Fermi surface reconstruction and approach to a metal-insulator QCP in the underdoped cuprates

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Quantum oscillation measurements on the underdoped cuprate YBa2Cu3O6+x are presented over a wide magnetic field range up to 85T, and a broad temperature range between 100 mK and 20K. We show that Fermi Dirac statistics govern the elementary excitations even in this strongly correlated material in close proximity to the Mott insulating phase. The high resolution of these measurements enable multiple small sections of Fermi surface located at different locations in the Brillouin zone to be detected, indicating reconstruction by a long range order parameter. While the precise nature of this order parameter remains elusive, we demonstrate via our measurements that it must involve spin degrees of freedom. We further trace a single small section of Fermi surface toward the Mott insulating regime, and find a dramatic increase in effective mass at a metal-insulator quantum critical point (QCP), located under a local maximum in the YBCO superconducting dome. Possible mechanisms that drive this QCP, and their potential relation to enhanced superconducting temperatures are further investigated.