Experimental report

08/02/2016

Proposal: **5-41-808**

Council: 10/2014

Title: Magnetic structure of UnRhIn3n+2 (n = 1, 2) compounds

Research area: Physics

This proposal is a new proposal

Main proposer: **Attila BARTHA**

Experimental team: Milan KLICPERA
Attila BARTHA

Local contacts: Bachir OULADDIAF

Samples: U2RhIn8
URhIn5

Instrument	Requested days	Allocated days	From	To
D10	9	7	15/07/2015	23/07/2015

Abstract:

Lanthanide compounds with the tetragonal HoCoGa5-type structure, often called 115, are extensively studied since the discovery of unconventional physical properties, like heavy fermion behavior, unconventional superconductivity and coexistence of magnetism and superconductivity in CeRhIn5, CeCoIn5 and CeIrIn5. With synthesize of Ce2RhIn8 and Ce2CoIn8 which crystallize in same structure type, this series was extended by an additional parameter 'dimensionality', i.e, from CeCoIn5 to Ce2CoIn8 the electronic structure is more 3D. Unconventional superconductivity has also been observed in PuRhIn5 and PuRhGa5, which widens the interest in the 115 series to the 5f electron compounds. Recently URhIn5 was synthesized which surprisingly orders antiferromagnetically (AFM) at high TN = 98K. We were able to grow U2RhIn8 for the first time. High quality single crystals with RRR of 500 were obtained from In-flux. The compound orders AFM at TN = 119K. We propose to determine the magnetic structure of U2RhIn8, to find out the magnetic moment on the Uranium and to follow the evolvement of the AFM state with temperature in order to comprehend the influence of 'dimensionality'.

Magnetic structure of U_nRhIn_{3n+2} (n = 1, 2) compounds

Compounds with the general formula $R_nT_mX_{3n+2m}$ (R = Rare Earth or Actinide, T = transition metal, X = p-element) demonstrate a wealth of interesting phenomena. For instance, $CeCoIn_5$ displays heavy Fermion behavior and enters an unconventional superconducting state below T_c = 2.1 K [1]. $CeRhIn_5$ and Ce_2RhIn_8 order antiferromagnetically at room temperature. Applying hydrostatic pressure tunes T_N towards zero. In the vicinity of this quantum critical point superconductivity emerges which coexists in a certain region of the temperature-pressure phase diagram with the AFM state [2, 3].

The discovery of Pu-based superconductors $PuCoGa_5$ [4] and $PuRhGa_5$ [5] which show T_c as high as 18 K and 8.7 K, respectively, suggested that the layered structure and the stronger hybridization of the f-electron is important for the appearance of superconductivity and stronger enhancement of T_c with respect to the Ce-based ones. It was this consideration which led to the synthesis of two new compounds, $URhIn_5$ and U_2RhIn_8.

Like the other $R_nT_mX_{3n+2m}$ compounds $URhIn_5$ and U_2RhIn_8 crystallize in the layered tetragonal Ho_2CoGa_{3n+2}-type structure (space group P4/mmm). The unit-cell can be viewed as a stack of n layers of UIn_3 alternating along c-axis with m layers of $RhIn_2$ [6].

Single crystals of $URhIn_5$ and U_2RhIn_8 were grown by In-flux. Prior to the neutron experiment the compounds were thoroughly studied by means of magnetic, transport and thermal properties measurements. The ordering temperatures are T_N = 98 K and 117 K. Interestingly, U_2RhIn_8 is the first known 2-1-8 U-based compound showing magnetic ordering. The propagation vector if $URhIn_5$ has been determined by a previous experiment on PANDA-FRM II and yields $\boldsymbol{k}$ = (0.5, 0.5, 0.5) [7]. In this experiment we used small single crystals (10 in total) of $URhIn_5$. These crystals were oriented by Laue backscattering and glued to an aluminum plate with their [001] axis perpendicular to the plane of the plate.

In the case of our U_2RhIn_8 neutron experiment on D10 ILL we could not proceed in a similar matter. Even a small misorientation of the crystals with respect to each other would lead to at least broadening of measured nuclear/magnetic peaks in diffraction patterns (especially, if using 2D detector), which is hardly acceptable for precise nuclear and magnetic structure determination. Therefore, we have chosen the largest prepared (m = 3.4 mg) for the D10 experiment.

