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Non-equilibrium dynamics of laser-excited electrons in a metal

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Femtosecond laser pulses irradiating a solid material induce a cascade of processes starting with the excitation of so-called hot electrons and passing through various relaxation processes. Several scattering mechanisms act on different timescales. At sufficiently high energy densities, phase transitions and ultrafast structural dynamics can be induced.

We simulate the dynamics of a large ensemble of electrons using complete Boltzmann collision integrals. We consider the excitation of conduction electrons in a metal with visible light. On a femtosecond timescale, the electrons' energy distribution deviates strongly from a Fermi distribution. Electron-electron and electron-phonon scattering mutually influence each other during thermalization. Secondary electron excitation is implicitly included.

We observe athermal electron distributions as well as highly excited electrons much longer than the single-electron lifetime predicts. We extract spectral electron densities within specific energy windows, and find complex behavior that cannot be matched with a simple relaxation time approach. Moreover, we show that the nonequilibrium occupation can affect the measurable optical response of a metallic system.

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