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Doping evolution of the magnetic excitations in the high-temperature superconducting cuprates

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High resolution resonant inelastic x-ray scattering (RIXS) has recently emerged as a highly sensitive probe of magnetic excitations –it can even be used to measure magnetic excitations in isolated one-unit-cell-thick La2CuO4 layers [1]. This talk will describe how RIXS has provided new insights into the magnetic excitations in the high-temperature superconducting cuprates.
Photoemission and scanning tunneling spectroscopy have given us exquisitely detailed picture of the electronic structure of Bi2Sr2CaCu2O8+delta, but little is known about its high-energy (>100 meV) magnetic response. Using RIXS we measure the magnetic response [2] and show that a phenomenological theory based on electron pockets can consistently describe the electronic and magnetic response of this cuprate [2, 3].
In the heavily overdoped cuprates such as La2-xSrxCuO4 (x>0.3) superconductivity disappears despite the high electronic density of states. We used RIXS to measure the magnetic excitations across the whole La2-xSrxCuO4 phase diagram. The magnons induced by local moment physics in La2CuO4 evolve smoothly into broadened paramagnons in the overdoped state where itinerant quasi-particles dominate most properties of 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, rather than the lower energy magnetic excitation in other regions of the Brillouin zone, are causing superconducting pairing [4].

[1] M. P. M. Dean et al. Nature Materials 11, 850–854 (2012)
[2] M. P. M. Dean et al. Phys. Rev. Lett. 110, 147001 (2013)
[3] A. J. A. James, T. M. Rice and R. M. Konik, Phys. Rev. B 86, 100508(R) (2012)
[4] M. P. M. Dean et al. arXiv:1303.5359 (2013) (in press at Nature Materials.)

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