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Near the superconducting edge: the central mode and spin confinement in cuprates

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Marginally above the critical doping for superconductivity, we find a dramatic softening of the spin fluctuations and a central mode spectrum similar to that above certain structural and magnetic phase transitions. We demonstrate in $YBCO_{6+x}$for x= 6.354, where T_c=18K is five times less than optimal, that the spins fluctuate an order of magnitude more slowly than a typical resonance energy[1,2], with a relaxation rate of only ∼3 meV. The central mode width is less than 0.1 meV but is finite and decreases below T_c. Its strength grows on cooling but there is no antiferromagnetic (AF) transition since the correlations indicate that spin clusters are confined to 8 cells in the plane and one cell between planes. Surprisingly, polarized neutrons show that the spins fluctuate equally in all directions with triplet symmetry, with none of the anisotropy of the ordered AF Mott insulator, x=6.15. Although the doping of 6% is close to critical for superconductivity, the system properties indicate it is relatively far from the AF critical point. Topological structures such as the Nagaoka polaron that destroy AF correlations over many sites per doped hole may be needed to account for a spin response that is both short range and unpolarized. The spin resonance behaves with reduced doping as a damped soft mode that drives a central mode and destroys the superconducting phase. 1. C. Stock, W.J.L. Buyers, et al., Phys. Rev. B 69, 014502 (2004) 2. C. Stock, W.J.L. Buyers, et al., condmat/0408071, Phys. Rev. B accepted (2005).

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