Experimental report

31/08/2018

Proposal: 4-01-1555 **Council:** 4/2017

Title: Magnetic Excitations in Ca3(Ru1-xTix)2O7: Investigating SOC in the 4d-electron ruthenates

Research area: Physics

This proposal is a continuation of 4-01-1495

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Samples: Ca3(Ru0.95Ti0.05)2O7

Instrument	Requested days	Allocated days	From	To
IN8 Flatcone	6	6	22/03/2018	28/03/2018

Abstract:

Ca3Ru2O7 plays host to a complex interplay between equivalent spin-orbit coupling (SOC) and electron correlation energies that foster exotic physics and an extreme sensitivity to external perturbation. Even with a nominal x=0.003 Ti substitution in Ca3(Ru1-xTix)2O7 is enough to push the system from a correlated metallic system into a Mott insulating state, concomitant with a magnetic structural transition. Recently we successfully used IN8 with the flatcone detector to map out the inelastic magnetic excitation spectra of Ca3Ru2O7. We now propose to continue our investigation and use IN8 to uncover the underlying changes that arise as the system transitions to the antiferromagnetic Mott insulating state in single crystal Ca3(Ru0.95Ti0.05)2O7.

Experimental Report on 4-01-1555 (IN8)

Magnetic Excitations in Ca3(Ru1-xTix)2O7: Investigating SOC in the 4d-electron ruthenates

Introduction

$Ca_3Ru_2O_7$ plays host to a complex interplay between equivalent spin-orbit coupling (SOC) and electron correlation energies that foster exotic physics [1] and an extreme sensitivity to external perturbation [2-4]. Even with a nominal x=0.003 Ti substitution in $Ca_3Ru_{(2-x)}Ti_{(x)}O_7$ is enough to push the system from a correlated metallic system into a Mott insulating state, concomitant with a magnetic structural transition [2]. Recently we successfully used IN8 with the flatcone detector to map out the inelastic magnetic excitation spectra of $Ca_3Ru_2O_7$. Here, we report on our latest experiment on $Ca_3Ru_{(2-x)}Ti_{(x)}O_7$ with x = 1% performed on IN8.

Setup

In order to investigate the dynamic magnetic response of the Ti substituted we performed an inelastic neutron scattering experiment using the thermal triple axis spectrometer IN8 at the ILL research facility. The spectrometer was used in its standard configuration with a single detector operating with a fixed kf=2.662 inv. angstrom. The incoming neutron wavelength was selected with Cu(200) and Si(111) monochromator crystals.

We were able to align a sample made up from about 30 single crystals with a twinning ratio of 1:3. The experiment itself was divided into two parts; in the first we investigated the H0L scattering plane. After changing the sample orientation we continued with the second part of the experiment in the 0KL plane.

Results

Surprisingly, the spectrum of the magnetic excitations changes completely from the pure $Ca_3Ru_2O_7$ to the 1% Ti substituted compound. The dynamic magnetism of the parent compound has essentially ferromagnetic character (as observed in our previous experiment), which manifests as a dispersion with a gap of 7meV at the Gamma point. In contrast, the magnon observed in $Ca_3Ru_{(2-x)}Ti_{(x)}O_7$ has its minimum at the antiferromagnetic ordering vector and features a maximum at the Gamma point. We note, that this

unconventional dispersion is surprisingly similar to the single layered compound Ca_2RuO_4 [5], the strictly two dimensional n=1 member of the Ruddlesden Popper series. We also observe a unexpected inelastic feature that does not disperse and is localized at 20meV at the magnetic zone center (see the energy scan at (10L) in figure 1).

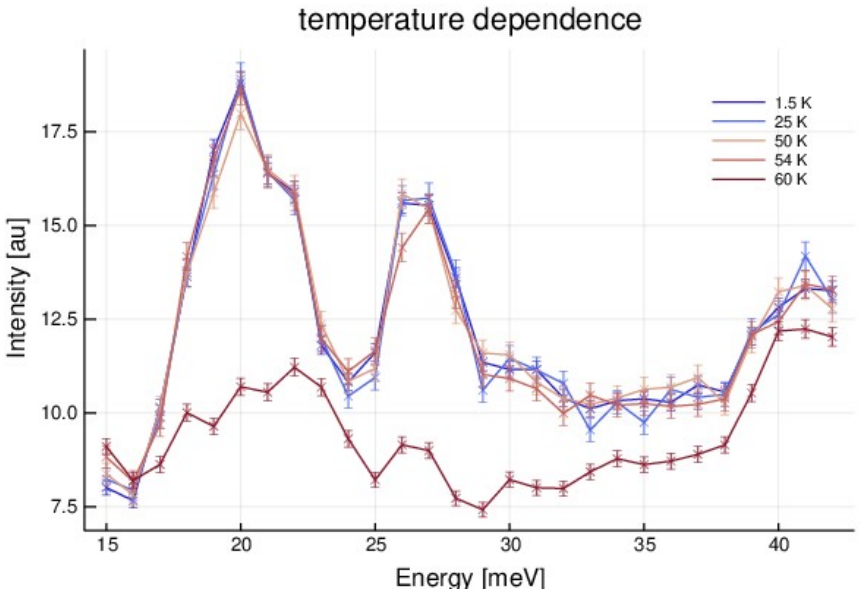

Figure 1: Temperature dependence of the magnetic excitations at (1 0 7.5). We observe two excitations that abruptly disappear above the magnetic ordering temperature (TN=55K). The low energetic excitation is localized in reciprocal space, the excitation at 27meV disperses.

References

[1] Cao et al New Journal of Physics 6 159 (2004).
[2] Tsuda et al Physical Review B 87, 241107 (2013).
[3] Karpus et al Physical Review Letters 93, 167205 (2004).
[4] Zhu et al Physical Review Letters 116, 216401 (2016)
[5] Jain, Krautloher, Porras et al, Nature Physics 13, 633 (2017)