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The radiation Theory of Feynman

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There are two points of view from which to consider this theory. First, one may consider it[1]) as a supplement to the Tomonaga-Schwinger theory, not differing from the latter in any of its basic assumptions but only in its method of handling problems. The theory then appears as a set of rules for the calculation of the element of the HEISENBERG S-matrix corresponding to any prescribed scattering process involving electrons, positrons and photons. These rules may be derived in a direct way from the SCHWINGER theory. From this viewpoint, the contribution of the FEYNMAN theory lies only in the following; by concentrating attention on the overall behaviour of a physical system as HEISENBERG has done in his S-matrix program, and ceasing to ask questions about the instantaneous state of the system at intermediate times, one finds quick and general ways to derive results which are otherwise obtained only by more laborious and special considerations.

The second point of view from which to consider the theory is the one followed by FEYNMAN himself. This point of view I wish to discuss to-day. Unfortunately there is as yet no published exposition of these ideas. I can refer only to one published paper[2]) and to two unpublished papers of FEYNMAN ("The Theory of Positrons" and "Space-time Approach to Quantum Electrodynamics") which are due to appear shortly. At least one paper in addition to these has still to be written before the foundations of the theory can be considered complete.

From the second viewpoint, it is not the similarity of the conclusions reached by SCHWINGER and FEYNMAN, but the dissimilarity of their starting-points, which is important. SCHWINGER's program has been to start from the HEISENBERG-PAULI electrodynamics and to reformulate it with the minimum modifications that are necessary to make it into a useable theory. FEYNMAN's program has been a critical re-examination of the basic principles of electrodynamics, taking nothing of the earlier theories for granted, building the whole theory up from postulates which are less mathematical and more physically intuitive than those to which we are accustomed. SCHWINGER has been constructing a single theory. FEYNMAN has been constructing a framework into which many different theories can be made to fit; the fact that the framework is loose, allowing a wide freedom of choice to the future, is regarded by FEYNMAN as one of its merits.

The first departure of FEYNMAN from orthodox quantum theory is his use of the Lagrangian instead of the Hamiltonian as the basic function characterizing a system. Already in his non-relativistic theory[2]) the Lagrangian method is used. And because the Lagrangian is relativistically invariant while the Hamiltonian is not, this theory can be made relativistic with much greater ease than the usual SCHRÖDINGER theory. The Lagrangian method is based on the following two postulates.

I. Suppose a system to be given in a state A at one time, then the probability that it will be in a state B at a later time is $| \Sigma_H \, c\,(H) \,|^2$. Here the variable of summation H denotes any conceivable history or route which the system might follow in passing from A to B, and $c(H)$ is a complex number depending on H, called the "probability amplitude for the history H".

II. The value of $c(H)$ is $N \exp\,(iS/h)$, where N is a normalizing factor independent of H, and S is the classical action-integral of the system computed for the history H. In the case of a system of particles, S will be a sum of time-integrals of the particle Lagrangians taken along the world-lines of the particles. In the case of a system of fields specified by a classical Lagrangian-density defined at each point of space and time, S is the integral of the Lagrangian-density, integrated over the whole space and over the duration of H.

Starting from these two postulates and using various types of Lagrangian, a variety of relativistic quantum-mechanical systems can be described. In particular, it is not difficult to include systems with retarded interactions which cannot be quantized by the Hamiltonian method.

A second departure of FEYNMAN from orthodox methods is his treatment of the positron. Here he uses an old idea of WHEELER[3]) and STUECKELBERG[4]) that a positron can be regarded as an electron travelling backwards in time. The hole theory of Dirac is reconstructed in terms of this idea. In resolving the paradoxes presented by particles travelling backwards in time, FEYNMAN has made an analysis of the conditions that have to be satisfied by a quantum-mechanical system in order that physical requirements of causality be preserved. This has led him to duplicate in his theory several ideas discovered earlier by STUECKELBERG.

In conclusion, I wish to stress that the FEYNMAN theory is not to be regarded as a theory in competition with the SCHWINGER theory. It is rather a collection of ideas, of a somewhat intuitive character, which create a deeper understanding, on the one hand of the physical assumptions underlying existing electrodynamics, and on the other hand of the possibilities which exist for new theoretical developments.

References.

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