Theory of Pump-probe Ultrafast Photoemission Theory

Takashi Fujikawa,
Graduate School of Science, Chiba University

Pump-probe femtosecond time-dependent photoemission spectroscopy can examine the transient nonequilibrium dynamics of solids after the pump optical irradiation.

Some theoretical approaches to pump-probe ultrafast photoemission processes have been developed on the basis of nonrelativistic Keldysh Green's function theory [1,2,3,4].

Here after brief introduction to the theory described in ref. [1], the theory described in ref. [2] is explained in some detail, which allows us to discuss intrinsic and extrinsic losses and their interference. Optical potential effects which describe the photoelectron wave damping inside the solids are also incorporated in that theoretical framework; the photoelectron Dyson orbital plays a crucial role. New ingredients compared with the ordinary stationary photoemission are time-dependent Dyson orbitals, which are important to discuss the transient behavior caused by pump LASER pulses. For the practical purposes quasi-boson approximation is extensively used : the pump radiation effects are renormalized to infinite order because their effects are rather strong. Furthermore some extension to discuss electron-phonon interactions and quantum electrodynamics (QED) effects. For the former Baym-Hedin theory is applied and the screened Coulomb interaction W is written as the sum of electronic and electron-phonon parts: W=We+Wp.

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