Experimental report

25/06/2018

Proposal: **5-31-2524** **Council:** 10/2016

Title: Pressure-induced magnetic phase inMn3Ge

Research area: Physics

This proposal is a new proposal

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Samples: Mn3Ge

Instrument	Requested days	Allocated days	From	To
D20	6	4	16/02/2017	20/02/2017
D2B	6	0		

Abstract:

The interest in the noncollinear antiferromagnet Mn3Ge was stirred by the recent observation of an anomalous Hall effect (AHE) driven by nonvanishing Berry curvature, which typically vanishes for conventional (collinear) antiferromagnets. Our most recent anomalous-Hall- effect and magnetization measurements suggest a very strong sensitivity of the magnetic transitions and presumably of the magnetic structure and AHE to hydrostatic pressure. Even very modest pressures of the order of a few kbar led to a notable reduction of the antiferromagnetic transition temperature and to the stabilization of a new low-temperature magnetic phase. We propose to study the magnetic structure of this pressure-induced phase transition by neutron powder diffraction at the D2B instrument with the conventional clamp pressure cell and at D20 instrument with Paris-Edinburgh cell available at ILL.

Pressure-induced magnetic phase in Mn_3Ge

Experimental report: 5-31-2497 (D20)

Here we proposed to study the pressure induced magnetic phase by means of neutron diffraction on a powder sample of Mn_3Ge both as a function of pressure and temperature. Measurements under hydrostatic pressure were performed at the D20 diffractometer. A standard Paris-Edinburgh pressure cell with a cryostat was used to control the applied pressure. A small amount of Pb powder, which served as the standard for determining the on-sample pressure, was added to the sample placed in a Zr-Ti (null-scattering alloy) gasket. An ethanol-methanol mixture was used as a pressure-transmitting medium. The neutron beam was monochromized to 2.41 °A by PG (002) reflection. The powder patterns were collected on stepwise increase of pressure in the range of (0.5–5) GPa at 300K. At a few selected values of pressure, the temperature scans from 80 to 300 K were recorded. First, the sample was cooled to low temperature, then the applied hydrostatic pressure was maintained. The process of heating the sample led to a temperature-dependent offset in pressure (up to approximately 10%) that was determined and considered. All the collected data have been analyzed by Rietveld refinement method using the FullProf software.

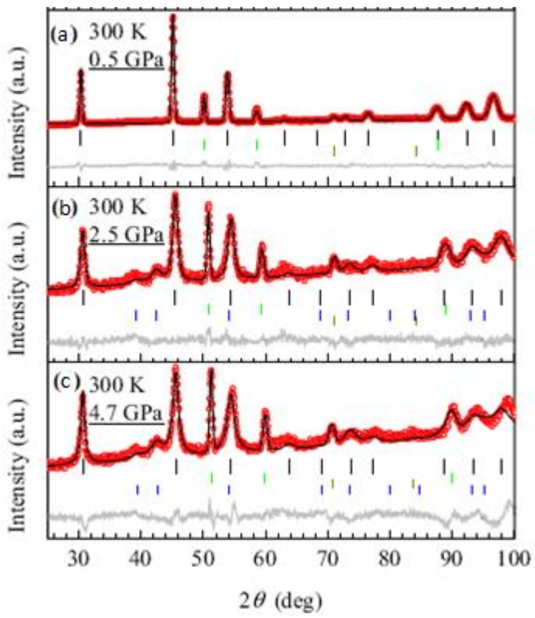

Fig.1: Set of diffraction patterns collected at different hydrostatic pressure at 300 K. The red circles are experimental data. Solid black line and solid gray line correspondingly denote the result of Rietveld refinement and the residue. Vertical ticks mark the position of the Bragg peaks for the main phase (hexagonal) as well for the additional (tetragonal) phases. Details given in text.

Diffraction patterns obtained under hydrostatic pressure are shown in Fig1. As can be seen, the effect of pressure results in a certain redistribution of intensity between the strong and the weak Bragg peaks. There are three additional phases with the Bragg peaks marked by the corresponding vertical lines along with the main phase of the Mn_3Ge compound. The second line (green ticks) shows Pb with two strong reflections at $2\theta \approx 50^\circ$ and 60°. The positions of the Bragg peaks of Pb were used to refine the lattice constant of the element, which allows us to calculate on-sample pressure for the given conditions if the equation of state for Pb is known. The dark yellow tick in the third line marks a spurious Bragg peak at $2\theta \approx 71^\circ$ coming from the boron nitride anvils of the Paris-Edinburgh pressure cell due to the incomplete absorption. The peak has a constant intensity throughout the whole set of data, however it is more pronounced at high pressures because the overall intensity from the sample in the gasket is reduced by the closing gap between the squeezed anvils, thus making it more visible on the relative scale. The last phase (blue ticks) is represented by the tetragonal polymorph of Mn_3Ge, which was absent before pressure was applied. Hexagonal Mn_3Ge is a metastable phase at $T < 953$ K, however the transition to the stable tetragonal phase does not occur unless the sample is annealed at sufficiently high temperature for a long time. The high barrier of hexagonal to tetragonal polymorph transformation seems to be noticeably lowered with high pressure. The tetragonal phase becomes visible as an impurity at $P > 1$ GPa and reaches as much as 15% of the weight of the whole sample at $P = 4$GPa. All the present phases were taken into account in the pattern refinement. Our results show that the crystal and magnetic structure of Mn_3Ge changes gradually with pressure. Results based on this experiment are published in **Phys. Rev. B 97, 214402 (2018).**