Control of superconductivity in cuprate high temperature superconductors using intense THz light pulses

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Several experimental findings suggest that underdoped cuprates display precursors of superconductivity well above the transition temperature Tc [1,2]. In these materials, unlike in conventional superconductors, the loss of long-range phase order is one of the determining factors which inhibits su! perconductivity with a higher Tc. Here we report on the use of femtosecond mid-infrared control of lattice distortions [3,4] to excite large-amplitude vibrations of the apical oxygen ions in underdoped YBa2Cu3Ox. In this way we can induce a transient superconducting state far above the equilibrium Tc [5]. This method is an important addition to optical techniques at near-visible wavelength, which have been used in the past to investigate quasi-particle dynamics [6-8]. Two underdoped compounds were studied, YBa2Cu3O6.6 and YBa2Cu3O6.5, corresponding to hole doping levels of 11% and 9% and exhibiting superconducting transition temperatures Tc=62 K and Tc=50 K, respectively. Their time-dependent optical properties were probed as a function of pump-probe delay by time-domain THz-reflectivity (0.5-2.5 THz), after excitation with mid-infrared pulses at ~15 Âµm. A finite, transient superfluid density was observed in both materials up to room temperature, evidenced by a characteristic 1/Ï‰ frequency dependence in the imaginary part of the in-plane optical conductivity. Gapping in the real part of the conductivity, as well as a short-lived Josephson plasma edge along the c-axis are further evidence of a light-induced superconducting state. This experiment opens exciting prospects for optically-driven superconductivity in new regions of the phase diagram of high-Tc cuprates or in new materials.

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