Experimental report

19/02/2018

Proposal: 5-31-2355 **Council:** 10/2014

Title: Magnetic structures of YbMn6(Sn,Ge,X)6 (X = Ga or In). Systems with magnetically ordered intermediate valency Yb at H.T

Research area: Materials

This proposal is a new proposal

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Samples: YbMn6(Sn,Ge,X)6

Instrument	Requested days	Allocated days	From	To
D1B	2	2	06/12/2015	08/12/2015

Abstract:

We aim at determining the magnetic structures of some YbMn6(Ge,Sn,X)6 (with X = Ga or In) representatives with neutron powder diffraction experiments performed on the D1B high-flux diffractometer. We recently showed that in YbMn6(Ge,Sn)6, there is a composition range within which intermediate valency Yb does magnetically order at an astonishingly high temperature (up to 110 K). Substituting Sn/Ge by Ga or In allows changing the valence electrons concentration and crystal field parameters, hence altering the magnetic behaviour of Yb. This study will help nderstanding the magnetism of intermediate valency Yb.

Experimental report ILL experiment 5-31-2355

A beam time of 2 days was devoted to the study of the temperature dependence of the magnetic structures of some $YbMn_6(Sn,Ge,Ga)_6$ representatives in the 2 – 320 K temperature range using the D1b diffractometer.

In a recent work [1], it was shown that intermediate valent Yb ($\upsilon \sim 2.9$) does magnetically order at an astonishingly high temperature in $YbMn_6Ge_{6-x}Sn_x$ (x = 4.2 and 4.4) reaching at least $T_{Yb} \sim 90$ K [2]. Further, the Yb valence was found to increase upon cooling [1] by opposition with the standard behavior. These two very unusual phenomena were tentatively linked to the interaction between intermediate valent Yb and the magnetic Mn sublattice ($T_C \sim 340$ K).

External parameters such as pressure or chemical substitution may alter the hybridization between the 4f states of Yb and the conduction electrons, thus changing the Yb valency. So, as a step towards a better understanding of the magnetic behavior of intermediate valent Yb, we investigate the effect of partial Ga substitutions on the $YbMn_6Ge_{1.8}Sn_{4.2}$ starting composition using DC magnetic measurements and powder neutron diffraction experiments. Gallium is used to partially replace Ge or Sn leading to the $YbMn_6Ge_{1.8-x}Sn_{4.2}Ga_x$ or $YbMn_6Ge_{1.8}Sn_{4.2-y}Ga_y$ alloys, respectively. Trivalent gallium has both a different valency and a different atomic size than Sn or Ge ($r_{Ge} < r_{Ga} < r_{Sn}$). That should help to descry chemical pressure influence from electronic effects.

Neutron diffraction data (see Figure) have allowed us to determine magnetic structures together with Yb and Mn magnetic moments in $YbMn_6(Sn,Ge,Ga)_6$. We investigated 6 different compositions: in each case, long duration patterns were recorded at 320 K and 2 K as well as a thermal scan between these two temperatures. For some compositions, some long duration patterns were recorded at intermediate temperatures.

Results of the ILL experiment **5-31-2355** have been published in ref [3].

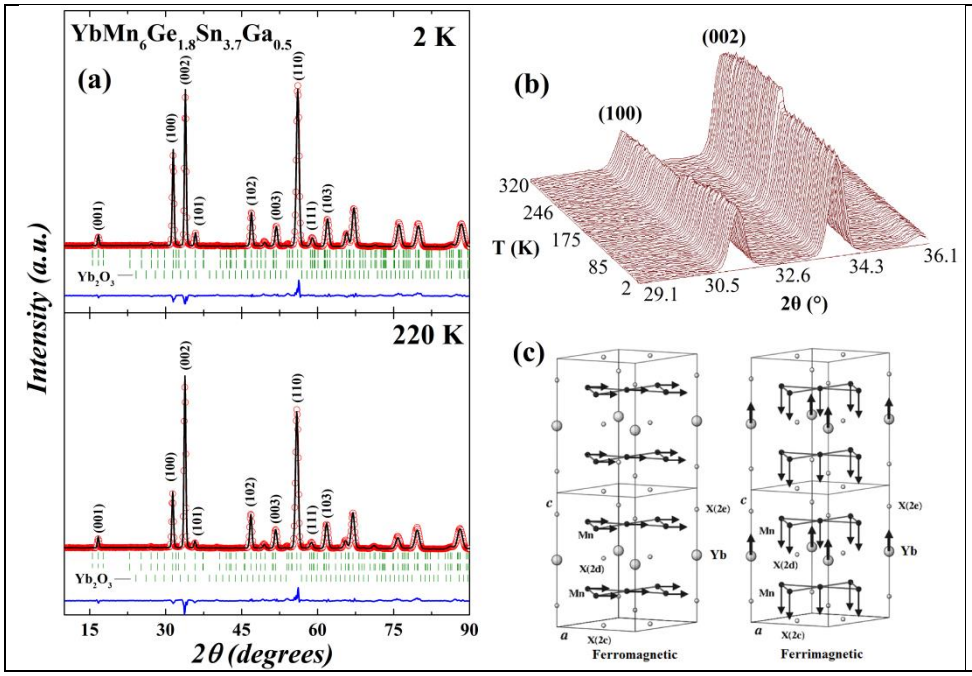

Fig.

(a) Refined neutron diffraction patterns of $YbMn_6Ge_{1.8}Sn_{3.7}Ga_{0.5}$ at 220K and 2K

(b) selected angular region of the neutron thermodiffractogram of $YbMn_6Ge_{1.8}Sn_{3.7}Ga_{0.5}$

(c) Schematic representation of the two magnetic structures in $YbMn_6Ge_{1.8-x}Sn_{4.2}Ga_x$ and $YbMn_6Ge_{1.8}Sn_{4.2-y}Ga_y$.

[1] T. Mazet, D. Malterre, M. François, C. Dallera, M. Grioni, G. Monaco, Phys. Rev. Lett. 111 (2013) 096402.

[2] T. Mazet, H. Ihou-Mouko, D.H. Ryan, C.J. Voyer, J.M. Cadogan, B. Malaman, J. Phys. Condens. Matter 22 (2010) 116005.

[3] L. Eichenberger, B. Malaman, T. Mazet, J. Magn. Magn. Mater. 405 (2016) 48.