Philip Stamp

Statement

and

Readings

Time Evolution of Path Integral Theory

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Abstract

At the end of the 1940's two alternative formulations of QED appeared—the functional formulation of Schwinger, and the path integral formulation of Feynman (with certain aspects of these being anticipated by Tomonaga). In various stages these 2 formulations were shown to be mathematically equivalent—the standard view nowadays is that they are the same theory formulated in 2 different ways. This theory has then provided a framework for almost all further developments in quantum field theory (QFT) since, both in its perturbative and non-perturbative aspects.

In this presentation I will discuss

(1) In what sense these 2 formulations really are equivalent. For practising physicists this is not really the case—a theory is best viewed as a constellation or family of different ideas, which is inevitably somewhat open-ended. Some of the ideas have an august heritage (eg., the action principle), others are less firmly established; but all are being constantly tried out in the course of the development of new theories. The path integral idea, viewed as an image and as a mathematical device, has repeatedly shown itself to reach well beyond the conventional framework of QFT in guiding new developments—this point deserves more philosophical attention.

(2) In semi-historical fashion, some of the successes of the path integral/functional framework. I will note particularly

- Polarons and superfluid He-4, to which Feynman himself allotted great importance
- The development of gauge theories, and calculations with them
- The development of topological field theories, in both condensed matter and particle physics.

There are a number of historical ironies in this story, not least of which is the way that Feynman failed to exploit path integrals in trying to understand gauge theories (and was thereby upstaged by Fadeev, Popov, and 't Hooft).

(3) The problematic history of quantum gravity, which suffers from difficulties not present in other QFT's. Nowhere in physics is the idealogical divide, between perturbative and non-perturbative views of field theory, more sharply exposed. Perturbative theory is non-renormalizable, and a path integral approach suffers apparently insuperable ambiguities. I will argue here that the fundamental problem, that gravity is extremely non-linear, can only be overcome by a very specific modification of the usual principles of quantum mechanics, which is most naturally formulated in path integral language. Such modifications should soon be experimentally testable.