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Ultrafast momentum-dependent quasiparticle dynamics in high-T_c superconductors[1]

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Femtosecond time- and angle-resolved photoelectron spectroscopy trARPES facilitates insight into electronic relaxation and electronic structure of non-equilibrium states of matter [1]. Hot electrons and holes relax in metals on ultrafast time scales due to the screened Coulomb interaction [2]. In superconductors the relaxation rates of quasiparticles at energies close to the superconducting gap edge are reduced because of the loss of quasiparticle states near E_F. Since in the superconducting state the relaxation of optically excited carriers proceeds partly by Cooper pair reformation, the study of the quasiparticle dynamics bears the potential to analyze the interaction responsible for Cooper pair formation. Results of trARPES will be discussed for optimally doped $Bi_2Sr_2CaCu_2O_{8+\delta}$ in the superconducting state [2] and on $EuFe_2As_2$ in the antiferromagnetic state [3]. In the cuprate system we find a predominant excitation of quasiparticles at momenta near the antinode. We show furthermore, that at excitation densities of several 10 μJ/cm^2 quasiparticle relaxation is dominated by Cooper pair reformation, which again proceeds near the antinode. In the Fe-pnictide material we monitor a difference in the relaxation rate for electrons and holes near the Fermi momentum, which disappears above the Neel temperature. We conclude that this anisotropic relaxation of electrons and holes is a consequence of the optical modification of the antiferromagnetic order. Analysis of energy transfer from electrons to phonons allows to determine the momentum averaged electron-phonon coupling constant λ. We find values below 0.25 for $Bi_2Sr_2CaCu_2O_{8+\delta}$ [5] and below 0.15 for $EuFe_2As_2$ [4].

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