Experimental Report

21/02/2014

Proposal:	**4-01-1255**	**Council:**	10/2012	
Title:	Nematic behaviour of Sr3Ru2O7 in an off-axis magnetic field			

This proposal is a new proposal

Researh Area: Physics

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Samples: Sr2Ru3O7

Instrument	Req. Days	All. Days	From	To
IN14	10	9	25/03/2013	03/04/2013

Abstract:
Sr2Ru3O7 is an unusual metamagnetic system which shows a novel "electron nematic phase" (ENP) at temperatures less than about 1K when a magnetic field of 8T is applied along the c-axis. This ENP phase can be identified by transport and thermodynamic anomalies, however, no order parameter has been associated with the phase. When the magnetic field is moved away from the c-axis, the transport properties of Sr2Ru3O7 become very anisotropic. Here we propose to investigate whether this anisotropy is due to the low energy magnetic excitations becoming isotopic. If this were the case, it would show that the ENP behaviour is due to the unusual low energy excitations present.

By suppressing the second-order metamagnetic transition in $Sr_3Ru_2O_7$ to low temperatures with a magnetic field, the system is driven into a new and highly unusual electronic ground state. This so-called electron-nematic phase (ENP) exists below approximately 1 K in the field region $\mu_0 H_c \approx 7.95$ T and is characterised by highly anisotropic transport properties. Increasing numbers of novel electronic ground states (e.g. high temperature superconductivity) have been found to form in close proximity to quantum critical points (QCPs), that is, the point where a second order phase transition occurs at zero temperature. Understanding the role that quantum criticality plays in the formation of the ENP in a clean system such as $Sr_3Ru_2O_7$ can facilitate a deeper understanding of the physics of many analogous systems.

In this investigation we attempted to perform measurements of softened spin excitations at 50 mK and high magnetic fields (~8 T) in $Sr_3Ru_2O_7$. *Unfortunately due to repeated failure of the dilution fridge insert we were not able to measure within in the quantum critical state of $Sr_3Ru_2O_7$ (i.e. at temperatures below 1.5 K). We were therefore unable to perform our proposed experiment.* We therefore made measurements in high magnetic fields and at temperatures above 1.5 K. Figure 1 shows our measurement of magnetic excitations in the normal state of $Sr_3Ru_2O_7$ as a function of applied magnetic field. The excitations are strongest and most developed at the lowest energies in the field region where the quantum critical phase occurs.

We continued to search for normal state properties which might give clues about the underlying physics of quantum critical phase formation in our system. One such property is *E/T* scale invariance. In the proximity of a QCP, the single energy scale governing spin and charge fluctuations is the temperature *T* of the system itself, a phenomenon known as *E/T* scaling. Figure 2 shows measurements of the strength of scattering intensity multiplied by temperature to the power 0.5 as a function of the ratio of energy transfer to temperature. Measured at several different temperatures, measurements at all temperatures seem to lie on roughly the same general curve. The measurement of possible *E/T* scaling in $Sr_3Ru_2O_7$ could shed new light on the role that quantum criticality plays in the formation of the ENP, which up to now has not been entirely clear.

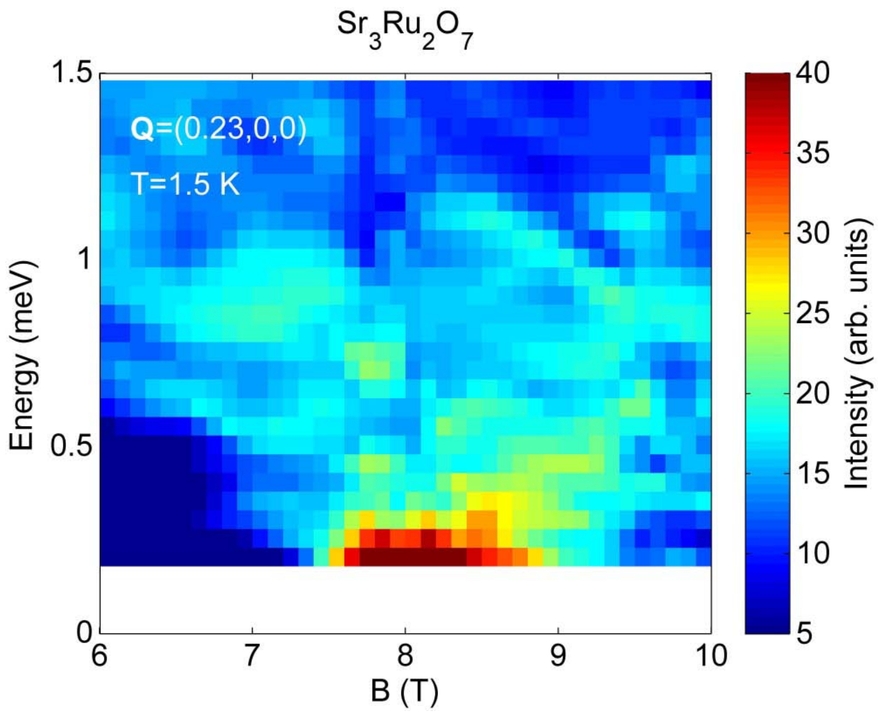

Figure 1 Scattering intensity measured at **Q**=(0.23,0,0) as a function of energy transfer and magnetic field applied along the crystallographic *c* axis. A field-independent background has been subtracted from the data.

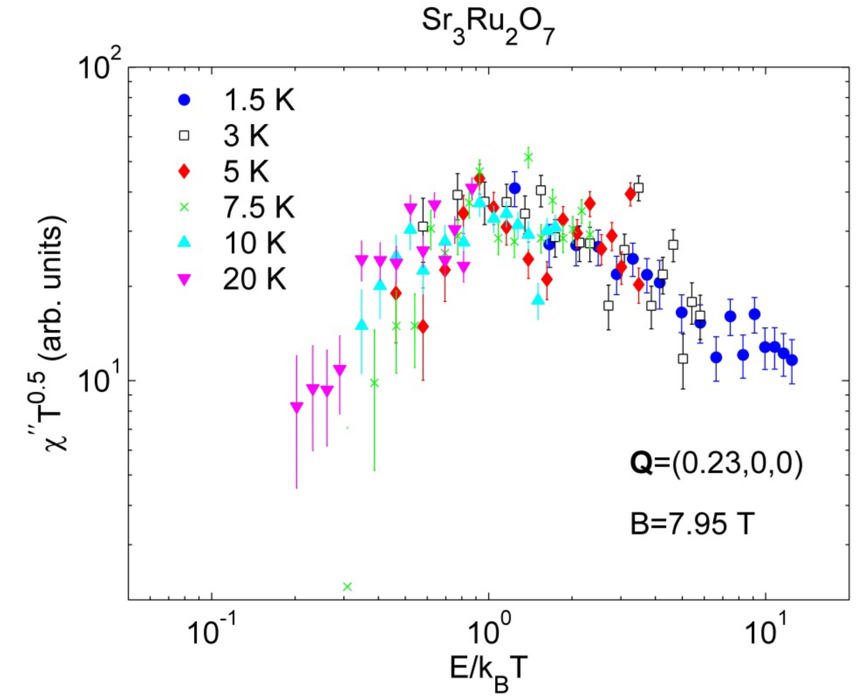

Figure 2 E/T scaling measured in $Sr_3Ru_2O_7$ at **Q**=(0.23,0,0) for various temperatures with magnetic field applied along the crystallographic *c* direction.