INVESTIGATING PAIRING INTERACTIONS WITH COHERENT CHAGE FLUCTUATION SPECTROSCOPY

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Nuclear magnetic resonance (NMR) and electron paramagnetic resonance (EPR) are well known tools to obtain dynamical information of spin degrees of freedom. A technique with similar versatility for charge degrees of freedom and their ultrafast correlations could move forward the understanding of systems like high-Tc cuprates. In conventional theories of superconductivity, the exchange of low-energy excitations produces an effective potential among electrons which is retarded in time, i.e. the action of one electron on another is delayed. Applicability of this idea to cuprates has been doubted and a completely different framework has been proposed involving non-retarded interactions.[1] Recently by perturbing the superconducting state in a cuprate using a femtosecond laser pulse, coherent oscillations of the Cooper pairs where generated for the first time[2]. The oscillations induce changes of the optical properties in resonance with well-defined electronic transitions which where detect with transient broad band reflectivity. We will show that the oscillations can be described by NMR/EPR-like formalism and provide information on the nature of the pairing interactions. In particular a resonance at the typical scale of Mott physics (2.6 eV) implies a substantial contribution of non-retarded interactions to the pairing, as in unconventional (non Migdal-Eliashberg) theories. These experiments demonstrate a new way to coherently control quantum states[3,4] on the fs time-scale, analogous to NMR/EPR, and suggest that in high-temperature superconductors almost instantaneous (1.5 fs) interactions play a role in the pairing mechanism.

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