Beam time Awareded on HB-2A at HFIR: Exploring the Newly Discovered Magnetic Order in non-centrosymmetric $Ru_{1-x}Co_xGe$

We have recently received confirmation that we received an allocation of 4 days of beam time on HFIR's Neutron Powder Diffractometer, HB-2A, to explore the magnetic properties of $Ru_{1-x}Co_xGe$.

The magnetism found in transition metal silicides and germanides having the *B20* crystal structure has fascinated condensed matter physicists for decades. The most celebrated of these is MnSi which has been investigated as a long wavelength helimagnet[1], a prototypical weak itinerant ferromagnet[2], a possible pressure induced quantum critical system[3], and most recently as a host for a Skyrmion lattice, a crystal of topologically stable knots of spin structure[4]. This class of compounds also includes FeGe, $Fe_{1-x}Co_xSi$, and MnGe all of which are helimagnets because of the importance of the Dzyaloshinskii-Moriya (DM) interaction in non-centrosymmetric systems. In addition, there is ample evidence for the nucleation and stability of the Skyrmion lattice phase in each of these materials over a limited range of both temperature and magnetic field. The occurrence of the Skyrmion lattice phase is intimately connected to the helimagnetism having a characteristic wavevector that matches the helimagnetic (HM) wavevector, q, for each of these systems despite the wide range of q's displayed (ranging from ~0.15 nm^{-1} in $Fe_{0.9}Co_{0.1}Si$ [5] to ~2.1 nm^{-1} in MnGe[6]). The case of $Fe_{1-x}Co_xSi$ is particularly interesting to us since the magnetism results from carrier doping the small band gap insulator FeSi to create a magnetic semiconductor. In addition, the two parent compounds, FeSi and CoSi (a diamagnetic semimetal), have no intrinsic magnetic moments apparent, let alone a magnetic transition.

Very recently we have discovered that Co substitution into the small band gap insulator RuGe[7] ($Ru_{1-x}Co_xGe$) also having the *B20* crystal structure, results in a magnetic ground state (Fig. 1)[8]. This is interesting and important for several reasons. First, it is a second example of magnetism found by chemically substituting between a nonmagnetic insulator (RuGe) and a non-magnetic semimetal (CoGe, also having the *B20* crystal structure)[9]. Second, it demonstrates conclusively that the presence of Fe is not necessary for nucleating a magnetic state in an FeSi-like system. Third, the magnetism is likely to be HM with a q determined by an expectedly larger spin-orbit coupling simply because of the larger atomic masses compared to that of

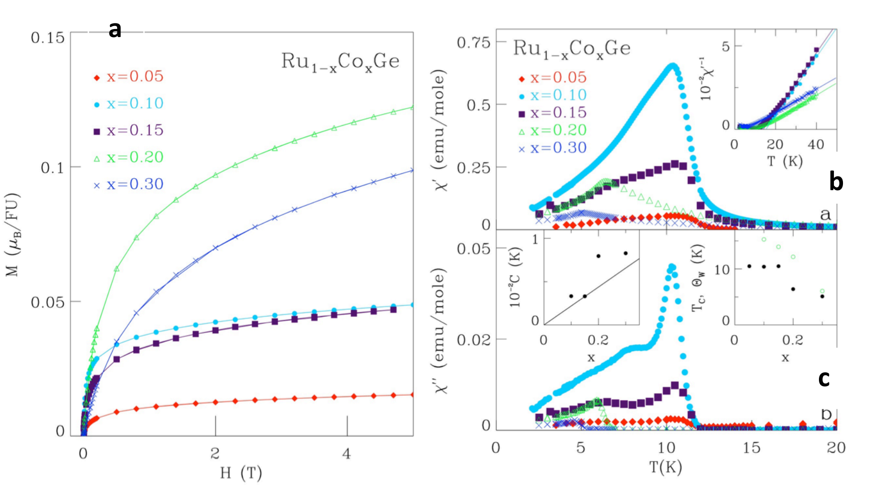

Fig 1: Magnetic properties of $Ru_{1-x}Co_xGe$. a) Magnetization, *M* at 4 K. b) Real, χ' and c) Imaginary , χ", part of the ac magnetic susceptibility. Inset in (b) is 1/χ' to illustrate Curie-Weiss behavior. Insets in (c) display the Curie constant (left) with the line representing a spin ½ per Co dopant, Curie temperature (black bullets) and Weiss temperature (green circles) (right)(unpublished).

the silicides, FeGe, or MnGe. Naively, this would argue for a larger *q* that varies with *x* in a similar fashion to the case of $Fe_{1-x}Co_xSi$[5].

In this experiment we will carry out extensive neutron diffraction measurements on polycrystalline samples of $Ru_{1-x}Co_xGe$, with $0<x<0.4$, synthesized via arc melting in order to establish the magnetic structure of this material. We expect to find helimagnetism and we will establish the wavevector as a function of *x*. The increased spin-orbit coupling may result in differences in the magnetic structure from the previously investigated *B20* materials and, thus, may lead to the discovery of novel magnetic behavior.

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