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Two Energy Scales in the Spin Excitations of $La_{2-x}Sr_xCu0_4$[1]

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There has recently been considerable progress in electronic quasiparticle spectroscopy of high-Tc superconductors. Angle resolved photoemission and tunnelling indicate that the quasiparticles are strongly coupled to excitations with energies in the range 40-70 meV. The recent debate has focused around phonons being the coupled excitations. The focus on phonons is largely because high-resolution phonon spectra are available and they contain considerable structure. Collective spin excitations are promising candidates for the strongly coupled excitations. However high resolution neutron data in the relevant 40-70 meV energy range have not been available for compounds where the quasiparticle anomalies are observed. In order to fill this gap in our knowledge, we have prepared 50g of single crystals of $La_{1.84}Sr_{0.16}CuO_4$ and carried out a new study of the magnetic excitations over a wide energy range, with considerably better energy resolution than our previous studies, and with good momentum resolution. Experiments were carried out using the MAPS spectrometer at the ISIS spallation neutron source. Our results demonstrate that the magnetic excitations have a two component structure with a low-frequency component strongest around 18 meV and a broader component strongest near 40-70 meV. The second component carries most of the spectral weight and its energy matches structure seen in photoemission and tunnelling spectra in the range 50-90 meV. Thus collective spin excitations may explain features of quasiparticle spectroscopies and are therefore likely to be strongly coupled excitations. The high-frequency excitations are most naturally interpreted as being due to residual antiferromagnetic interactions.

[1] e.g. A. Lanzara, Nature 412, p510 (2001)
[2] e.g. J Lee et al., Nature 442, p546 (2006)

[1]Work in collaboration with B. Vignolle, D.F. McMorrow, H.M. Ronnow, C. Frost and T.G. Perring.