Experimental Report

Proposal: **4-01-1368** **Council:** 4/2014

Title: Study of the temperature dependence of the hour-glass dispersion in cobaltates

This proposal is a new proposal

Researh Area: Physics

Main proposer: **KOMAREK ALEXANDER CHRISTOPH**

Experimental Team: LI Zhiwei
GUO Hanjie

Local Contact: PIOVANO Andrea

Samples: La2-xSrxCoO4 (x=0.4)

Instrument	Req. Days	All. Days	From	To
IN8	4	4	20/11/2014	24/11/2014

Abstract:

The discovery of charge stripe ordering in nickelate and cuprate systems has triggered a lot of research activity due to the possible relevance of charge stripes for the pairing mechanism in the HTSC cuprates. Recently, an hour-glass magnetic spectrum resembling on the famous excitations in the cuprates has been found in La5/3Sr1/3CoO4. This observation was believed to corroborate the connection between hour-glass-shaped magnetic excitation spectra and charge stripes (either static or dynamic). In contrast to that we were able to show that charge stripes play no crucial role for the emergence of the hour-glass dispersion in the cobaltates. Instead, frustration seems to be the key feature that triggers the onset of the hour-glass spectra in these materials. In our recent study the temperature dependence of these hour-glass spectra was missing. Exactly this temperature dependence could give important information for our spin wave simulations and help us to understand the detailed mechanism of the hour-glass dispersion. Therefore, we propose to measure the missing temperature dependence of the hour-glass dispersion in our La1.6Sr0.4CoO4 high quality single crystals.

Study of the temperature dependence of the hour-glass dispersion in cobaltates

Experimental Team: Z. W. Li, H. J. Guo, and A. Piovano

Hour-glass shaped magnetic excitation spectra have been observed by neutron scattering measurements in high temperature superconducting cuprate materials [1,2]. Understanding the origin of the hour-glass spectrum would be an important step towards a final microscopic model for the high temperature superconductivity. Fluctuating charge stripe and band structure approaches are two promising models proposed for these hour-glass magnetic excitations [3]. Recently, hour-glass spectra have been also observed in single-layered cobaltates [4] and manganates [5]. Very recently, our work on these hole-doped cobaltates has shown that there is essentially no significant role of charge stripes and revealed nanoscopic phase separation as the origin of these hour-glass spectra [6,7]. In this experiment we studied the temperature dependence of the hour-glass spectrum at the IN8 spectrometer. Our 38% Sr-doped cobaltate sample was aligned with [100]/[010] orientation in the scattering plane. A PG monochromator and analyzer with double focusing mode were used. First, we measured the hour-glass dispersion at base temperature as shown in **Fig. 1**. It is clear that the magnetic excitation matches well with our recent publication for similar compounds with x=1/3 and 0.4 [6,7]. The incommensurability for the elastic scan amounts to $2x\varepsilon=0.385$ being very close to the value expected from our nominal doping level which confirms that our sample essentially has a stoichiometric oxygen content. To follow the temperature dependence of the hour-glass dispersion, we measured Q-scans at constant energy of 5 meV and 30 meV as shown in **Fig 2**. For the 5 meV scan, the observed two peaks changes significantly with increasing temperature. Namely, the peak position shift towards Q_{AFM} with increasing temperature. This feature, however, was different for the 30 meV scan where we observed almost no shift for the peak positions and the peaks only broadens as the temperature going up to 300 K. The different temperature dependence of low- and high-energy parts of the hour-glass dispersion suggests that the two parts have a different origin which would nicely fit in our recently proposed *nano phase separation scenario* of the hour-glass dispersion in cobaltates [7].

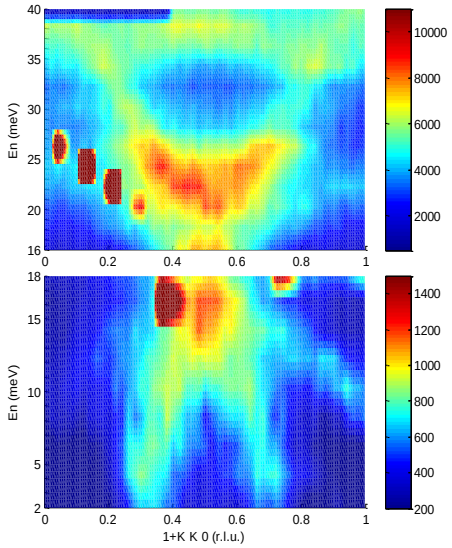

Fig. 1 Neutron scattering intensity maps of the magnetic excitation spectrum of $La_{1.62}Sr_{0.38}CoO_4$.

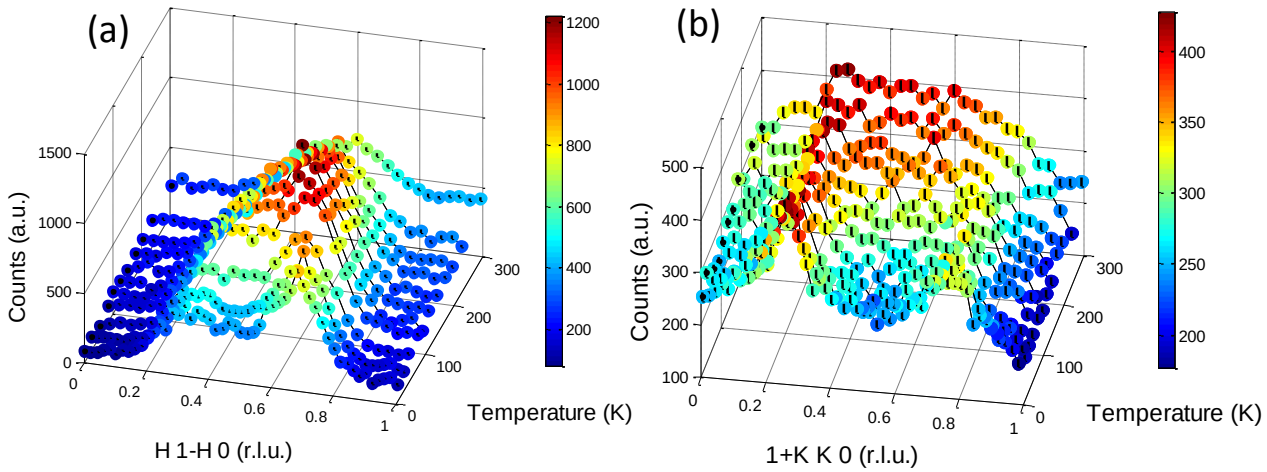

Fig. 2 Temperature dependence of the hour-glass dispersion (a) Temperature dependence of constant energy-scans at 5 meV. (b) Temperature dependence of constant energy-scans at 30 meV.

References:

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[2] J. M. Tranquada, et al., Nature 375, 561 (1995)

[3] M. Vojta, Adv. Phys. 58, 699 (2009)

[4] A. T. Boothroyd, et al., Nature 471, 341 (2011)

[5] H. Ulbrich, et al., Phys. Rev. Lett. 108, 247209 (2012)

[6] Y. Drees, et al., Nat. Commun. 4, 2449 (2013)

[7] Y. Drees, et al., Nat. Commun. 5, 5731 (2014)