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Real-time observations of the quasi-particle relaxation dynamics in various complex systems by means of femtosecond laser spectroscopy

We have performed systematic study of the quasiparticle relaxation dynamics in various complex systems such as cuprates, iron-based pnictides superconductors and charge-density wave systems.
In undoped iron-based pnictides, exhibiting a spin-density wave (SDW) ordering, we observe a bottleneck associated with a partial charge-gap opening. Similarly as in the previous reported studies, a single relaxation process is observed, showing a remarkable critical slowing down of the quasiparticle (QP) relaxation dynamics at the SDW transition temperature. On the other hand, in the optimally doped crystals, a multiple relaxation processes are present with distinct SC-state quasiparticle recombination dynamics exhibiting a BCS-like T-dependent superconducting gap, and a pseudogap (PG)-like feature at higher temperatures. In all optimally doped cuprates and iron-based pnictides, we observe a saturation of the superconducting relaxation component. By taking into account the optical constantssuch as penetration depth and reectivity we can accurately calculate energy needed for destruction of the superconducting state. If we compare the magnitudes of the destruction and condensation energies we notice a significant discrepancy in cuprates and iron-based pnictides, which can be explained with a phonon-mediated QP bottleneck mechanism. In contrast, in the charge-density wave systems, the destruction is faster and electronic; therefore it can not be explained in the frame of the proposed QP bottleneck mechanism.
The second moment of the Eliashberg function, obtained from the relaxation rate in the metallic state at higher temperatures, has similar values in different iron-based pnictides,which indicates a moderate electron phonon coupling.
More recently we have observed a switching between an equilibrium state to a metastable in 1T-TaS_2 charge-density wave system by means of ultrafast laser quench through a symmetry breaking transition.

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