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Quantum-Orbit Theory in Strong-Laser-Field Physics

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The quantum-mechanical amplitude for the transition from an initial state i to a final state f can be represented in terms of Feynman's path integral. This integral includes all histories of the transition i -> f, i.e. the sum over all paths in space with fixed end points. In the classical limit this sum reduces to a sum over all classical paths for which the action S is stationary. In quantum mechanics the summation over all paths is equivalent to the exact solution of the time-dependent Schrödinger equation. For atomic processes in strong fields the sum over all paths can be substantially reduced. These relevant paths are complex due to the tunnelling nature of the quantum-mechanical ionization process. The quantum nature of these paths is also expressed through the interference of the contributions of different paths. Such paths, in analogy with classical orbits, are called quantum orbits. In our contribution we present quantum-orbit theory and apply it to various processes in strong laser fields. In particular, multi-step high-order processes, such as high-order harmonic generation and above-threshold ionization in tailored laser fields have recently attracted a lot of attention.

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