Possibility of tuning the size of Antiskyrmions in Mn1.4PtSn with Iridium doping

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Skyrmions are topologically stable particle like spin vortex structure which arise due to competition between Heisenberg exchange interaction, Dzyaloshinskii-Moriya interaction, and Zeeman Effect. Various types of skyrmions such as Bloch-type, Neél- type and Antiskyrmion were predicted to occur in magnetic systems based on their crystal symmetry [1] and in last few years with extensive research in this field, these exotic spin structures have been observed in both real space and k-space with different techniques such as Lorentz transmission electron Microscopy and Small Angle Neutron Scattering (SANS). Bloch-type Skyrmion was found in many chiral compounds such as MnSi, FeGe, MnGe, $Fe_{1-x}Co_xSi$, Co-Mn-Zn *etc*. while Neel-type was observed in spinel GaV_4S_8 (C_{3v} symmetry). Antiskyrmions were predicted to exist in compounds having D_{2d} symmetry many years ago and recently, with Lorentz Transmission electron microscopy, this was proved in $Mn_{1.4}PtSn$ where well-formed triangular lattice of Antiskyrmions was observed [2].

Size of Antiskyrmion in $Mn_{1.4}PtSn$ is 130 nm which is quite large for practical applications such as Skyrmion Racetrack memory device. Next goal, which comes in this field is reducing the size of these exotic spin structures somehow! A general equation for periodicity (λ) for helical structure has been stabilized which is, $\lambda \propto J/D$ where D and J are the constants of Dzyaloshinskii–Moriya (DM) interaction and ferromagnetic exchange interaction respectively. Iridium substitution at Platinum leads to reduction of Number of valance electrons which in turn results into the reduction of J. Therefore, with Iridium substitution, periodicity of ground state helical structure can be reduced or in other words, size of Antiskyrmion can be reduced.

We have Synthesized polycrystalline samples of $Mn_{1.4}Pt_{1-x}Ir_xSn$ (x= 0 -1) and measured their detailed magnetization properties and found that Curie temperature decreases linearly with increasing Iridium concentration. We also found Moment/f.u. was decreasing linearly with Ir substitution. Powder Neutron diffraction performed of some of the compounds in this series gave clear indication of non-collinear spin structure. SANS measurement carried out on twinned Single Crystal of one of the compositions shows that size of Antiskyrmion can be tuned upto 7 nm.

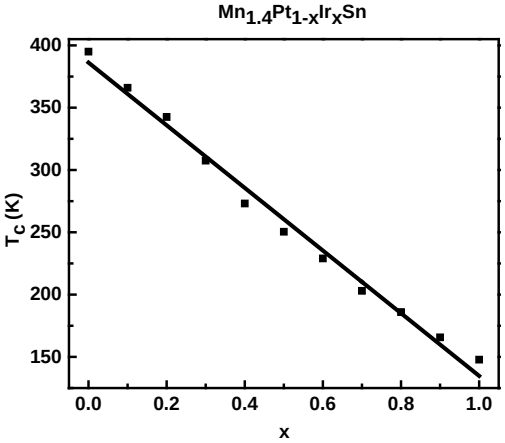

Fig. 1. Variation of Curie temperature with Iridium subtitution in Mn1.4PtSn.

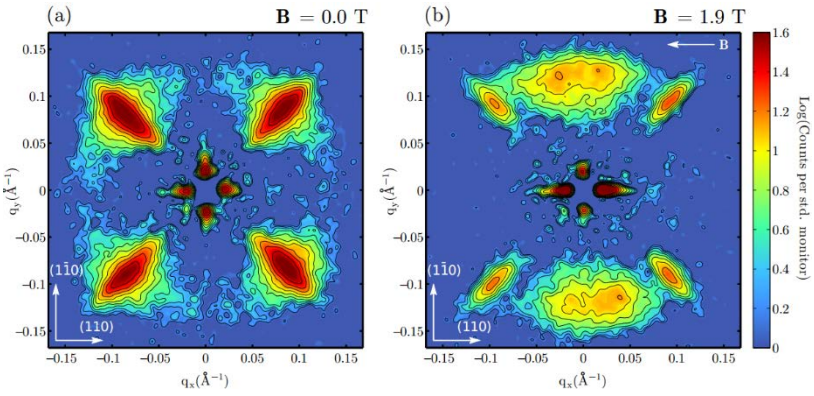

Fig. 2. SANS patterns of Mn-Pt-Ir-Sn helimagnetic system below ordering temperature at (a) *H*=0 and (b) 1.9 T. (Unpublished result)