

## DIRAC ON QUANTUM MECHANICS

*The Principles of Quantum Mechanics.* By P. A. M. Dirac. Second edition. Oxford, Clarendon Press, 1935. xii+300 pp.

The first edition of Dirac's *Principles of Quantum Mechanics* appeared in 1930.\* The second edition is essentially the same book, but is in many respects clarified and recast in exposition, with a shift in emphasis to the non-relativistic conception of *state*, and with additional matter, in particular, a chapter on the quantization of the electromagnetic field.

In the introductory generalities, comprising the preface and first chapter, such matters are discussed as the inadequacy of the classical theory with its determinism and causality, and the notions of states, probability, and the principles of superposition and indeterminacy. The non-technical reader is apt to be misled by the form of the discussion, which is that of a logical analysis of experimental data with the drawing of necessary physical and philosophical conclusions. Yet we believe that this is not at all what the author is undertaking. One hardly needs to be a practiced epistemologist to be aware of the order of magnitude of philosophical analysis required to treat adequately such questions as those of causality and indeterminacy, of which the author disposes—too often with scarcely more than the conventional phrases. Nor is unusual penetration needed to perceive that the experimental evidence claimed as overthrowing classical physics and establishing the new theory, requires a far more penetrating critique. As a pure matter of logic, one is left with the impression that all might about as well have been argued in the opposite direction. We believe that what the author has attempted to do here is a task far more important for the needs of a student of contemporary physics. He is attempting to *prepare the intuition* of the reader, so that the old theory becomes replaced by the new by a sort of *intuitive* necessity, and so that the form and substance of the new theory may be apprehended not only as a logical abstraction but in terms of a new conceptualism—almost a new imagery. In this respect he has made a distinguished contribution. The present edition is far clearer at this point than the first.

The next section of the book, from the second to the fifth chapters, deals with mathematical preliminaries and their physical interpretation: the linear vector spaces and operators and their representations, the transformation theory, and the quantum conditions. The point of view is to regard the aggregate of states of a system somehow as forming a linear vector space, the elements of which both are and are not the states (there is an indeterminate phase factor!), and the linear transformations of which are *en rapport* with the observables of the system. The familiar spaces of the quantum theory, com-

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\* Reviewed by me in this Bulletin, vol. 37 (1931), p. 495. The observations in the review of the first edition apply to a considerable extent to the second; we take the occasion of the present review to treat a rather different side of the question.