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Landau—Lifshitz

Relativistic Quantum Theory
by V. B. Berestetskii, E. M. Lifshitz
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Pergamon. £6.00. ISBN 08 016025 5

It has always been a somewhat awesome experience for professional theoretical physicists to read the Soviet *Course of Theoretical Physics* —universally known as "Landau and Lifshitz"—because of the authors' total domination of the vast range of their subject. This English translation of the latest instalment of that justly celebrated work is no exception, even though Landau, the late "grand master" of Russian physics, is not among the authors.

Quantum mechanics has enabled us to achieve a detailed understanding of the structure of atoms, of matter in bulk, and of the empirical rules of chemistry. Yet the simplest form of the theory, based on "Schrödinger's wave equation", contains the time as a universal variable, the same for all observers, and is thus in conflict with Einstein's theory of relativity, according to which time is but one of four coordinates which vary with the motion of the observer.

This book is part of a treatment of the intricate formalisms that have been developed in the still-incomplete attempt to marry the two theories into a "relativistic quantum mechanics". This generalization is necessary in order to discuss microscopic processes involving particles travelling near the speed of light, such as the decays, transitions and transformations of "elementary particles" and radiation.

Of course this is a tough subject, and the authors' approach demands serious study; they believe that "a reader whose study . . . has extended as far as the quantum theory has no need of predigested material". This is a bit forbidding, but in fact the authors are sensitive to the difficulties faced by students, and there are very many of those parenthetical remarks which characterize a good textbook, explaining in the middle of a complicated calculation "where the factor of 2 comes from".

It would have been easy for the authors to have confined themselves to empty formalism, and there is indeed a great deal of pure mathematics—the theory of four-dimensional spinors, for example. But in fact the book lives up to Landau's reputation, and does not shirk basic physical questions. Thus the introduction shows how Heisenberg's famous "uncertainty principle", when applied to the relativistic case, implies that the "wave function", so important in non-relativistic quantum mechanics, no longer has a simple interpretation. The only physically-meaningful quantities involve the probabilities that various "velocity states" will result from the interaction between given objects.

Again, it is emphasized in chapter two that the relativistic interconvertibility of mass and energy implies that particles need not be conserved, so that a "variable-particle-number" formalism is required (the non-relativistic Schrödinger equation can cope only with systems where the number of particles is fixed).

It is a sound pedagogical principle, which applies just as much at the present abstruse level as it does at the level of the "new maths" in primary schools, that the power of new formalisms should be demonstrated by applying them in a variety of contexts. The authors are well aware of this, and there are copious examples, some of which are the highly non-trivial "problems" for which this Course is famous.

The book starts with the wave equations, operators, and so on, required to describe the "objects" of the theory—photons, bosons and fermions. Then the Dirac equation is solved for an electron in an external field. Next the theory of the emission and scattering of radiation is developed, and many examples are given. There follows a treatment of the scattering matrix, which includes a particularly thorough discussion of the "physical regions" in the space of the invariant quantities describing scattering with two particles in the initial and final states.

Next comes an account of "perturbation theory" applicable to weakly interacting systems, containing a careful statement of the rules for using the technique of "Feynman diagrams". Finally, there is an abundance of calculations, illustrative of the whole theory but important in their own right, of the probabilities for processes involving electrons, muons and radiation. I have only one small criticism of the authors' selection of material: there is no discussion of the strange "zitterbewegung" predicted by Dirac's theory of the electron.

It is perfectly possible to read this book on its own, even though the course has been planned as a whole, so that there are frequent references to the earlier volumes. Despite inevitable delays in Soviet-British collaboration, the work is up-to-date (the latest references in the text are for 1970). The translation, by J. B. Sykes and J. S. Bell, is elegant, the book is well produced, and the price does not seem excessive for a work of this kind. Although not for beginners, this treatise is strongly recommended to theoreticians working in the field, and to university libraries.

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