MAR14-2013-001440

Abstract for an Invited Paper
for the MAR14 Meeting of
the American Physical Society

Doping evolution of the magnetic excitations in the cuprates and its implications for high temperature superconductivity[1]

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In the heavily overdoped cuprates such as $La_{2-x}Sr_xCuO_4$ ($x > 0.3$) superconductivity disappears despite the high electronic density of states. We used Cu L_3 edge resonant inelastic x-ray scattering (RIXS), to measure the magnetic excitations across the whole $La_{2-x}Sr_xCuO_4$ phase diagram. In the region of the Brillouin zone accessible with RIXS, the magnons resulting from local moment physics in La_2CuO_4 evolve smoothly into broadened, damped paramagnons in the overdoped state where itinerant quasi-particles dominate most properties of the cuprates [1]. I will discuss the implications of this observation for theoretical models of magnetism in the cuprates. The fact that paramagnons persist relatively unchanged as superconductivity disappears is very difficult to reconcile with theories that suggest these high-energy paramagnons seen by RIXS are causing superconducting pairing. This does not, however, exclude the lower energy magnetic excitations in other regions of the Brillouin zone, as possible candidates for causing superconducting pairing. Looking to the future, the availability of higher energy resolution and full angular freedoms in RIXS instrumentation will allow us to measure the relationship between static ordering such a charge stripes and magnetic excitations in a single experiment, as illustrated by our studies of $La_{1.875}Ba_{0.125}CuO_4$.

[1] M. P. M. Dean et al. Nature Materials 12, 1019-1023 (2013).

[1]Support from the Center for Emergent Superconductivity and the Department of Energy is gratefully acknowledged.