Experimental report

15/09/2016

Proposal: **5-51-513**

Council: 4/2016

Title: Magnetic state of triple layer ruthenate Sr4Ru3O10

Research area: Physics

This proposal is a continuation of 5-51-452

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Samples: Sr4Ru3O10

Instrument	Requested days	Allocated days	From	To
D3 High field >1T	9	9	27/05/2016	05/06/2016

Abstract:

We propose to continue our study of the magnetic state of the triple-layer strontium ruthenate Sr4Ru3O10. Structurally closely related to recently
studied single- and bilayer Ruthenates, it is - in contrast to these - a ferromagnet at low temperature with very anisotropic response
to magnetic fields. Weak fields are sufficient to align the domains along the c-axis, whilst a metamagnetic transition occurs around 2T
for fields in the ab-plane. In our first experiment on D3, we have studied the response to a magnetic field applied in the ab plane (metamagnetic regime) and would like now to study the magnetisation density when a field is applied along the c-axis.

Using polarised neutrons we have measured the flipping ratio in the itinerant triple layer ruthenate $Sr_4Ru_3O_{10}$ on D3. This system is ferromagnetic along the c axis with a Curie temperature of 105 K, whilst in the ab plane it has a metamagnetic behaviour i.e. it shows a rapid increase of the magnetisation for applied magnetic fields higher than 2 T and at temperatures lower than 50 K. In order to understand the interplay between ferromagnetism and metamagnetism in this system we have investigated the evolution of the magnetic moments within the unit cell with particular attention to any transfer between different sets of ruthenia. As far as the magnetism is concerned, the structure is made up of piles of three blocks in each of which the ruthenia are octahedrally coordinated with the oxygens. Of the twelve ruthenium atoms in the unit cell, 4 are placed in the central octahedra of the triple layers, and 8 are sited in the external octahedra. The central ruthenia are supposed to be responsible for the ferromagnetism while the external would be connected with the metamagnetism.

