The Genesis of Feynman Diagrams

Adrian Wüthrich

Universität Bern

Abstract:

Around the year 1948, Richard P. Feynman began to use a particular kind of diagrams for the theoretical treatment of recalcitrant problems in the theory of quantum electrodynamics (QED), e.g., the calculation of the self-energy of the electron. Soon thereafter, these Feynman diagrams became an ubiquitous tool in theoretical elementary particle physics up to the present day. In primary as well as secondary literature, physicists, philosophers and historians of science appraise the diagrams' remarkable usefulness for calculations and, at the same time, remind us of the pitfalls as regards their physical interpretation. As a consequence, Feynman diagrams are usually presented as an uninterpreted computational device that has been invented in order to come to terms with practical problems concerning the evaluation of complicated mathematical expressions. However, a detailed reconstruction of the genesis of Feynman diagrams reveals that their development was constantly driven by the attempt to resolve, at least in part, fundamental problems concerning the uninterpretable infinities that arose in quantum as well as classical theories of electrodynamic phenomena. Accordingly, as a comparison with the graphical representations that were in use before Feynman diagrams shows, the resulting theory of QED, featuring Feynman diagrams, differed significantly from earlier versions of the theory in the way in which the pertaining phenomena were conceptualized and modelled.

In his PhD thesis (defended in May 1942), Feynman began to develop a formulation by path integrals of quantum mechanics, into which he later, in unpublished manuscripts dating from ca. 1947, tried to incorporate the physical interpretation of the Dirac equation by Erwin Schrodinger and Gregory Breit. Feynman continued his quest for an alternative representation of phenomena, which are described by the Dirac equation in two published papers, which appeared in 1949. The two papers contained a theory of quantum electrodynamics in which the wave function would represent, e. g., the probability amplitude for the position of the particles, like in quantum mechanics. In two published papers, which appeared a few months before Feynman's papers, i.e. even be- fore Feynman published his first diagram, Dyson rescued the diagrams from the by-then obsolete quantum mechanical framework and systematized them in the framework of the state-of-the-art quantum field theory of electrodynamics. Dyson thus provided the community of physicists with the framework in which the uninterpretable infinities that had arisen in the old form of the theory could be precisely identified and subsequently removed in a justifiable manner.