Experimental report

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Title: Polarization analysis of hour-glass-shaped magnetic excitations in La2-xSrxCoO4

Research area: Physics

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Samples: La2-xSrxCoO4 (x=0.4)

Instrument	Requested days	Allocated days	From	To
IN20 CPA	6	6	30/06/2015	06/07/2015

Abstract:

The recent discovery of an hour-glass shaped magnetic excitation spectrum in insulating layered cobaltates has shown that Fermi surface effects are not needed for the emergence of hour-glass spectra. Very recently, we were able to go one step further and show that, in addition, also charge stripes are not needed for the observation of hour-glass spectra (i.e. in these cobaltates). Instead, we proposed a different scenario entirely based on frustration. Our spin wave simulations support this interpretation. Moreover, our spin wave simulations predict a different polarization dependence for certain well-separated excitations within the hour-glass dispersion. We were able to verify our predictions in a first test measurement on our cobaltates with polarized neutrons at the IN22 spectrometer. Here, we propose to study the entire hour-glass magnetic excitation spectrum of our cobaltate with polarized neutrons up to highest energies. We will provide an extremely large sample mass of 50 g in total by co-aligning several huge high-quality single crystals in order to guarantee the success of this proposed experiment. For these purposes we ask for 6 days at the IN20 spectrometer

Polarization analysis of hour-glass-shaped magnetic excitations in $La_{2-x}Sr_xCoO_4$

In most high-temperature superconducting cuprates a magnetic excitation spectrum with an 'hourglass' shape was observed [1]. It was at first a singular property of these high Tc cuprates so that the recent observation of such an hour-glass spectrum in a non-copper containing, hole doped cobaltate, which also exhibits incommensurate magnetic order, attracted considerable attention [2,3]. It was proposed that these hourglass features are induced by (diagonal) charge stripes [2] which then, in return, corroborates (fluctuating) charge stripe scenarios in the high Tc cuprates [2]. However, we have discarded this charge stripe scenario recently [3-6]. Instead we were able to connect the emergence of hour-glass spectra to *nano phase separation* [4-6]. We also observed a hitherto unknown magnetic mode above the entire hour-glass magnetic spectrum that could be understood within our *nano phase separation* scenario, see Ref. [4].

In order to clarify the origin of the upper and lower branches of the hour-glass shaped magnetic excitations in $La_{2-x}Sr_xCoO_4$ (x = 0.37) we have performed neutron scattering experiments with polarization analysis at the IN20 spectrometer. The experimental configuration was as follows: doubly focusing Heusler monochromator – sample – PG filter – horizontally focusing Heusler analyzer. The sample was aligned with the *ab*-plane in the scattering plane. Low energy branches were measured with kf = 2.662 $Å^{-1}$, and the high energy branches were measured with kf = 4.1 $Å^{-1}$. For each (Q,E)-point we measured the four polarization channels: $\sigma_{x\bar{x}}$, $\sigma_{\bar{x}x}$, $\sigma_{y\bar{y}}$ and $\sigma_{z\bar{z}}$. Thus, we were able to extract the in-plane and out-of-plane excitations (i.e. $1/2\,\sigma_{x\bar{x}} + 1/2\,\sigma_{\bar{x}x} - \sigma_{y\bar{y}}$ and $1/2\,\sigma_{x\bar{x}} + 1/2\,\sigma_{\bar{x}x} - \sigma_{z\bar{z}}$ respectively). The resulting neutron scattering intensities are plotted as a function of energy and momentum transfer in **Fig. 1**. As can be seen from **Fig. 1(c-d)**, all magnetic excitations within the "conventional" hour-glass spectrum are in-plane excitations whereas the novel high energy branch above the hour-glass entirely consist of out-of-plane excitations, see **Fig. 1(e-f)**. Our results, therefore, nicely confirm our numerical spin wave calculations in Ref. [4] and, thus, our novel *nano phase separation* scenario.

References

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

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

[3] Y. Drees,.. and A.C.Komarek, Nature Communications 4, 2449 (2013)

[4] Y. Drees,.. and A.C.Komarek, Nature Communications 5, 5731 (2014)

[5] H. Guo,.. and A.C.Komarek, Phys. Status Solidi RRL 9, 580-582 (2015)

[6] Z. W. Li,.. and A.C.Komarek, J Supercond Nov Magn (2015) accepted, doi: 10.1007/s10948-015-3302-4

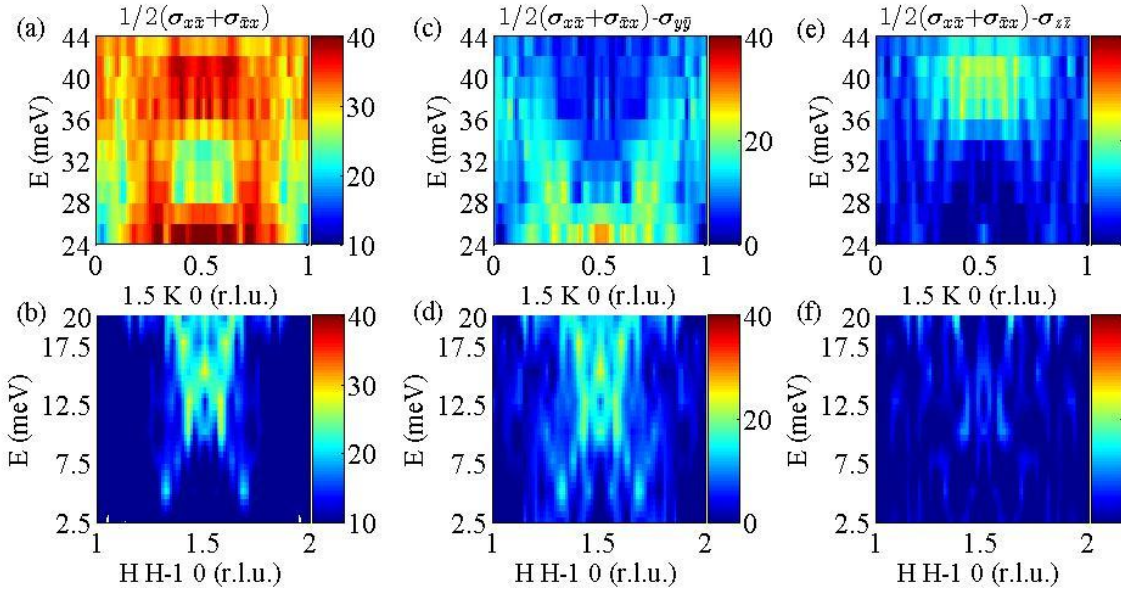

Fig. 1 Polarized neutron scattering measurements in four channels. (a) and (b) show the excitations from both in- and out-of-plane components, (c) and (d) show the in-plane excitations, and, (e) and (f) show the out-of-plane excitations.