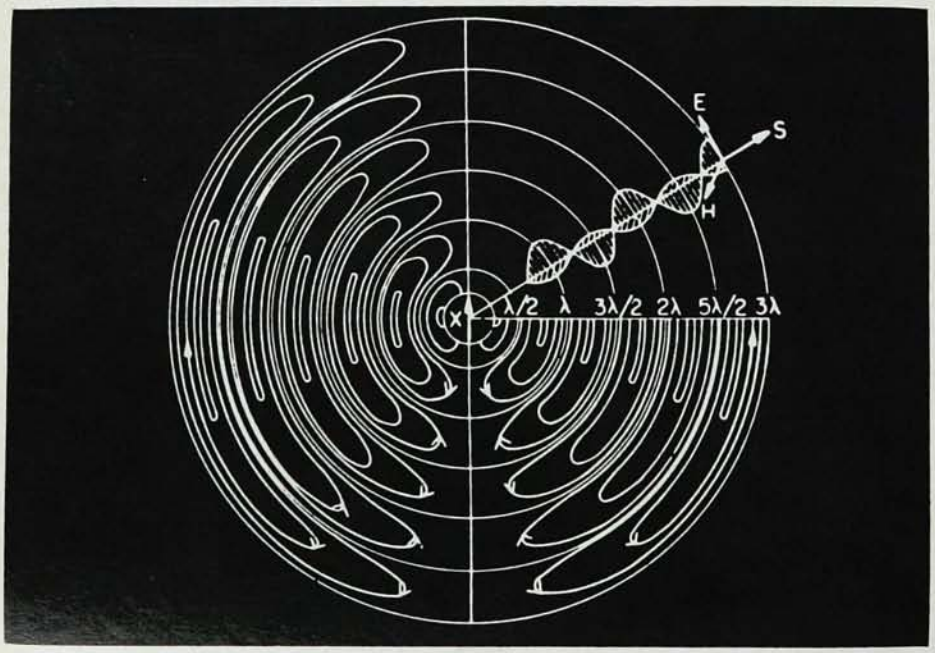

HERTZIAN PATTERN of spreading electromagnetic waves generated by an oscillating dipole. Contours shown are instantaneous configurations of the electric field in the near- and far-zone. Complete spatial pattern is obtained as a figure of revolution around the dipole axis. Shaded curves are phase variation of electric and magnetic field in direction of Poynting vector. From *Optical Physics*.