# Experimental report

14/02/2017

**Proposal:** 4-01-1495 **Council:** 4/2016

**Title:** Magnetic Dispersion of Ca3Ru2O7: Investigating the role of SOC in the4d-electron ruthenates

**Research area:** Physics

**This proposal is a new proposal**


**Main proposer:** Joel BERTINSHAW

**Experimental team:** Joel BERTINSHAW
Maximilian Josef KRAUTLOHER

**Local contacts:** Alexandre IVANOV


**Samples:** Ca3Ru2O7

| Instrument | Requested days | Allocated days | From | To |
|---|---|---|---|---|
| IN8 Flatcone | 8 | 6 | 24/11/2016 | 30/11/2016 |


## Abstract:

In the 4d-electron layered calcium ruthenate series Ca[n+1]Ru[n]O[3n+1], a complex interplay between equivalent spin-orbit coupling (SOC) and electron correlation energies foster exotic physics, an area of physics that has shown significant growth in recent years. In 5d-electron systems, competition between SOC and electron correlations results in a wide array of unconventional electronic phases, which can be generally described in terms of an effective J pseudospin moment arising from crystal field splitting and mixed spin-orbit (S-L) states. In 4d-electron systems on the other side, far less is known about the role of SOC. Indeed, many prior studies consider orbital order to play a dominant role, with SOC as a perturbative effect, similar to 3d-electron systems. Our recent work on Ca2RuO4, however, points to a more significant role of SOC in the ground state. Here we propose to explore the evolution the role of SOC in Ca[n+1]Ru[n]O[3n+1] as the dimensionality increases and a more metallic state is approached by studying magnetic excitation spectrum of the bilayer Ca3Ru2O7 using the triple axis spectrometer IN8 at the ILL, Grenoble.

# Experiment Report

Magnetic Dispersion of $Ca_3Ru_2O_7$: Investigating the role of SOC in the 4d-electron ruthenates

*J. Bertinshaw, BJ Kim, J. Porras, B. Keimer, M. Krautloher*
*Max Planck Institute for Solid State Research, Stuttgart, Germany*

**Proposal ID**: 4-01-1495
**Instrument:** IN8 Flatcone
**Contact**: Alexandre Ivanov

## Introduction

In the 4d-electron layered calcium ruthenate series $Ca_{n+1}Ru_nO_{3n+1}$, a complex interplay between equivalent spin-orbit coupling (SOC) and electron correlation energies foster exotic physics, an area of physics that has shown significant growth in recent years [1]. While many prior studies of this series consider orbital order to play a dominant role with SOC as a perturbative effect, similar to 3d-electron systems [2], our recent work on Ca2RuO4 points to a more significant role of SOC in the ground state [3,4,5]. For this experiment we extended our study to the next member in the series, Ca3Ru2O7, to investigate the evolution the role of SOC as the dimensionality increases and a more metallic state is approached.

## Setup

The inelastic neutron spectrometer IN8 with flatcone detector was utilised to studying the magnetic excitation spectrum of the bilayer system. The flatcone detector was configured to use the Si analyser with $k_f = 3$Å. We also used the recently commissioned Si111 monochromator in order to reduce signal contamination as compared with pyrolytic graphic monochromator option. A crystal array was mounted on a silicon plate and mounted in the ab-orientation to access the (HK0) scattering plane.

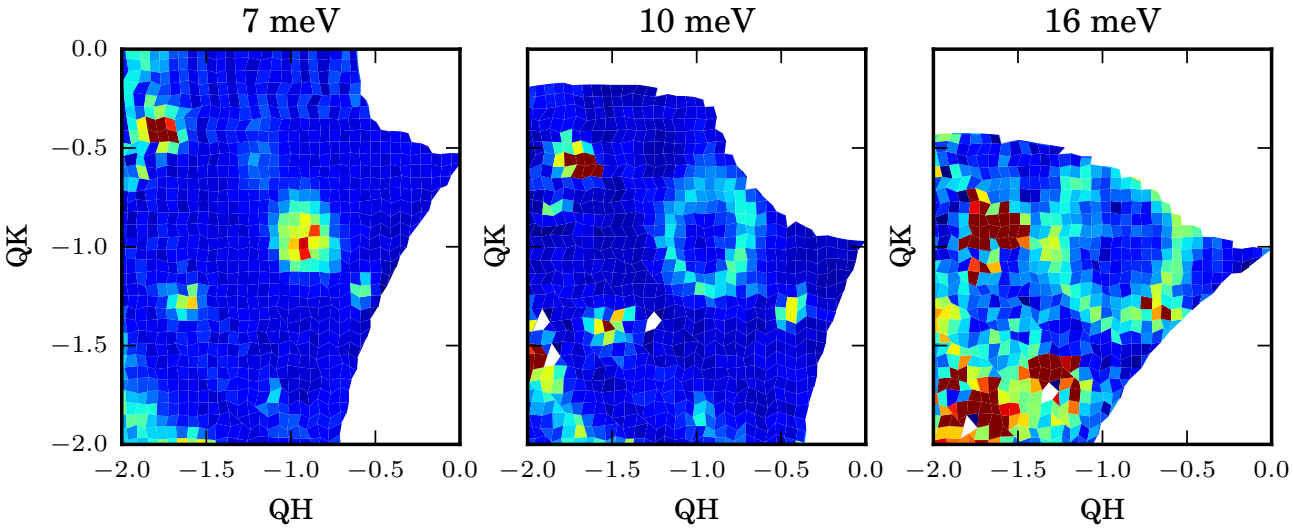


*Fig 1. Magnon dispersion in $Ca_3Ru_2O_7$ measured on IN8 with a flatcone detector. Constant-E maps in the HK0 plane around (1,1,L) at (a) 7meV (b) 10meV and (c) 16meV.*

## Results

Constant energy cuts of S(Q,w) around the magnetic zone centre (-1-10) were measured from 5 meV up to 25 meV. The signal was strong and did not require temperature subtraction to reveal a trend. Measurements conducted at T=2K are shown in Figure 1, reveal a clearly dispersion feature. The results show a gap of 6meV that disperses in the HK-plane up to an energy of 22meV. Full measurements of the dispersion were conducted at T=50K and T=2K, as well as additional measurements to track the evolution with temperature at 10 meV. Further analysis of the data in order to extract the salient correlation parameters of the magnon dispersion is currently ongoing.

## Outlook

$Ca_3Ru_2O_7$ is very sensitivity to external perturbation. Even with a nominal x=0.003 Ti substitution in $Ca_3(Ru_{1-x}Ti_x)_2O_7$ is enough to push the system from a correlated metallic system into a Mott insulating state, concomitant with a magnetic structural transition and ferromagnetic to antiferromagnetic correlations. This current dataset will provide the basis for our study into the underlying changes to the electron correlations that arise with Ti-doping.

## References


[1] Witczak-Krempa et al. Ann. Rev. Cond. Matt. **5**, 57 (2014).
[2] Bao *et al*. *PRL* **100**, 247203 (2008).
[3] Khaliullin, *PRL* **111**, 197201 (2013)
[4] Akbari & Khaliullin, *PRB* **90**, 035137 (2014)
[5] Jain *et al*. arXiv:1510.07011