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Ultrafast Control of Electron-Phonon Coupling in LNSCO and LESCO

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The emergence of d-wave superconductivity from the Mott insulating state in the cuprates is widely understood to result from the action of strong electron-electron interactions. Nevertheless, the parallel role of the electron-phonon interaction in defining the cuprate phase-diagram is highlighted by the ubiquitous presence of charge-density-wave correlations in these materials. Although non-equilibrium studies have reported the observation of a transient superconducting state generated in response to the resonant pumping of select phonon modes [1], relatively little is understood about the dynamic properties of the electron-phonon interaction itself. Using time-resolved resonant x-ray scattering from $La_{1.65}Eu_{0.2}Sr_{0.15}CuO_4$ we studied the dynamic evolution of charge-density-wave order in response to ultrafast optical excitation, as a function of temperature and excitation fluence [2]. In a recent follow-up investigation, we tracked the corresponding structural dynamics across a wide doping range in both $La_{1.6-x}Nd_{0.4}Sr_xCuO_4$ and $La_{1.8-x}Eu_{0.2}Sr_xCuO_4$, which demonstrates that the transfer of energy from the transiently excited electronic system to the lattice becomes more rapid by at least one order of magnitude when entering the charge-density-wave phase. Most intriguingly, we demonstrate that the electron-phonon interaction strength can be renormalized by manipulating electronic degrees of freedom alone, thereby allowing ultrafast control of the electron-phonon coupling in these cuprates.

References:
1. D. Fausti et al. *Science* **331**, 189–191 (2011).
2. M. Bluschke, N. Gupta et al. *PNAS* **121**, e2400727121 (2024).

Primary author: BLUSCHKE, Martin (Quantum Matter Institute - University of British Columbia, Vancouver, Canada)

Presenter: BLUSCHKE, Martin (Quantum Matter Institute - University of British Columbia, Vancouver, Canada)

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