Experimental report

24/09/2024

Proposal: 5-31-2920 **Council:** 10/2022

Title: Investigation of the magnetic structure of Ce2Rh3Ge5 using neutron diffraction

Research area: Physics

This proposal is a new proposal

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Samples: Ce2Rh3Ge5

Instrument	Requested days	Allocated days	From	To
D20	1	1	05/06/2023	06/06/2023

Abstract:

The compound Ce2Rh3Ge5 was reported to form in the orthorhombic U2Co3Si5-type structure. A marked peak in the susceptibility and a sharp drop in the resistivity are observed at TN = 5.5 K indicating an antiferromagnetic ordering of the Ce moments. Isothermal magnetization curves at 1.3 K reveal a field induced metamagnetic transition at 23 T in Ce2Rh3Ge5. The saturation moment of 0.8μB/Ce is suggestive of the ¿7 doublet ground state. The specific heat exhibits a ¿-type anomaly around TN, while the value of magnetic entropy at TN is reduced to 50% of Rln2. The linear coefficient of specific heat is 148 mJ/K2 mol Ce above TN. Interestingly, application of rather weak pressure of Pc = 4.5kbar suppresses TN to zero temperature and reveals a pressure tuned quantum critical point, which is confirmed by our muon spin rotation measurements. In order to shed light on the pressure induced QCP the first step consists in the determination of the ambient pressure magnetic structure of Ce2Rh3Ge5.

Magnetic Structure of the Kondo Lattice Compound $Ce_2Rh_3Ge_5$ Using Neutron Scattering

Proposal No: 5-31-2920

Abstract: The compound $Ce_2Rh_3Ge_5$ was reported to form in the orthorhombic $U_2Co_3Si_5$-type structure. A marked peak in the susceptibility and a sharp drop in the resistivity are observed at T_N = 5.5 K. Isothermal magnetization curves at 1.3 K reveal a field induced metamagnetic transition at 23 T in $Ce_2Rh_3Ge_5$. The saturation moment of 0.8μ_B/Ce is suggestive of the Γ_7 doublet ground state. The specific heat exhibits a λ-type anomaly around T_N, while the value of magnetic entropy at T_N is reduced to 50% of Rln2. The linear coefficient of specific heat is 148 mJ/K^2 mol Ce above T_N. Interestingly, in applied pressure of P_c=4.5kbar T_N suppresses to zero temperature and it exhibits pressure tuned quantum critical point. In order to shed more light on the magnetic properties and pressure induced QCP, we proposed to carry out neutron diffraction study using D20.

Experimental results and discussion:

Neutron powder diffraction measurements were performed on a polycrystalline sample (8g) of $Ce_2Rh_3Ge_5$ on the high-intensity two-axis D20 diffractometer, in the high-flux mode, with an incident wavelength of 2.42 Å at 1.6 K, 4 K, and at 10 K. The high-resolution powder diffractometer D2B (ILL) was used, with a wavelength of 1.594 Å for the structural investigation at room temperature.

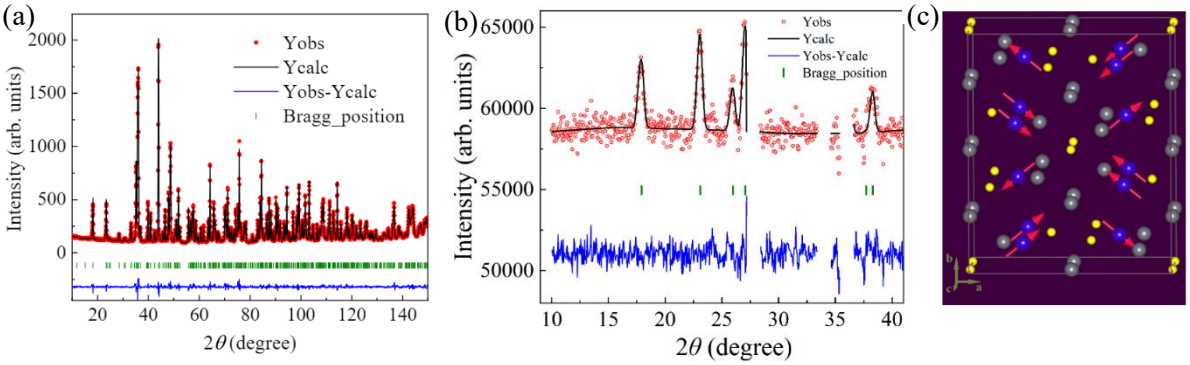

Fig.1 (a) Refind neutron diffraction pattern of Ce2Rh3Ge5 measured at room temperature. **(b)** Refinement of the temperature difference data 1.6 K – 10 K. The solid black line shows the calculated intensity of a magnetic structure with a propagation vector of k = 0 and AFM couplings within the a-b-plane. **(c)**The crystal structure of Ce2Rh3Ge5 (blue spears Ce, yellow spears Rh and gray spears Ge atoms) along with the magnetic structure corresponding to the AFM coupling in a- and in b-direction. No component in c-direction.

The high-resolution neutron powder diffraction (NPD) data from D2B confirm the orthorhombic $U_2Co_3Si_5$-type structure of $Ce_2Rh_3Ge_5$, with lattice parameters and atom positions in good agreement with previous reports (Fig.1a). The D20 data reveal weak magnetic

reflections at 1.5 K and 4 K, which are absent at 10 K. These magnetic reflections were analysed using the Fullprof suite, where a magnetic propagation vector $k = 0$ was identified.

The magnetic structure determined from temperature difference data (1.5 K – 10 K, 4 K – 10 K) indicates antiferromagnetic (AFM) coupling along the a- and b-axes, with no component in the c-direction (Fig.1b). At 1.6 K, the magnetic moments are $\mu_x = 0.24(1)\ \mu_B$, $\mu_y = 0.19(1)\ \mu_B$, with a total moment of $\mu_{Ce} = 0.31(1)\ \mu_B$. At 4 K, the moments decrease to $\mu_x = 0.17(1)\ \mu_B$, $\mu_y = 0.15(1)\ \mu_B$, and $\mu_{Ce} = 0.23(1)\ \mu_B$. The reduced magnetic moment compared to the theoretical value suggests Kondo screening and crystal electric field (CEF) effects.