Anomalous Hall effect and magnetic structure of the topological semimetal: Hexagonal-$(Mn_{0.78}Fe_{0.22})_3Ge$

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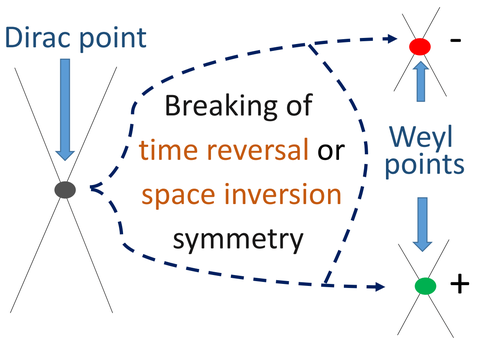
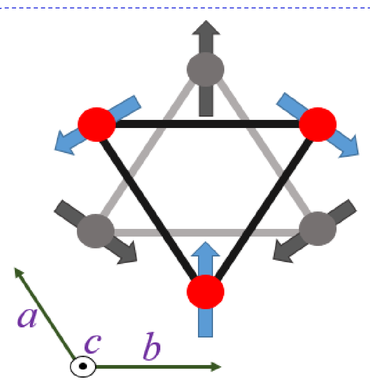
Introduction:

- Interests in the Weyl semimentals developed due to the observed anomalous transport effects.
- Mn_3Ge is the magnetic Weyl semimetal.
- Fe doping in Mn_3Ge changes the magnetic structure and magnetic moment.
- *Study of magnetic and electrical transport behavior of the Fe doped Mn_3Ge can help us understand the role of magnetism and lattice parameters in controlling the anomalous transport properties originated duo to the Weyl points.*

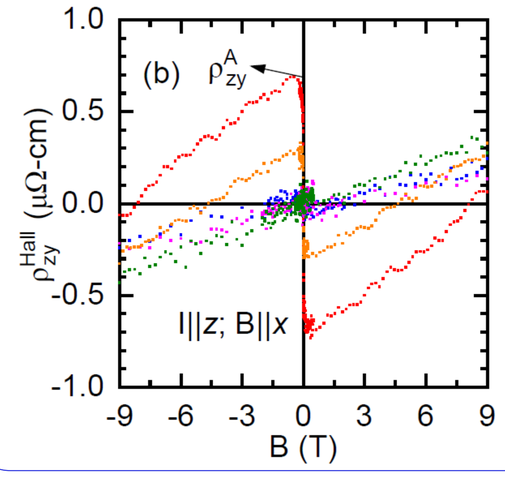


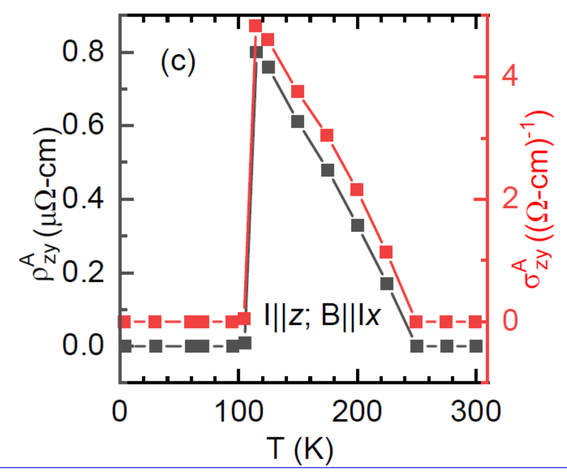


Magnetic structure of Mn_3Ge

Anomalous Hall effect:

- Non zero anomalous Hall conductivity is observed between T_{N1} and T_{N2}.
- Most probable origin: presence of Weyl points

