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Phase competition in trisected superconducting dome

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The momentum-resolved nature of angle-resolved photoemission spectroscopy (ARPES) has made it a key probe of emergent phases in the cuprates, such as superconductivity and the pseudogap, which have anisotropic momentum-space structure. ARPES can be used to infer the origin of spectral gaps from their distinct phenomenology—temperature, doping, and momentum dependence, and this principle has been used to argue that the pseudogap is a distinct phase from superconductivity, rather than a precursor [1]. We have studied $\text{Bi}_2\text{Sr}_2\text{CaCu}_2\text{O}_{8+\delta}$ (Bi-2212) using laser-ARPES, and our data give evidence for three distinct quantum phases comprising the superconducting ground state, accompanied by abrupt changes at $p \sim 0.076$ and $p \sim 0.19$ in the doping-and-temperature dependence of the gaps near the bond-diagonal (nodal) direction [2]. The latter doping likely marks the quantum critical point of the pseudogap, while the former represents a distinct competing phase at the edge of the superconducting dome. Additionally, we find that the pseudogap advances closer towards the node when superconductivity is weak, just below T_c or at low doping, and retreats towards the antinode well below T_c and at higher doping. This phase competition picture together with the two critical doping are synthesized into our proposed phase diagram, which also reconciles conflicting phase diagrams commonly used in the field. Our results underscore the importance of quantum critical phenomena to cuprate superconductivity, provide a microscopic picture of phase competition in momentum space, and predict the existence of phase boundaries inside the superconducting dome which are different from simple extrapolations from outside the dome.

[1] I. M. Vishik, W. S. Lee, R.-H. He, M. Hashimoto, Z. Hussain, T. P. Devereaux, and Z.-X. Shen. *New J. Phys.* **12**, 105008 (2010).

[2] I. M. Vishik, M. Hashimoto, R.-H. He, W. S. Lee, F. Schmitt, D. H. Lu, R.G. Moore, C. Zhang, W. Meevasana, T. Sasagawa, S. Uchida, K. Fujita, S. Ishida, M. Ishikado, Y. Yoshida, H. Eisaki, Z. Hussain, T. P. Devereaux, and Z.-X. Shen, *Submitted* (2011).