Experimental Report

Proposal: **TEST-2327** **Council:** 10/2012

Title: Investigation of unusual spin-density-wave order in YBa2Cu3O6+x with spin-polarized neutrons

This proposal is a new proposal

Researh Area:

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Local Contact: IVANOV Alexandre

Samples: YBa2Cu3O6.4

Instrument	Req. Days	All. Days	From	To
IN14	2	2	07/08/2013	09/08/2013

Abstract:

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(07/08/2013 to 09/08/2013)

Summary: With this experiment we performed polarized neutron scattering measurements of the incommensurate spin density wave (SDW) order in strongly underdoped $YBa_2Cu_3O_{6.4}$ (superconducting T_c=20K, hole doping p=0.07). Our previous measurements revealed an unusual in-plane structure of the quasi-elastic magnetic response in this sample, with both a commensurate central peak at the antiferromagnetic wave vector Q_{AF} = (0.5, 0.5, L) and incommensurate shoulders in the H-direction, which could be resolved for the first time [1]. In order to improve our understanding of the orientation of the magnetic moments, we compared the intensities at (0.5, 0.5, 2) and (1.5, 0.5, 2) in this experiment.

Sample and setup: Our sample was a mosaic of about 80 detwinned $YBa_2Cu_3O_{6.4}$ single crystals on a silicon sample holder (total mass of the crystals: 2.5g). We used IN14 equipped with Helmholtz coils for polarization analysis. The final wave vector was fixed to k_f=2.662A^{-1}. No collimation was used to maximize the neutron flux.

Report: The $YBa_2Cu_3O_{6.4}$ sample was aligned in the (H, K, 4*K) scattering plane and quasi-elastic H-scans were performed through the antiferromagnetic wave vector Q_{AF} = (0.5, 0.5, 2) and (1.5, 0.5, 2). As our sample is superconducting with T_c=20K, we heated up above T_c when changing the polarization. The spin density wave sets in below the crossover temperature T_{SDW}~30K and measurements were performed at T=2K.

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). It is essential to measure at several values of Q in order to be able to reconstruct the incommensurate spin structure in underdoped $YBa_2Cu_3O_{6+x}$, as one thereby probes different projections of the magnetization to the plane perpendicular to Q. We therefore attempted to compare the intensities at (0.5, 0.5, 2) and (1.5, 0.5, 2).

As shown in Figure 2, the intensity at (1.5, 0.5, 2) amounts to ~33% of the intensity at (0.5, 0.5, 2). This is less than expected from magnetic structure factor measurements and calculations assuming an aspherical Cu(2) form factor performed on the $YBa_2Cu_3O_{6+x}$ parent compound [2]. The $YBa_2Cu_3O_{6+x}$ parent compound has equally populated domains with moments along the two in-plane directions and our results suggest that the moments in $YBa_2Cu_3O_{6.4}$ are dominantly oriented along the crystallographic a-direction. However, it would be important to compare to the intenisty at (0.5, 1.5, 2), which should be higher.

Problems during the measurement: As is apparent in Figure 1, we suffered from a high spin-flip background for both (0.5, 0.5, 2) and (1.5, 0.5, 2). In future measurements a PG filter might be helpful. Due to limited time, we sticked to the initial experimental configuration without a PG filter.

References

[1] T. Loew *et al.*, ILL experimental reports 4-01-1053 and 4-01-1121.
[2] S. Shamoto *et al.*, *PRB* **48**, 13817 (1993); H. Casalta *et al.*, *PRB* **50**, 9688(R) (1994).

