Experimental report

05/02/2016

Proposal: 7-01-421 **Council:** 10/2014

Title: Comparison of electron phonon coupling in cobaltates and nickelates

Research area: Physics

This proposal is a continuation of 7-01-356

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Samples: La2-xSrxNiO4 (0.5<x<1)
La2-xSrxCo4 (0.5<x<1)

Instrument	Requested days	Allocated days	From	To
IN8	6	5	18/09/2015	23/09/2015

Abstract:

The discovery of an hour-glass shaped magnetic excitation spectrum in copper-free cobalt oxides has triggered enormous research activity. Very recently, we started studying the impact of electron phonon coupling in these materials. In a direct comparative study of a nickelate and cobaltate material with same Sr-concentration x, we observed a very opposing behaviour of the high-frequency metal-oxygen bond-stretching phonon dispersions in both materials. We attribute this opposing behaviour to the differnt charge correlations in these materials which was quite surprising since diagonal charge stripe correlations were expected for both materials. For further insight in electron phonon coupling in these interesting materails we propose to start a systematic study, where we always compare the topmost Sigma_1 bond-stretching phonon dispersion of a cobaltate and a nickelate reference material with same hole-concentration x similar as we have done in the past for x=0.4. Additionally, we would also like to study the temperature dependence of these bond-stretching phonon modes, if time would be left. For all these purposes we ask for 6 days at the IN8 spectrometer.

Comparison of electron phonon coupling between cobaltates and nickelates

Remarkable attention has been re-attracted to the physics of stripe phases due to the recent findings of charge stripes in many cuprate materials around 1/8 hole-doping (see e.g. our study in Ref. [1]) but also due to the discovery of an "hour-glass"-shaped magnetic excitation spectrum in $La_{2-x}Sr_xCoO_4$ [2] resembling on the famous observations in the superconducting cuprates.

Apart from the cobaltates, the nickelates are another important reference system since a rather robust diagonal charge stripe order has been observed in these systems. Although these findings have triggered a lot of research activity in the past, very few is known about the highly hole doped nickelate materials. This might be owed to the extreme difficulties of single crystal growth at such high Ni oxidation states. Therefore, most studies on highly hole-doped LSNO are based on powders. Most studies of magnetic excitations in stripe-ordered LSNO are limited to samples in a certain doping-range around 1/3 hole-doping and don't exceed 50% hole-doping.

We have successfully synthesized the highly hole-doped nickelates $R_{2-x}Sr_xNiO_4$ (R=rare earth) by high pressure (pO_2 ~ 150 bar) optical floating zone growth. The large single crystals we obtained are suitable for inelastic neutron scattering experiments.

Here, we studied high energy Ni/Co-O bond-stretching phonon modes in the highly hole-doped nickelates and cobaltates $NdSrNiO_4$ and $LaSrCoO_4$ on the IN8 high flux triple-axis spectrometer. The experimental configurations is as follows: double focusing monochromater (Cu(200)) – sample – 2 PG filter – double focusing PG analyzer – detector, and fixed kf = 2.662 $Å^{-1}$. The samples were aligned with [100]/[010] in the scattering plane, and cooled down to 2 K for measurements. All the measurements were performed in the constant Q mode and scan energy. Typical phonon scans for $NdSrNiO_4$ and $LaSrCoO_4$ are shown in **Figs. 1-2**. The phonon spectrum is quite different for these two compounds (not shown here).

References:

[1] H.-H Wu,… A. C. Komarek et al., Nature Communications **3**, 1023 (2012)

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

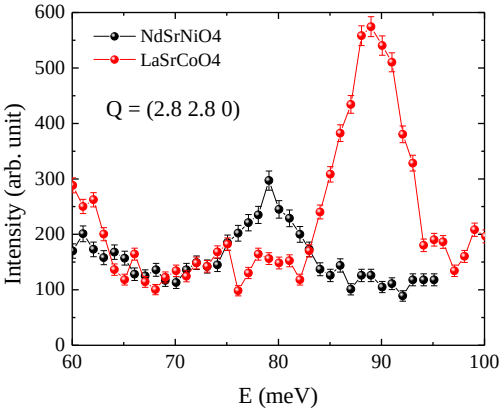

Fig. 1 Comparison between NdSrNiO4 and LaSrCoO4 at (2.8 2.8 0).

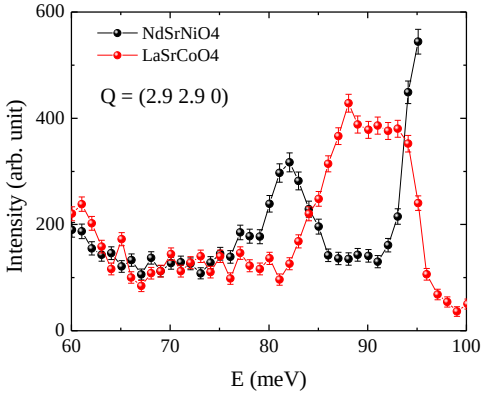

Fig. 2 Comparison between NdSrNiO4 and LaSrCoO4 at (2.9 2.9 0).