# Experimental report

17/12/2021

**Proposal:** **5-31-2814** **Council:** 10/2020

**Title:** Neutron powder diffraction of a novel magnetic phase in Sr2Rh1-xIrxO4

**Research area:** Physics

**This proposal is a new proposal**

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**Samples:** Sr2RhO4
Sr2Rh0.6Ir0.4O4

| Instrument | Requested days | Allocated days | From | To |
|---|---|---|---|---|
| D20 | 2 | 2 | 26/05/2021 | 28/05/2021 |

**Abstract:**

The ground state of correlated electron materials depends strongly on the strength of the on-site Coulomb repulsion U as well as the spin-orbit-coupling (SOC). While either of the interactions dominate materials of the 3d and 5d series, interesting physics arise when the couplings strengths are of similar scale, which is the case for materials of the 4d series. In the case of unconventional superconductor Sr2RuO4, tuning of the Coulomb interaction by calcium doping destroys the superconducting state and in turn creates a highly correlated antiferromagnetic Mott-insulator. In the compound Sr2Rh1-xIrxO4 in contrast, the strength of spin-orbit coupling increases by substituting the 5d transition metal iridium into Sr2RhO4, which resides next to the ruthenates in the periodic table. Sr2RhO4 shows paramagnetic Fermi-liquid behavior, while Sr2IrO4 is an antiferromagnetic insulator. For the mixed compound Sr2Rh0.6Ir0.4O4 a putative magnetically ordered state was recently reported. Since the nature of this phase has not been investigated so far we propose to perform neutron powder diffraction to resolve its magnetic structure.

# Neutron powder diffraction of a novel magnetic phase in $Sr_2Rh_{1-x}Ir_xO_4$

*V.Zimmermann[1], H. Trepka[1], T. Hansen[2], Y. Matsumoto[1], B. Keimer[1] and M. Hepting[1]*

*The ground state of correlated electron materials depends strongly on the strength of the on-site Coulomb repulsion U as well as the spin-orbit-coupling (SOC). While either of the interactions dominate materials of the 3d and 5d series, interesting physics arise when the couplings strengths are of similar scale, which is the case for materials of the 4d series. In the compound $Sr_2Rh_{1-x}Ir_xO_4$, the strength of spin-orbit coupling increases by substituting the 5d transition metal iridium into $Sr_2RhO_4$. $Sr_2RhO_4$ shows paramagnetic Fermi-liquid behavior, while $Sr_2IrO_4$ is an antiferromagnetic insulator. For the mixed compound $Sr_2Rh_{0.6}Ir_{0.4}O_4$ a putative magnetically ordered state was recently reported. Since the nature of this phase has not been investigated so far we performed a neutron powder diffraction experiment to resolve its magnetic structure.*

Transition metal oxides (TMOs) have attracted enormous interest in the past due to the emergence of highly unconventional phenomena which have significantly advanced our understanding of correlated electrons in condensed matter. In this research project we investigate $Sr_2Rh_{0.6}Ir_{0.4}O_4$, an isostructural compound to the high-$T_c$ superconductor parent $La_2CuO_4$. A large Curie-Weiss temperature of $\theta_{CW}$ = -59 K signals strong magnetic correlations and a field-dependent peak observed in specific heat was attributed to a magnetic transition [1].

We synthesized several grams of polycrystalline $Sr_2Rh_{0.6}Ir_{0.4}O_4$ for the beamtime. The sample was loaded in a narrow copper tube, since both Rh and Ir are strong neutron absorbers, and tightly compressed to avoid orientation effects in a magnetic field. Given the strong neutron absorption of the sample and requirement for ultra-low temperatures, the experiment was conducted at the D20 instrument which has the advantage of an exceptionally large flux and the possibility to install a dilution cryostat. A neutron wavelength of $\lambda$ = 2.41 Å and a take-off angle of 42° were used.

The reference measurement in the paramagnetic regime was taken at 15 K in zero field and subsequent measurements in the expected magnetically ordered phase were taken at 60 mK. Since previous characterizations observed an increase of the transition temperature in a magnetic field, we performed the low temperature measurements in various fields up to 1 T. However, as shown in Fig. 1, we could not observe any sign of magnetic Bragg peaks. The change in background can be attributed to varying exchange gas pressure.

Our results therefore dispute the claim from Qi *et al.* [1] and require further investigation into the true ground state of $Sr_2Rh_{0.6}Ir_{0.4}O_4$.

[1]: Qi *et al.*, Phys. Rev. B **86**, 125105 (2012)

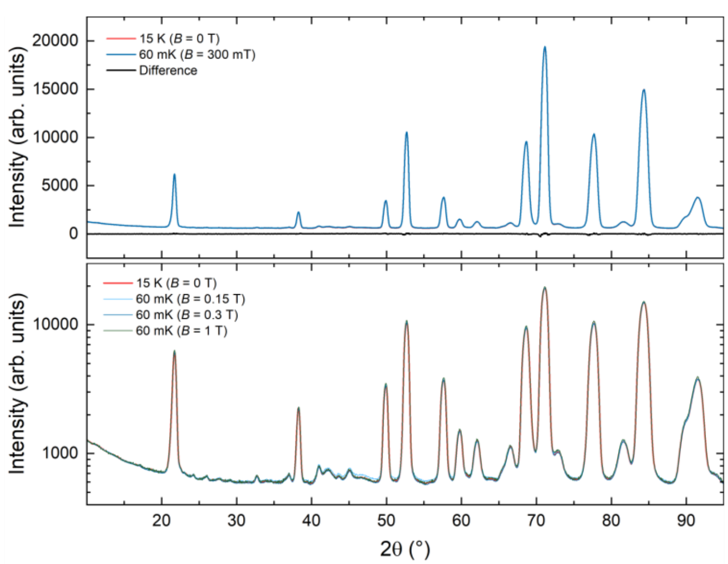


Figure 1. a) Neutron diffraction pattern of $Sr_2Rh_{0.6}Ir_{0.4}O_4$ for temperatures above and below the proposed magnetic transition. The difference pattern shown by the black line shows no significant deviation across the transition. b) The diffraction pattern on a log-scale shows no substantial change between 15 K and 60 mK in fields up to 1 T.