Experimental report

14/02/2019

Proposal: **4-02-540**

Council: 4/2018

Title: First discovery of an hour-glass spectrum in oxygen doped cobaltates

Research area: Physics

This proposal is a continuation of 5-15-614

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Samples: $La_2CoO_{4.18}$

Instrument	Requested days	Allocated days	From	To
IN20 CPA	7	7	12/10/2018	19/10/2018

Abstract:

For the first time we discovered an hour-glass magnetic spectrum in an oxygen-doped cobaltate. Compared to the Sr-doped cobaltates the exchange interactions are distinctly smaller in this system which enables us to study our novel nano phase separation model for an entirely different scenario (with differnt J) which will help us to obtain an understanding of hour-glass spectra. As an 'input' parameter for such a model, we need to know all structural details. However, we are already facing the problem to distinguish and to disentangle magnetic from structural (i) octahedral tilting, (ii) charge and (iii) oxygen ordering contributions. Are there charge stripe correlations together with checkerboard charge order? How many different kinds of magnetic correlations are present? In order to address these fundamental questions, we need to perform temperature dependent polarized neutron scattering experiments. The IN20 spectrometer will allow us to answer these questions. Furthermore, we will be also able to study the in-plane and out-of-plane character of the magnetic correlations at the IN20 spectrometer and to search for anomalous out-of-plane high energy excitations around 40 meV.

First discovery of an hour-glass spectrum in oxygen doped cobaltates

The hourglass shaped magnetic excitations have been observed recently in a copper-free insulating cobaltate system isostructural to the high temperature superconducting cuprates. The microscopic origin of the suppression of the outwards dispersion was first explained by a scenario based on the disordered charge stripe ordering [1]. However, our studies by means of neutron and x-ray scatterings show that there is no significant volume fraction of charge stripe ordered phases. Thus, the hourglass shaped magnetic excitations were alternatively accounted for by a novel nanophase separation model which consists of nanometersized undoped La_2CoO_4–like and hole-rich $La_{1.5}Sr_{0.5}CoO_4$–like islands [2-3]. However, there exist a very recent study indicating that a charge stripe ordered phase might also additionally coexist with the checkerboard charge order phase.

It is surprising that an hourglass shaped magnetic excitation spectrum was observed in an oxygen doped cobaltate La_2CoO_{4+d}, where *commensurate* magnetic correlations are observed instead of the *incommensurate* case for the Sr-doped cobaltate $La_{2-x}Sr_xCoO_4$.

Here, we study the magnetic excitations with polarization analysis. The experiment was performed on the IN20 spectrometer equipped with cryopad setup. Both the Heusler monochromator and analyzer were doubly focused**. It should be mentioned that during our experiment, there was a problem with the reactor which resulted in a loss of more than 2.5 day of the beam, and the reactor was running with about 60% of normal powder afterwards.**

Due to the reduction of the beamtime and reactor power, we only measured at characteristic energies and half of the Brillouin zone. We measured the SF_{xx}, SF_{yy} and SF_{zz} channels, which enable us to separate the magnetic excitation components along the y- and z-direction. Since our scattering plane is within the [100]/[010] plane, the y-direction correspond to the in plane component, whereas the z-direction corresponds to the out of plane component. As can be seen in Fig. 1, all the excitations within the hourglass shaped magnetic excitations originate from in-plane excitations.

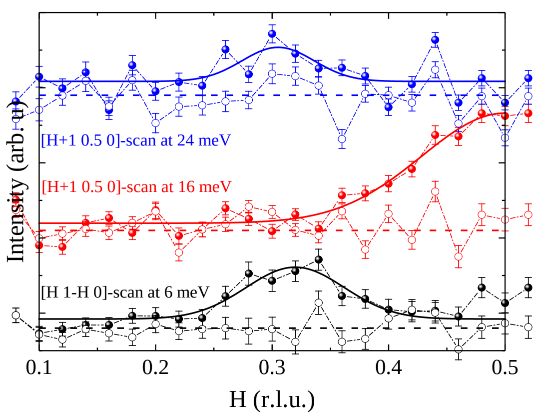

Fig. 1 Polarized inelastic neutron scattering measurements for La2CoO$_{4+d}$ performed on the IN20 spectrometer. The solid (open) symbols represent the neutron intensities from the M_y (M_z) component.

References:

[1] A. T. Boothroyd, P. Babkevich, D. Prabhakaran, and P. G. Freeman, Nature 471, 341 (2011).

[2] Y. Drees, D. Lamago, A. Piovano, and A. C. Komarek, Nature Commun. 4, 2449 (2013).

[3] Y. Drees, Z. W. Li, A. Ricci, M. Rotter, W. Schmidt, D. Lamago, O. Sobolev, U. Rütt, O. Gutowski, M. Sprung, A. Piovano, J. P. Castellan, and A. C. Komarek, Nature Commun. 5, 5731 (2014).