Change in density wave mechanism at cuprate quantum phase transition

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Strong electronic interactions within the cuprates give rise to an array of unconventional phases. Multiple broken symmetries have been observed, and yet a complete description of how they arise is missing. It has long been proposed that the phase diagram is shaped by a quantum critical point beneath the superconducting dome. The T=0 phase transition thought to host this critical point is characterized by a topological change in the Fermi surface structure, where at hole doping p*, truncated Fermi arcs jump to a large Fermi surface. Decoding the structure of the phase diagram requires understanding the evolution of the driving electronic interactions across the phase diagram, but especially in the vicinity of the quantum phase transition.

In $(Bi,Pb)_2(Sr,La)_2CuO_{6+\delta}$ (Bi2201), density wave (DW) order extends across p*, such that the low temperature charge modulations are a fingerprint of the evolving ground state electronic interactions. Using sub-unit-cell spectroscopic imaging, we discover a dramatic change in the doping dependence of the wavevector, Q_{DW}, coincident with the Fermi surface transition. On the overdoped side, an incommensurate Q_{DW} evolves with doping, while on the underdoped side, Q_{DW} is doping independent and consistent with a commensurate four unit cell modulation. While an incommensurate to commensurate transition suggests a dichotomy between fermiology-driven and strong coupling mechanisms, a discrepancy between the doping-dependence of the incommensurate wavevector and the Fermi surface, provides evidence for persistent effects of strong correlations past the transition.