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Separation of charge-order and magnetic QCPs in heavy fermions and high T_c cuprates

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The Fermi surface topology of high temperature superconductors inferred from magnetic quantum oscillation measurements provides clues for the origin of unconventional pairing thus previously not accessed by other spectroscopy techniques. While the overdoped regime of the high T_c phase diagram has a large Fermi surface consistent with bandstructure calculations, the underdoped regime of $YBa_2Cu_2O_{6+x}$ is found to be composed of small pockets. There is considerable debate as to whether the small observed "pocket" is hole-like or electron-like− whether the Fermi surface is best described by a t-J model or a conventional band folding picture− whether or not a Fermi liquid description applies− or− whether bilayer coupling splits the degeneracy of the observed pockets. We (myself and collaborators) have now collected an extensive body of experimental data that brings this debate to rest, but raises new questions about the nature of itinerant magnetism in underdoped high T_c cuprates. Quantum oscillation measurements are performed on multiple samples in magnetic fields extending to 85 T, temperatures between 30 mK (dilution fridge in dc fields to 45 T) and 18 K, over a range of hole dopings and with samples rotated in-situ about multiple axes with respect to the magnetic field. We perform a topographical map of the Fermi surface, enabling the in-plane shape of one of the pockets to be determined− imposing stringent constraints on the origin of the Fermi surface. While quantum oscillations measurements are consistent with a topological Fermi surface change associated with magnetism near optimal doping, they also point to a secondary instability deep within the underdoped regime beneath a high T_c superconducting sub-dome. An steep upturn in the quasiparticle effective mass is observed on underdoping, suggestive of a quantum critical point near $x = 0.46$ separating the metallic regime (composed of small pockets) from a more underdoped insulating charge-ordered regime (earlier reported in neutron scattering measurements). Our findings suggest the importance of two critical instabilities affecting the Fermi surface beneath the high T_c superconducting dome(s). While one of these has been proposed to provide the likely origin of unconventional pairing in the cuprates, the other can be an important factor in boosting transition temperatures.

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