Experimental Report

Proposal: **DIR-121** **Council:** 10/2012

Title: Polarized-neutron verification of the magnetic nature of a new feature in high-temperature superconductor YBa2Cu3O6.6

This proposal is a new proposal

Researh Area:

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Samples: YBa2Cu306.6

Instrument	Req. Days	All. Days	From	To
IN20	2	2	04/08/2013	06/08/2013

Abstract:

Experimental report DIR-121

Search for a new type of magnetic excitations with spin-polarized neutrons in high-temperature superconductor $YBa_2Cu_3O_{6.6}$

Summary: Following up on the discovery of weakly dispersing magnetic excitations which are present throughout the entire 2D Brillouin zone in the pseudogap phase of the single-layer cuprate superconductor $HgBa_2CuO_{4+x}$ (Hg1201) [1], we investigated the presence of analogous magnetic modes in the double-layer system $YBa_2Cu_3O_{6+x}$ ($YBCO_{6+x}$). In our previous polarized IN20 experiment in March 2013 [2] on an underdoped $YBCO_{6.6}$ sample, we found no evidence for such new excitations in the energy range from 25meV to 65meV for a momentum transfer with even parity upon exchange of the two nearest CuO_2 layers (L=6.8). With this experiment on the same sample, we investigated a momentum transfer away from the antiferromagnetic wave vector with odd parity (L=5.1) in a similar energy range. Again, we found no evidence for the new type of magnetic excitations. Since in Hg1201 the new excitations seem related to the antiferromagnetic spin fluctuations, with one mode at the energy of the resonance mode [1], our data on $YBCO_{6.6}$ could indicate that such new types of magnetic excitations are not generic to the cuprate superconductors.

Sample and setup: The $YBCO_{6.6}$ sample which we investigated is a large array of more than 80 twinned single crystals with a total mass of more than 9 grams. We were using IN20 equipped with CryoPAD and an orange cryostat, employing a Heusler (111) monochromator and analyzer with fixed k_f = 4.1Å^{-1}. A good flipping ratio of around 11 has been determined on nuclear Bragg peaks as in our previous experiment. The problem with the CryoPAD nutator cables giving rise to a spurion in the polarization analysis [2] had been fixed prior to this experiment.

Report: We mounted our $YBCO_{6.6}$ sample inside CryoPAD with reciprocal-lattice vectors (H, H, L) in the horizontal scattering plane. Performing a longitudinal polarization analysis, we measured with neutron polarizations along Q, perpendicular to Q in the scattering plane, and out of the scattering plane (x, y, and z, respectively). After obtaining a rough momentum dependence of the resonance mode with a scan at constant energy transfer of 35meV through Q=(-0.5, -0.5, 5.1), we performed an energy scan at Q=(-0.25, -0.25, 5.1) for energies between 23meV and 47meV, see Figure 1. The extracted magnetic signal from the intensity combination (2X-Y-Z) is shown in the right panel of Figure 1, with no detectable intensity.

Special care had been taken to perform this experiment with the same experimental settings as for our previous experiment [2]. We note, however, that while we had similar neutron flux for both experiments (monitor per time), the efficiency (intensity per monitor) of this experiment was considerably lower than for the previous experiment in March 2013. We need to apply a factor of ~1.5 to scale up our new data to match the intensities of Bragg peaks, a phonon and the resonance mode at 35meV. We suspect that this might be related to a change in the efficiency of the IN20 analyzer between the two experiments.

These data put tight constraints on the presence of weakly dispersing Ising-like magnetic modes in $YBCO_{6+x}$. Our strategy of studying a large array of high-quality single crystal $YBCO_{6+x}$ has proven successful, with good signal-to-background ratio [2]. Therefore, we

think that further searches for new magnetic excitations in $YBCO_{6+x}$ should follow up on this strategy.

References

[1] Y. Li *et al.*, *Nature* **468**, 283–285 (2010); *Nature Phys.* **8**, 404–410 (2012).
[2] IN20 experimental report 4-01-1196.

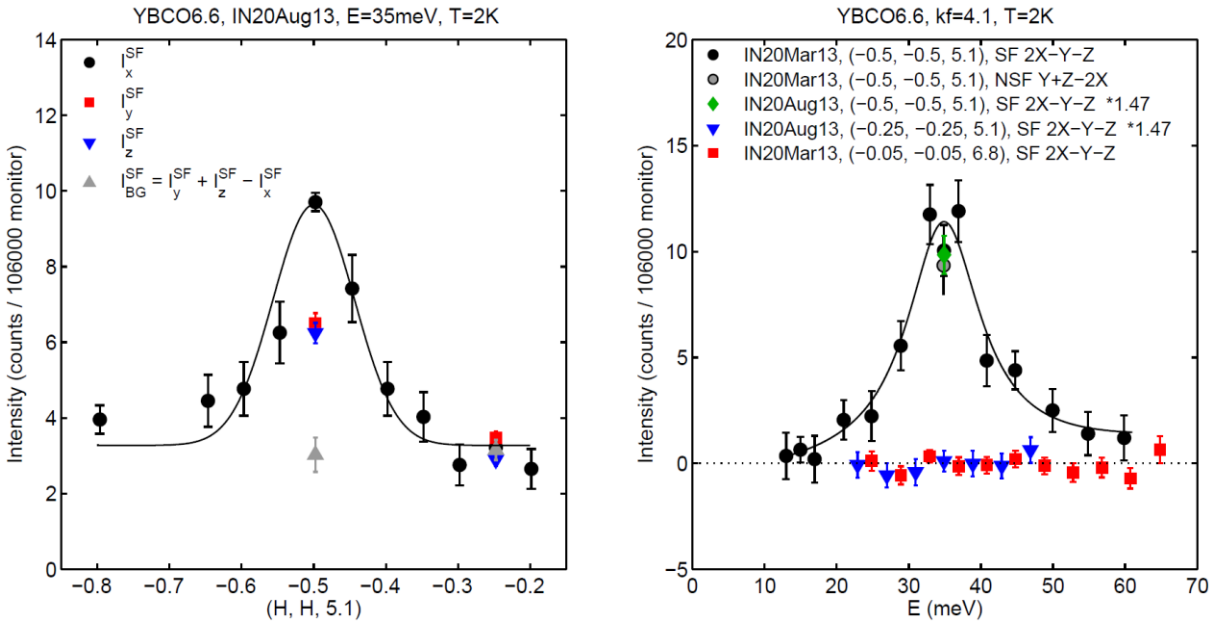

Figure 1 Left: Momentum scan through the resonance mode at 35meV energy transfer. The main part of this experiment has been spent on an energy scan with Q=(-0.25, -0.25, 5.1) for energies close to the resonance energy. These data are shown in the right panel, scaled up to match the data obtained at IN20 in March 2013 on the same sample.