Experimental report

05/02/2016

Proposal:	**4-01-1418**	**Council:**	10/2014
Title:	Spin correlations in RNiO3 (R=La)		
Research area:	Physics		

This proposal is a new proposal

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Local contacts: Wolfgang F SCHMIDT

Samples: $LaNiO_3$

Instrument	Requested days	Allocated days	From	To
THALES	0	4	21/07/2015	25/07/2015
IN12	4	0		

Abstract:

Until now single crystal neutron diffraction and spectroscopy of the intriguing rare earth nickelate materials were hampered due to the lack of sizeable single crystals. By using high pressure floating zone mirror furnaces at oxygen pressures above 150 bar we were able to grow large nickelate single crystals for the first time. Neither impurity phases nor other crystallites are visible within Laue diffraction, powder and single crystal X-ray diffraction measurements of these high quality single crystals. Synchrotron radiation X-ray absorbtion spectroscopy measurements confirm that our samples are stoichiometric and contain neither additional Ni^{2+} nor Ni^{4+} ions. Here, we propose to study the spin correlations of these fascinating materials in detail on our novel single crystals. Especially we would like to re-analyze the magnetism in the metallic state of $LaNiO_3$ which exhibits weak magnetic anomalies at transition temperatures similar to that of the insulating nickelate materials within our magnetization measurements on oriented single crystals. For all these purposes we ask for 4 days at the IN12 cold triple-axis spectrometer.

Spin correlations in $LaNiO_3$

Experimental Team: Z. W. Li, H. Guo, A. C. Komarek, and W. Schmidt

Transition metal oxides close to a metal-insulator (MI) transition have attracted enormous interest. , The $RNiO_3$ Nickel oxides exhibits such a MI-transition. Concomitant with this MI transition, changes of several orders of magnitude of the electrical resistivity can be observed. These nikelates change from paramagnetic metals at high temperatures to antiferromagnetic insulators at low temperatures (with R≠La) [1, 2]. The insulating phase is highly debated and connected to charge ordering or charge disproportionation $2Ni^{3+}$ -> $Ni^{(3-\delta)+}$ + $Ni^{(3+\delta)+}$. $LaNiO_3$ is the only member in the nikelate series that does not display any MI transition or any type of magnetic ordering phenomena at all temperatures. However, recent experimental and theoretical work [3-5] has shown further insights into this material. For example, muon spin rotation measurements yield evidence of an antiferromagnetic ground state in thin layers of $LaNiO_3$ when the layer thickness below three unit cells sandwiched between insulating blocking layers [6]. Exchange-bias effects revealed by magnetometric measurements also indicate an antiferromagnetic state or spin glass order in heterostructures of $LaNiO_3$ [7]. Moreover, depending on chemical composition, dimensionality, and strain state of the $RNiO_3$ layers, various ground states have been predicted by theoretical work, including both insulating and metallic antiferromagnetic state. However, these fascinating states have never been observed in bulk $LaNiO_3$.

Using a high pressure optical floating zone furnace, we have successfully grown large volume single crystal of $LaNiO_3$ which, interestingly, show a magnetic transition at around 156 K in the magnetic susceptibility measurement as shown in Figure 1. To get further insight to this transition, we performed neutron scattering experiments at the Thales triple axes spectrometer. Pseudo-cubic notation was used due to the nature of intrinsic twinning of the crystal. [110]/[001] orientation in the scattering plane was used for this experiment. Focusing pyrolytic graphite monochromator and analyzer working in constant final-energy mode was used. A Be filter was positioned between the sample and the analyzer to remove higher order contaminations. An elastic map measured near **Q** = (3/4 3/4 3/4), as predicted by theory, is shown in Figure 2 where a clear peak can be seen. We further measured the temperature dependence of this peak which is plotted in Figure 3. A transition temperature of ~ 156 K can be deduced, this is in excellent agreement with our susceptibility measurement shown in Figure 1.

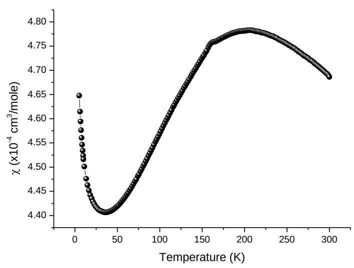

Figure 1 Magnetic susceptibility χ of $LaNiO_3$ single crystal as a function of temperature measured in a magnetic field of H = 0.5 T.

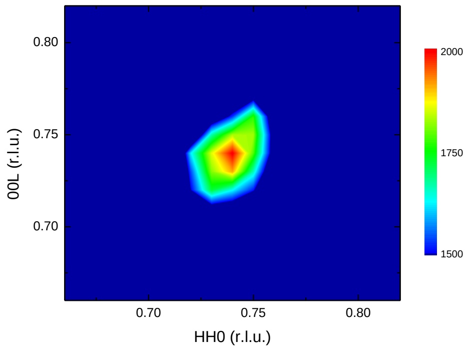

Figure 2 Neutron scattering intensities in the HHL-plane for LaNiO3 at 1.6 K near **Q** = (3/4 3/4 3/4) in pseudo-cubic notation.

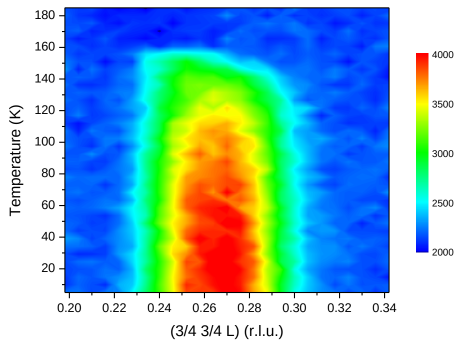

Figure 3 Temperature dependence of the elastic Q-scans at Q = (3/4 3/4 3/4) along the (0 0 1) direction.

References:

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