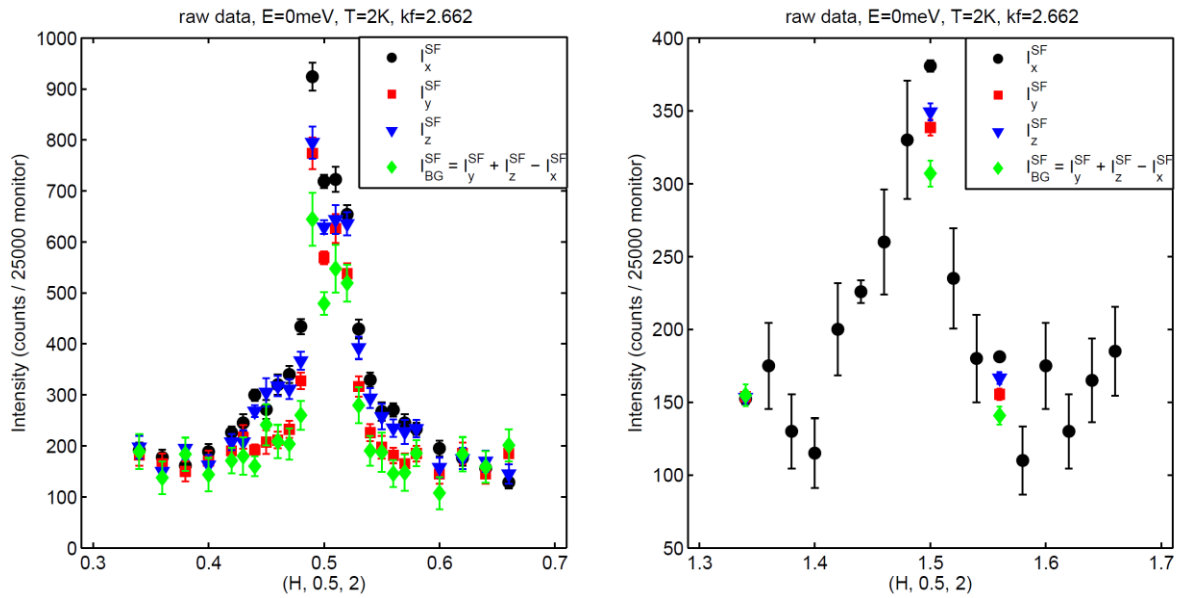

Figure 1 Raw polarized neutron scattering data of the quasi-elastic response of $YBa_2Cu_3O_{6.4}$ (T_c=20K, p=0.07) at T=2K. Left: H-scan through (0.5, 0.5, 2). Right: H-scan through (1.5, 0.5, 2). Shown is the neutron scattering intensity in the spin-flip (SF) channel for x, y, and z polarizations (see text). A high spin-flip background due to second order contamination is apparent in both panels. Measurements with fixed k_f = 2.662A^{-1}.

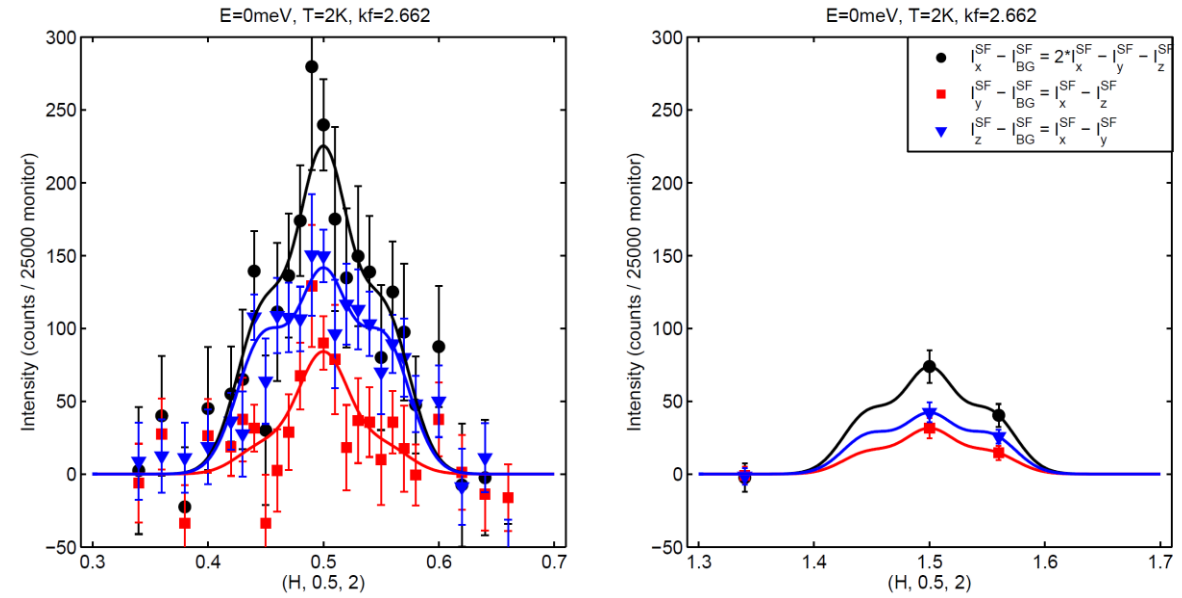

Figure 2 Intensity comparison of polarized neutron scattering data shown in Figure 1 after correcting for the background (see legend). Shown is the neutron scattering intensity for (0.5, 0.5, 2) and (1.5, 0.5, 2) at T=2K in the spin-flip (SF) channel for x, y, and z polarizations. The intensity at (1.5, 0.5, 2) amounts to ~33% of the intensity at (0.5, 0.5, 2).