Tracing non-thermal electrons in laser-excited metals with an extended two-temperature model

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Understanding materials' response to laser excitation with pulse durations below one picosecond is of significant importance for industrial applications. The energy of ultrashort laser pulses in the visible range is mainly absorbed by the electrons, resulting in non-thermal electrons above the Fermi edge, often called "hot electrons". This non-equilibrium thermalizes to a Fermi-distribution with elevated temperature typically in the following hundreds of femtoseconds. On the picosecond timescale, electrons and phonons relax to a joint temperature.

The electron-phonon relaxation process can be described by the well-known two-temperature model (TTM) [1], which, however, neglects the possible influence of non-thermal electrons. Kinetic models, such as full Boltzmann collision integrals [2], can describe the non-thermal stage but with a much higher computational cost. Based on the approach of Tsibidis [3], we have developed an intermediate model that extends the TTM to describe non-thermal electrons [4]. We investigate energy-resolved electron dynamics and the influence of non-thermal electrons on electron-phonon coupling, which have been previously studied using kinetic models [5,6]. Our future plans include the study of non-equilibrium transport effects. We believe that the extended TTM can be a useful tool to capture the influence of non-thermal electrons similar to a full kinetic approach, while maintaining the conceptional and numerical simplicity of the standard TTM.

References:

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