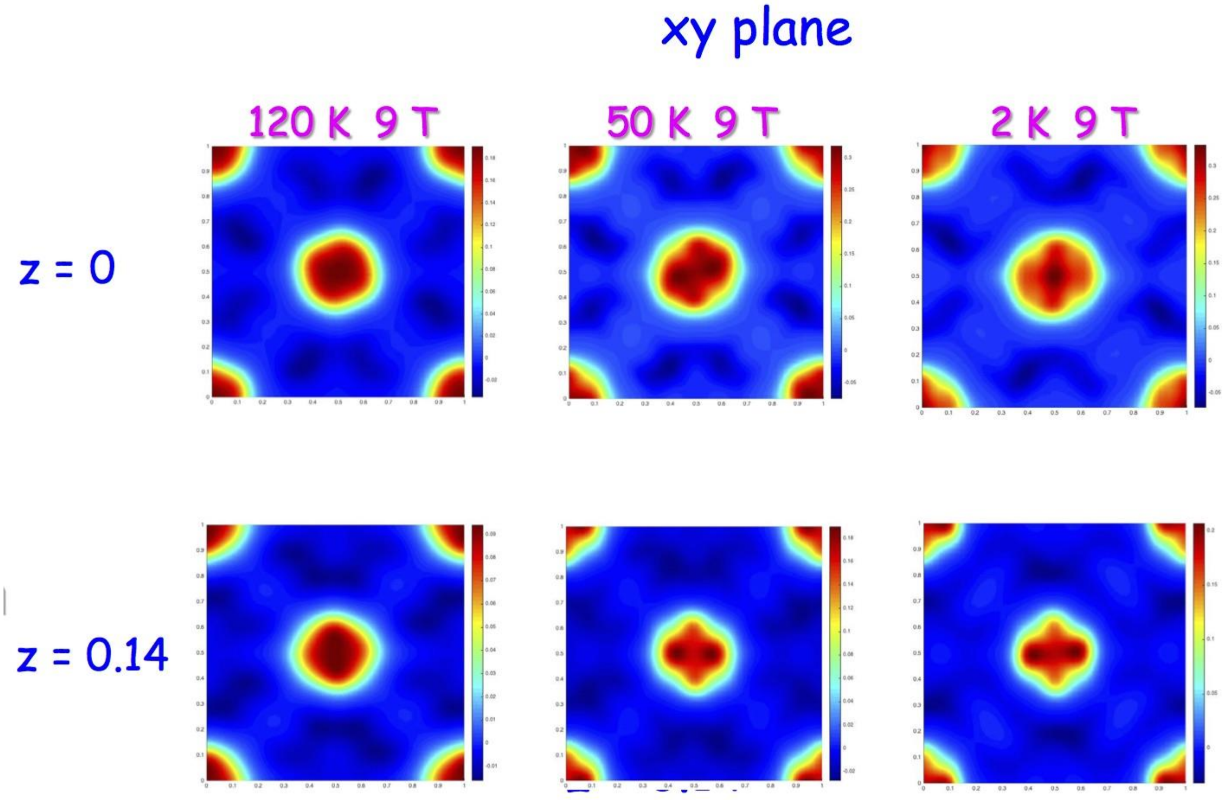

Fig.1 *Magnetisation curves in the xy plane* ***as deduced from a maximum entropy analysis in the triple layer*** *$Sr_4Ru_3O_{10}$, In the upper panel of the figure, the z=0 slice shows the evolution of the magnetisation of the central ruthenia as the temperature is varied from the paramagnetic phase (120K) to the ordered phase 2K. In the lower panel the external ruthenia are depicted, z=0.14.*

An external magnetic field was applied along the c axis and around 70 flipping ratios of independent Bragg reflections were measured at different values of temperature and applied field. Figure 1 shows a summary of the resulting magnetisation obtained with the maximum entropy method whilst Figure 2 shows the temperature dependence for the flipping ratio R for a few selected reflections. In the table finally we give the vaues obtained with Fullprof for the magnetic moments on the relevant ions.

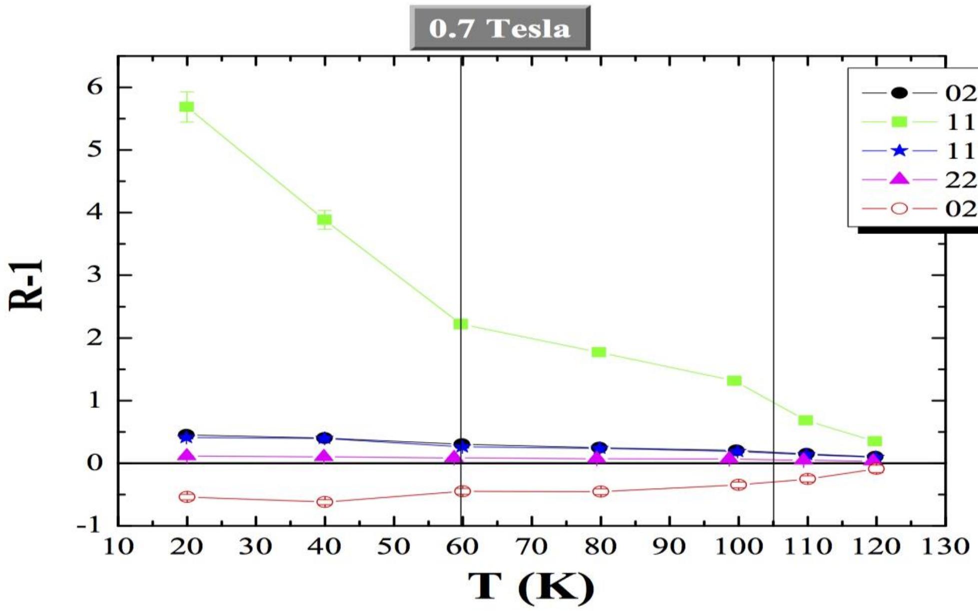

Figure 2 *The temperature dependence of the flipping ratio for a few selected reflections.*

	T=2K B=9T		T=50K B=9T		T=120K B=9T		T=2K B= 07T		T=2K B=2T	
	M_{tot}	M_{orb}	M_{tot}	M_{orb}	M_{tot}	M_{orb}	M_{tot}	M_{orb}	M_{tot}	M_{orb}
Ru_i	1.8(1)	0.1(2)	1.5(1)	0.5(3)	0.97(8)	0.3(1)	1.7(1)	0.2(3)	1.8(1)	-0.0(3)
Ru_o	1.2(1)	-0.1(1)	1.1(1)	-0.3(2)	0.6(1)	0.0(1)	1.1(1)	-0.1(2)	1.0(1)	0.0(2)
O_{ap}	0.15(1)		0.14(2)		0.07(1)		0.14(2)		0.15(2)	
O_{bas}	0.03(2)		0.04(2)		0.02(1)		0.04(2)		0.06(3)	

Figure 3 *A summary of the magnetic moments refined with Fullprof using a J_0J_2 model, i.e. allowing for orbital components on the ruthenium atoms. A measurable magnetic moment is detected on the oxigens anions.*