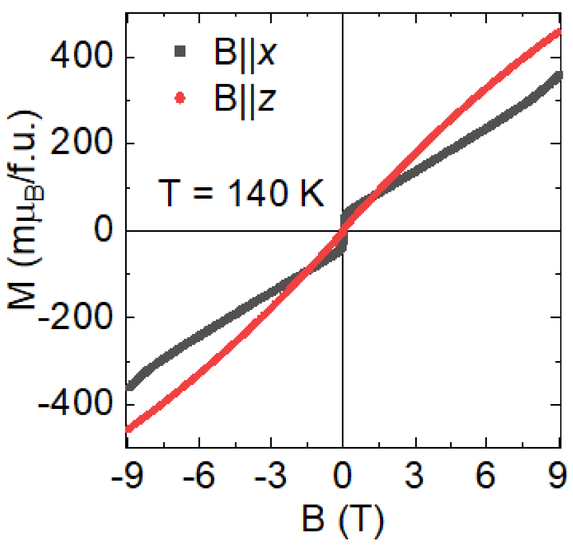




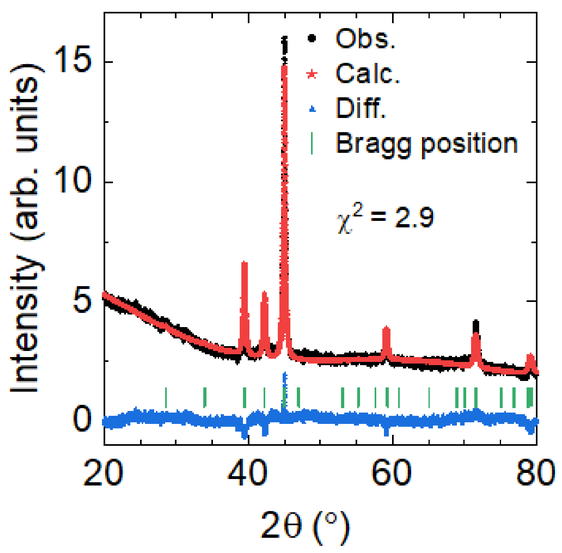
Sample characterization:

- Single crystal $(Mn_{0.78}Fe_{0.22})_{3.2}Ge$ was synthesized.
- X-Ray powder diffraction (XRD) analysis shows pure hexagonal phase.
- Space group: $P6_3/mmc$; a = 5.2978(4) Å , c = 4.2976(9) Å.
- Magnetization and resistivity measurements show magnetic phase tansitions at 240 K (T_{N1}) and 110 K (T_{N2}).
- T_{N1} decreases from 365 K to 240 K compared to Mn_3Ge.

