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Decoupling of static and dynamic charge correlations revealed by uniaxial strain in a cuprate superconductor

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The physics of charge order in high-temperature superconducting cuprates is still largely unexplained. While the formation of one-dimensional charge modulations is a common feature of the two-dimensional Hubbard model, no calculation yet succeeds in reproducing even the basic properties of charge order. Recent experiments revealed the presence of strong quantum fluctuations associated to the charge order parameter [1]. Their doping and temperature dependence suggests the closeness to a quantum critical point (QCP). The energy of such collective modes also links them to the strange metal phase, associating this QCP with the pseudogap endpoint at doping $p \sim 0.19$ [2]. Indeed, the scattering provided by charge fluctuations could explain the quasi-isotropic scattering rate at the base of the strange-metal behavior. The study of the interplay between charge order, fluctuations and phonons has therefore the potential to shed light on the complex normal state of cuprates.

We used high-resolution Resonant Inelastic X-ray Scattering (RIXS) to investigate the electronic and phonon excitations in the prototypical stripe-ordered cuprate $\text{La}_{2-x}\text{Sr}_x\text{CuO}_4$. We employed a strain device developed in our group to apply a small, in-plane uniaxial strain along the copper-oxygen direction, pinning charge order to the perpendicular direction [3]. This allowed us to investigate the properties of the associated quantum fluctuations, of phonon softening and of the electron phonon coupling in a detwinned striped state. Our measurements highlight a clear connection between quantum charge fluctuations and bond-stretching phonons. At the same time, we reveal a non-trivial relationship between the charge order parameter and its quantum fluctuations, which display a different symmetry [4].

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