**Path Integrals in Quantum Mechanics** (specialized course, 2 SWS)
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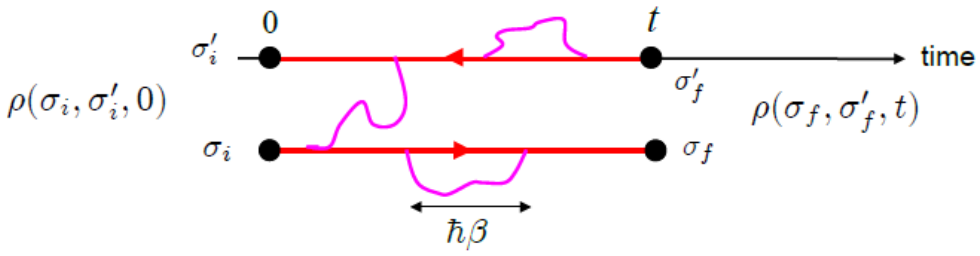
Modern quantum mechanical theories are often formulated within the language of path integration. Pioneered by Wiener, Dirac, and Feynman, the path integral representation is equivalent to the conventional formulation based on Schrödinger's equation, but generalizes the classical action principle. To compute a quantum mechanical transition amplitude, one sums over all paths (not only classical ones) which connect an initial with a final state, where the contribution of each path is weighted by its action factor. This provides an understanding of quantum mechanics in terms of classical-like quantities and allows for powerful perturbative approaches such as semiclassical treatments. Since the 1970s path integrals and related methodologies have been developed as THE formulation in modern field theory, cosmology, quantum statistics, condensed matter physics, and classical statistical physics to name but a few.

In this course, we will start with very basic derivations of path integrals for simple quantum systems (e.g. harmonic oscillator) to learn techniques to evaluate them and to get insight into their subtleties. We will then proceed with perturbative techniques (semiclassics), open quantum systems (reduced densities), coherent state path integrals and path integrals for fermionic systems (Grassmann fields).

$$\langle \sigma_f | \rho(t) | \sigma'_f \rangle \sim \int D[\sigma] D[\sigma'] \; \mathrm{e}^{i\Sigma_0[\sigma,\sigma']} \, \mathrm{e}^{i\Phi[\sigma,\sigma']} \, \langle \sigma_i | \rho(0) | \sigma'_i \rangle$$




Literature: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L. Schulman, Techniques and Applications of Path Integration, John Wiley & Sons.

R. Feynman, A. Hibbs, Quantum mechanics and Path Integrals, McGraw Hill