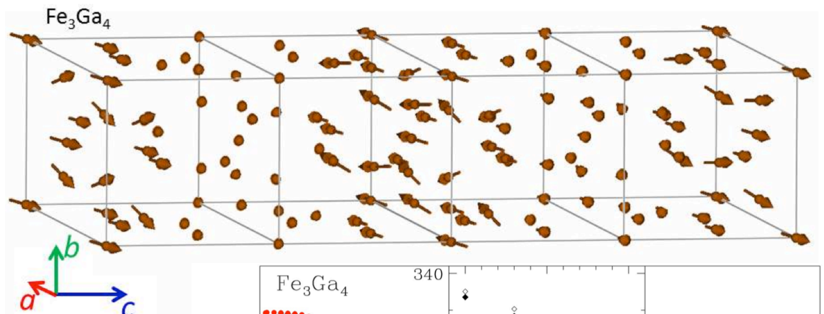
Beam time on HB3A at HFIR: "Exploration of the Effect of Pressure on the Spin Density Wave State of Fe_3Ga_4."

We have recently been awarded 6 days of beam time on the Four-Circle Diffractometer, HB-3A through the ORNL HFIR proposal process to carry out an exploration of the effect of pressure on the magnetic states of Fe_3Ga_4. Previously we have shown that the magnetic metal Fe_3Ga_4 displays a close competition between itinerant ferromagnetic (FM) and spin density wave (SDW) AFM states[1]. This compound forms in a somewhat complex monoclinic crystal structure ($C12/m1$) which contains 4 crystallographically distinct Fe and 4 distinct Ga sites[1-6]. We have synthesized single crystals via vapor transport and optical furnace methods and have characterized their magnetic, thermodynamic, and electrical transport properties[2]. These reveal a FM ground state with a transition to an AFM state at T_1=68 K followed by a re-entrance into the FM state at T_2=350 K (See Fig. 1b). Above T_3=420 K the magnetization is greatly reduced although there is a hint of a magnetic transition involving a small magnetic moment at T_4=685 K. Our transport measurements reveal a large anomalous Hall effect rivaling that of magnetic semiconductors, along with a contribution of topological origin which we attribute to a small non-coplanar magnetic moment in the AFM state. Prior to our success growing crystals, almost all investigations were performed on polycrystalline materials where attempts to determine the magnetic structure via neutron scattering were inconclusive [1-6]. Thus, we have performed neutron diffraction measurements on an optical furnace grown crystal of Fe_3Ga_4 using the HB3A four-circle single crystal diffractometer at HFIR. This exploration revealed that in the FM state the magnetic moment lies along the c-axis in both the low



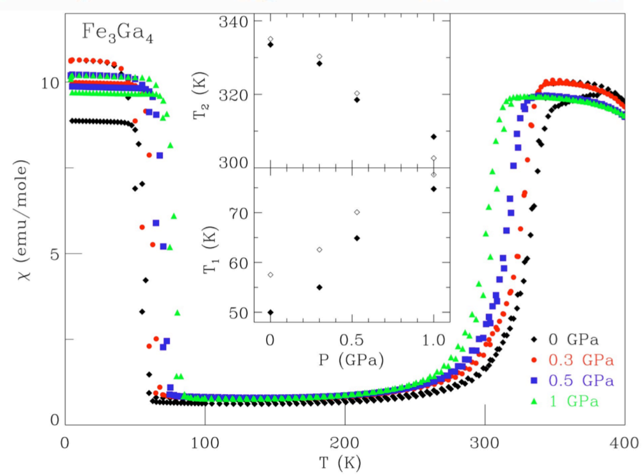


Fig 1: a) Magnetic structure of Fe_3Ga_4 at 100 K determined from HB3A Neutron diffraction. For modeling purposes the wave vector has been set to a commensurate value of 0.25c* in this figure. [Y. Wu, H. Cao, A. Karki, R. Jin, and J. F. DiTusa in preparation.] b) Effect of pressure on the magnetic susceptibility. (unpublished).

temperature phase and between T_2 and T_3. More interestingly, the AFM phase between T_1 and T_2 was found to be an incommensurate SDW phase with a wave vector of 0.27c* (Fig.1a).

In the experiment to be carried out at HFIR, we will perform extensive neutron diffraction measurements on our Fe_3Ga_4 single crystals with the application of hydrostatic pressure. The effect of pressure on the SDW wavevector will be explored with the aid of a CuBe piston–cylinder-type clamp cell designed to reach 2 GPa for neutron diffraction. We expect interesting changes to the SDW state based upon our magnetic measurements performed on a single crystal of Fe_3Ga_4 with the application of hydrostatic pressure of up 1 GPa (Fig1b). These measurements reveal an increased T_1 and a decreased T_2 along with a slightly increased magnetic moment in the FM phase below T_1. So it appears that pressure favors the FM state, however, the changes that occur to the SDW phase can only be accessed via neutron scattering.

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