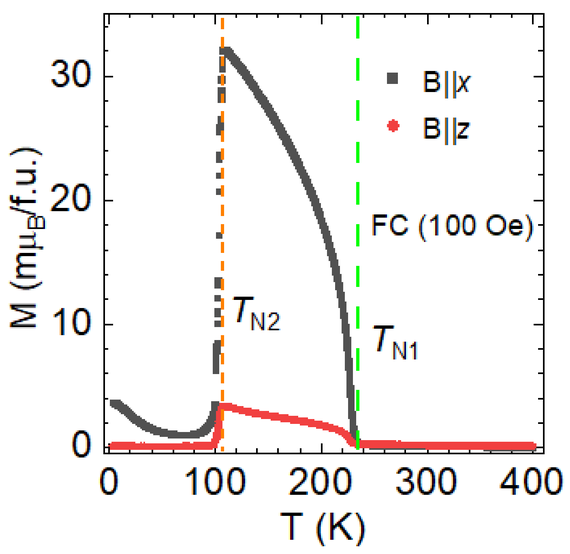
Magnetization-field



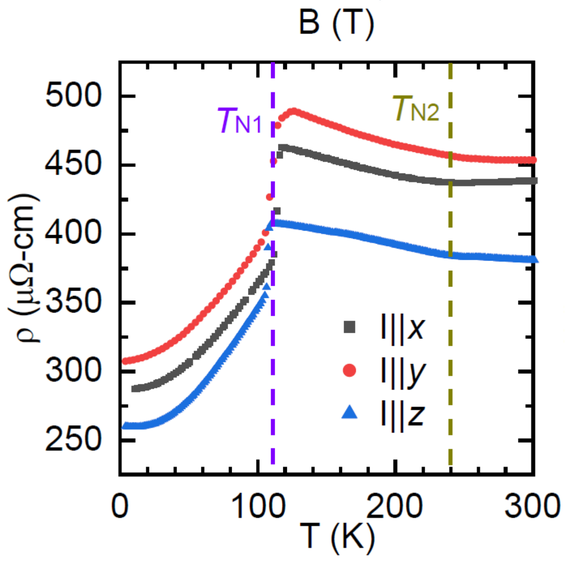
Powder XRD



Magnetization-temperature

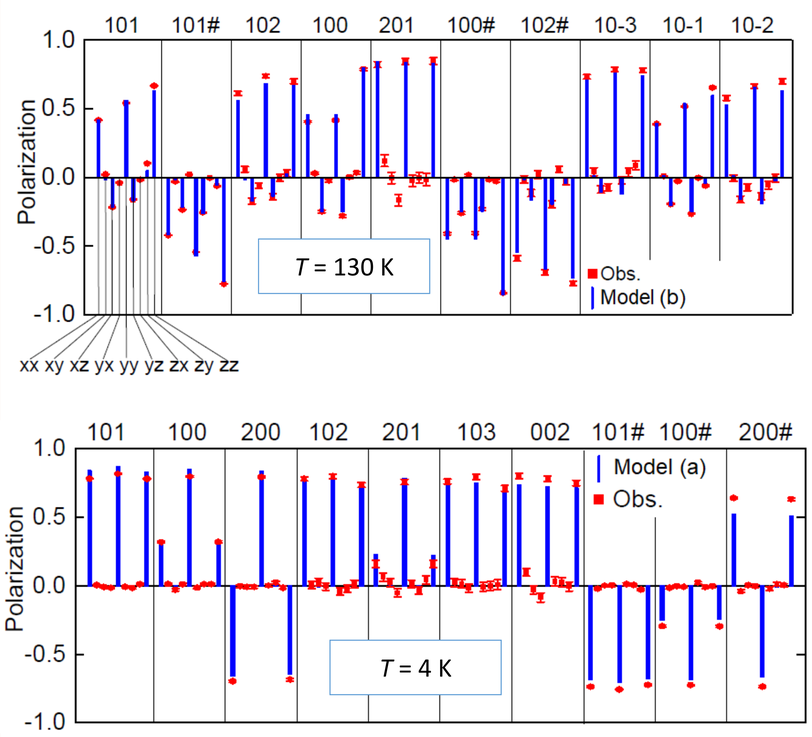


Resistivity

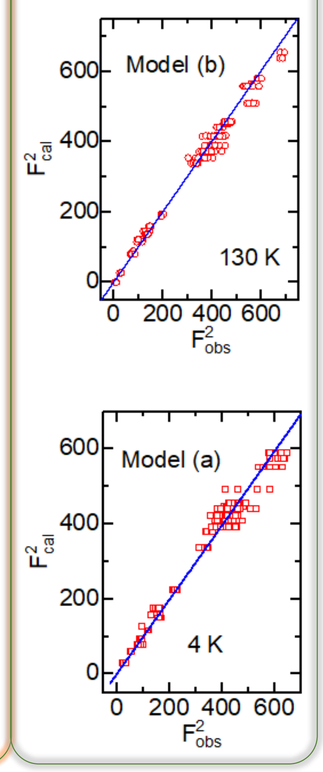


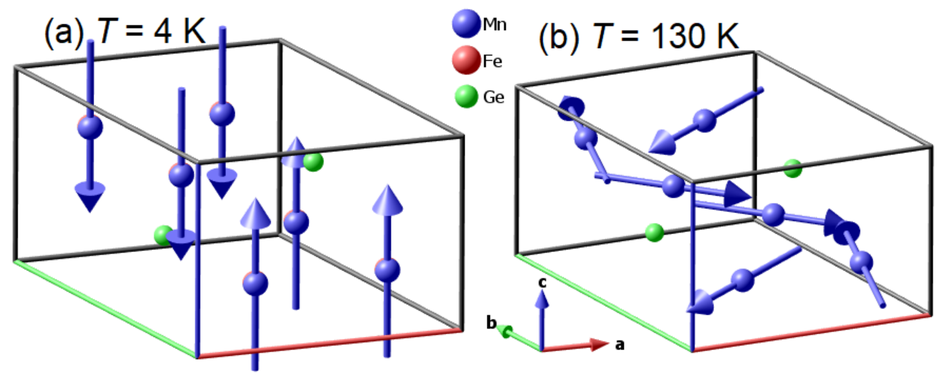
Single crystal neutron diffraction (@ ILL):

Polarized neutron (CRYOPAD, D3)



Unpolarized Neutron (D23)





- T = 4 K: antiferromagnetic (AFM) with moment along c axis.
- T = 130 K: magnetic structure remains same as Mn_3Ge (in plane AFM).
- Magnetic moment at 4 K and 130 K remains nearly same: 1.53(2) μ_b .

Conclusion:

- Magnetization and Hall resistivity measurements of the sample show similar behavior as Mn_3Ge, in the temperature range of T_{N1} and T_{N2}.
- Neutron diffraction analysis at 130 K confirms that the magnetic structure of 22% Fe doped sample remains same as Mn_3Ge. However, sample possesses AFM structure along c axis at 4 K.
- *Weyl points are likely to be present in 22% Fe doped sample in the temperature range of 110 K – 240 K.*
- *Magnetic structure and Weyl points are intimately connected as AHE vanishes below T_{N2}.*