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Ultrafast electric field gating of quantum transport in a cuprate superconductor

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In cuprate superconductors, tunneling between copper-oxide planes constitutes three-dimensional coherent transport. When a phase gradient of the condensate wavefunction is introduced perpendicular to the planes, the interlayer tunneling amplitude is reduced. As such, c-axis superconductivity becomes controllable by an external electric field resulting in a time-dependent phase modulation. Here, we use a single-cycle terahertz electric field to gate of superconducting transport bi-directionally in La1.84Sr0.16CuO4. Oscillations between superconducting and resistive states are induced, at a frequency controlled by the electric field strength. In-plane superconductivity remains unperturbed, giving rise to an exotic state in which the dimensionality of superconducting transport is time-dependent. Ultrafast gating of interlayer coupling across individual Copper-oxide planes is of interest for device applications in high-speed nanoelectronics. It also represents a novel example of nonlinear terahertz physics, applicable to nanoplasmonics and active metamaterials.

Primary author: DIENST, Andreas (University of Oxford)

Co-authors: CAVALLERI, Andrea (University of Hamburg - CFEL - University of Oxford); FAUSTI, Daniele (University of Hamburg - CFEL); TAKAGI, Hidenori (University of Tokyo - RIKEN); PETERSEN, Jesse (University of Oxford); HOFFMANN, Matthias (University of Hamburg - CFEL); PYON, S (University of Tokyo); TAKAYAMA, Tomohiro (University of Tokyo)

Presenter: DIENST, Andreas (University of Oxford)

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