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Momentum-resolved ultrafast electron dynamics in superconducting BSCCO

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In comparison to metals or semiconductors the decay of hot quasi-particles proceeds in superconductors not only by scattering of quasiparticles among each other and with phonons, but also through Cooper formation. Analysis of Cooper pair formation in the time domain has the potential to shed light on the interaction which is responsible for it. This interaction is well understood for conventional BCS superconductors, but remains controversial for High-Tc-Superconductors (HTSC). The decay of laser-excited quasi-particles in HTSC has been investigated by optical pump-probe experiments. It proceeds on femto- and picosecond time scales [1,2]. Two decay processes were distinguished in the superconducting state at temperatures T_0 < T_c for a pump fluence of ˜10 µJ/cm2. The slower time of several ps increases towards T_c and was attributed to Cooper pair reformation. The faster time is several 100 fs and is rather independent on T_0 [1]. At higher fluence a significant part of the superconducting condensate is evaporated and hot quasiparticles are excited which leads in the optical experiment to a fast contribution in the monitored relaxation [2].

In comparison to optical techniques angle-resolved photoelectron spectroscopy (ARPES) is sensitive to the electron momentum parallel to surface. Therefore, time-resolved ARPES might provide new, relevant information for HTSC. In an earlier study we investigated BSCCO by time-resolved ARPES and estimated after high fluence excitation the electron-phonon coupling constant [4]. Recently, we achieved a sensitivity to low fluence excitation down to 6 µJ/cm2 and analyzed the quasi-particle decay as a function of momentum from the nodal towards the anti-nodal point of the gap function \Delta(E,k). We observe a hot quasi-particle population that increases towards the anti-node as expected from \Delta(E,k) and conclude that quasi-particles off the node become metastable due to phase space restrictions in a d-wave superconductor. The decay times agree with Cooper pair recombination, however, they bear no momentum dependence, which will be discussed in the context of the boson bottleneck active in Cooper pair recombination.

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