Experimental Report

12/03/2015

Proposal: **5-41-767** **Council:** 4/2014

Title: Determination of the magnetic structure of TmCu in high magnetic fields

This proposal is a new proposal

Researh Area: Physics

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Samples: TmCu Large
TmCu

Instrument	Req. Days	All. Days	From	To
D10	10	7	02/12/2014	09/12/2014

Abstract:

The earth copper systems RCu (R = Dy, Ho, Er, Tm) crystallize in the CsCl structure and exhibit multi-k commensurate antiferromagnetic structures due to competing electronic interactions. So far, however, only neutron powder diffraction studies in zero field were carried out. In order to investigate the detailed magnetic structures across the entire magnetic phase diagram we have grown large single crystals of RCu compounds and have performed a comprehensive bulk and transport characterization. Here, we propose to determine the magnetic structure of single crystal TmCu under applied magnetic fields up to 10 T for the <100>, <110>, and <111> direction.

The backround of our experiment was, that we have constructed different magnetic phase diagrams for TmCu for the magnetic field along high symmetry axes and we got very complex diagrams (Fig. 1). Previous measurements with polycrystalline samples in zero magnetic field admit the existence of multi-k structures below the Neel temperature. However its interpretation suffers the intrinsic ambiguity of scattering from multi-k structures in powder samples [1]. In each of the phase pockets at zero field a multi-k-structure without any incommensurate modulation is expected [1].

The aim of our project is to get a full understanding of the magnet ordering in the compounds RCu (R= Ho, Tm, Er). This project is the main part of the PhD thesis of Wolfgang Simeth. The Experiment at D10 was the first neutron-experiment on the compound TmCu with single crystals.

With our investigation at D10 we wanted to confirm several pockets of magnet order and collect data sets of reflex lists at different temperatures in different pockets of the phase diagram.

When we were at D10 the 10T magnet was used for the first time on D10. We had problems with the instrumental setting we had not expected before. After the detector crashed into the magnet we had to set new constraints on the angle ranges of the instrument and we could not measure enough reflexes for a refinement any more.
Another problem was that the sample fell down a couple of times due to the large magnetic moment of Ho.

The main results of our measurements are:

(i) We confirmed several magnetic phases of k = (π, π, 0) type propagation and confirmed all the phase transitions but not very precisely.
(ii) We discovered re-entrant incommensurate magnetic phases (in contrast to the results from literature [2]) with an unvonvential arrangement of higher-order incommensurate peaks around (π, π, 0) (Fig1c.).
(iii) We observed an exotic field-dependence of the integrated intensities of magnetic reflexes (Fig1a.)

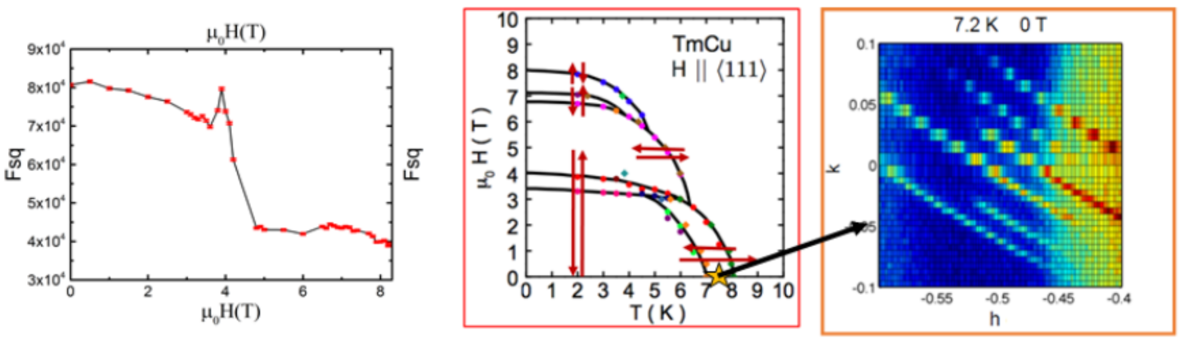

Figure 1: left: a) Field dependence of the intensity at nuclear position 110. **middle: b)** Phase diagram of TmCu with H||<111> determined from magnetization, ac suceptility and transport measurements. Red arrows mark the measured sweeps at D10. **right: c)** hk map around (0.5 0 -0.5) shows incommensurate satellites .

One problem now is that we do not know of the mechanisms that lead to the incommensurate modulations. In our model they come either from solitons that are topologically saved by the group $\pi_3(S^2)$ or by solitonic domain walls. Similar results were found in $TbFeO_3$ [2]. Our results from Hall measurements support a topologically non trivial structure as well. For a first step we want to get an idea of the positions of the incommensurate peaks and the higher harmonics. Therefore we will propose measurements with an area detector. For the exact positions of the phase transitions we will propose another experiment at D10 with magnetic fields.

All in all Wolfgang Simeth is confident with the experimental results as it were his first own neutron experiments. The incommensurate modulations show that the magnetic ordering mechanisms are not as easy as claimed in previous investigations [1].

[1] P. Morin and D. Schmitt, J. Magn. Magn. Mater. 21, 243 (1980);
[2] Sergey Artyukhin et al., Nature Materials. 11, 694-699 (2012);