Before employing D10 diffractometer, we conducted a preliminary test experiment on CYCLOPS with orange cryostat on the m = 3.4 mg U_2RhIn_8 crystal. We looked for additional reflections arising from magnetic Bragg scattering when comparing the diffraction pattern above (paramagnetic state) and far below T_N (AFM state) from which the propagation vector can be calculated. Unfortunately, if there were any additional reflections those were too weak to be detected. Hence, the propagation vector could not be determined from the measured patterns.

We continued the search for the propagation vector on D10 diffractometer. First we performed the sample orientation and UB matrix determination. The scans along the most symmetric directions of 1st Brillouin zone at T = 2 K did not bring any information on the magnetic structure. Therefore we mapped systematically the 1st and 2nd Brillouin-zones. Eventually, we were able to locate two magnetic reflections while scanning in the (*h* 0.5 1) direction (see FIG. 1). From that partial result it is possible to deduce the information about the magnetic propagation vector which is suggested to be $\boldsymbol{k}$ = (0.5, 0.5, 0). We note, that no magnetic peak was observed in scans along (*h h* 0) or (*h k* 0). The magnetic structure remains still undetermined and propose for the continuation of the experiment on D10.

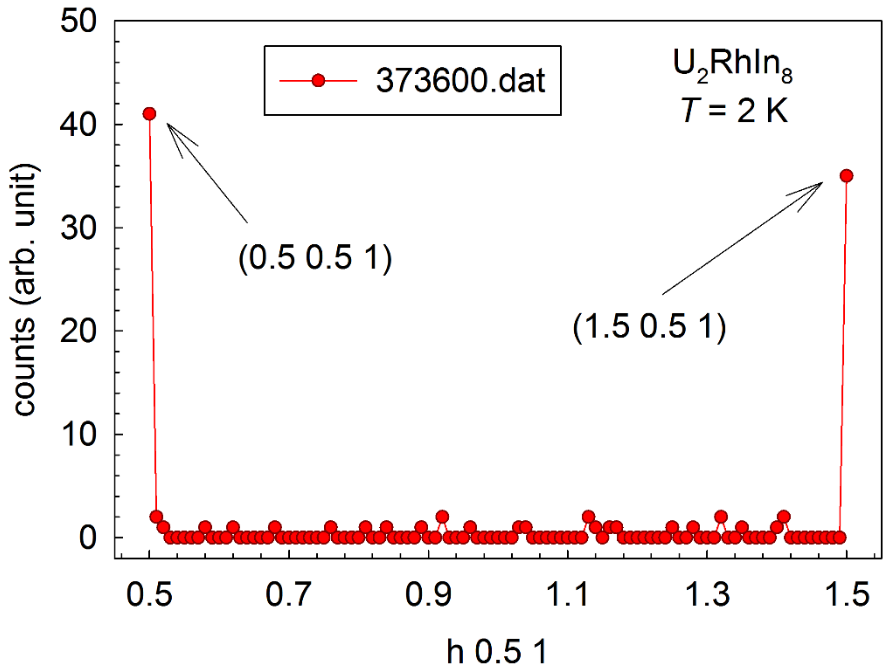

FIG 1: Two magnetic reflections along the (*h* 0.5 1) direction pointing to a propagation vector (0.5 0.5 0).

References:
[1] J. D. Thompson et al., J. Magn. Magn. Mater. 5 226-230 (2001)
[2] H. Hegger *et al.*, Phys. Rev. Lett. **84,** 4986 (2000)
[3] M. Nicklas *et al.*, Phys. Rev. B **67,** 020506(R) (2003)
[4] J. L. Sarrao et al., Nature **420**, 297 (2002)
[5] F. Wastin et al., J. Phys.: Condens. Matter **15**, S2279 (2003)
[6] A. Bartha *et al.*, J. Magn. Magn. Mater. **381,** 310 (2015)
[7] P. Čermák et al., Magnetic structure of recently discovered $URhIn_5$, experimental report for proposal p8818