Exploring Magnetic Phase Boundaries in Half-Heusler Intermetallics

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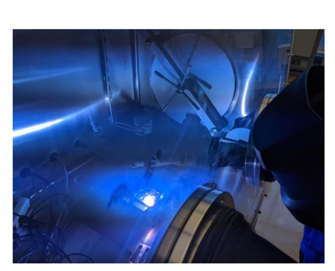
Introduction

In this project, we explore the compositional space between two half-Heusler intermetallic compounds, MnFeGe and MnFeAs. The former belongs to the hexagonal Ni_2In structure type,[1] while the latter exhibits either the Fe_2P or the Cu_2Sb structure type.[2] We explore the transition between these structures as a function of composition and temperature. To study the compositional phase space, we explore compositions $MnFeGe_{1-x}As_x$. We hypothesize that the change in the valence electron concentration, driven by an addition of one valence electron in As vs. Ge, will trigger the change in the structure type, thus resulting in a structural phase transition. We also aim to investigate how the structural changes impact magnetic properties of these materials. The coupled magneto-structural phase transition can make these Half-Heusler alloys promising materials for applications in magnetic refrigeration.[3] Unusual spiral or helical spin textures that can develop in the region of structural instability are also of interest in the context of using these materials in spintronic devices.[4]

Experimental Methods

Mn+1Fe+1Ge → Pelletize → Air-sensitive Pellet → Arc Melt → Air-stable ingot



Flame-seal in silica tube under vacuum → Furnace

Anneal at 975°C for 7 days

→ Single-crystal X-ray diffraction

→ Powder X-ray diffraction

Mn+1Fe+1As → Pelletize → Air-sensitive pellet → Anneal at 975°C for 12 hours

Flame-seal in silica tube under vacuum → Furnace

Anneal at 975°C for 7 days

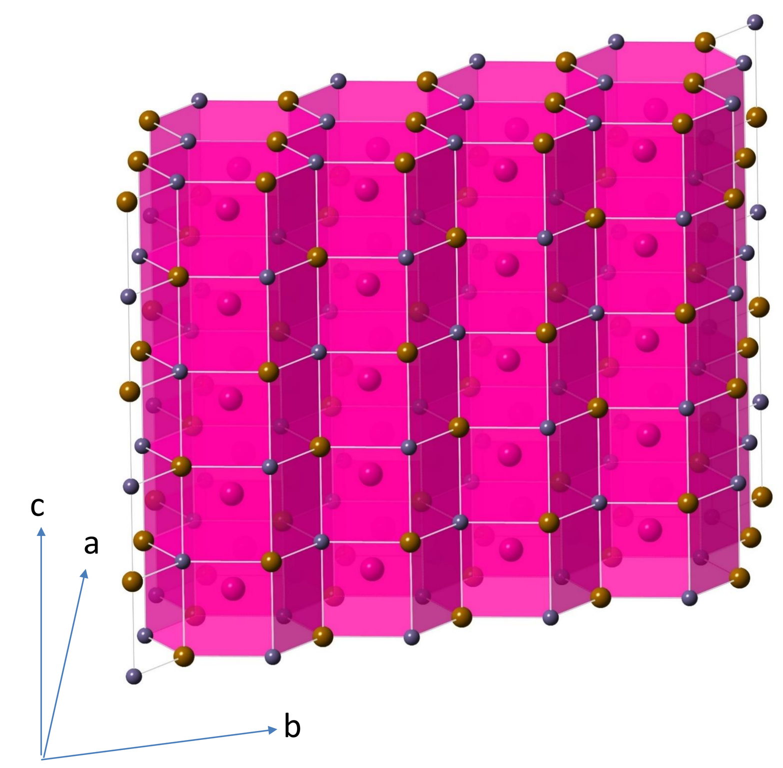
→ Single-crystal X-ray diffraction

→ Powder X-ray diffraction

Crystal Structure

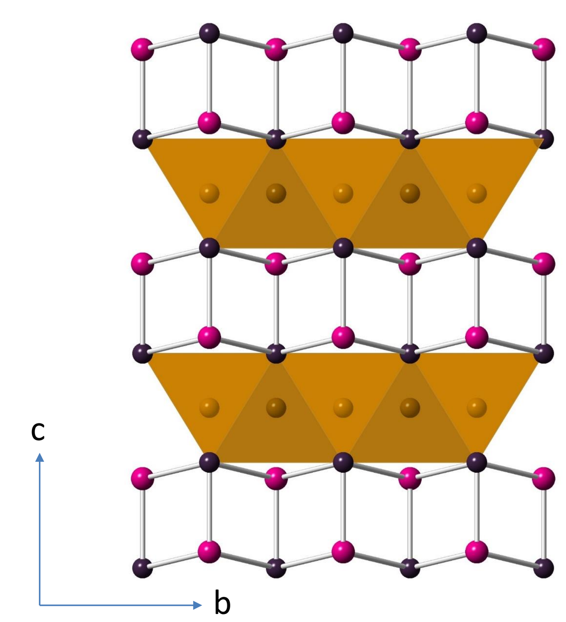
MnFeGe

- Mn
- Fe
- Ge



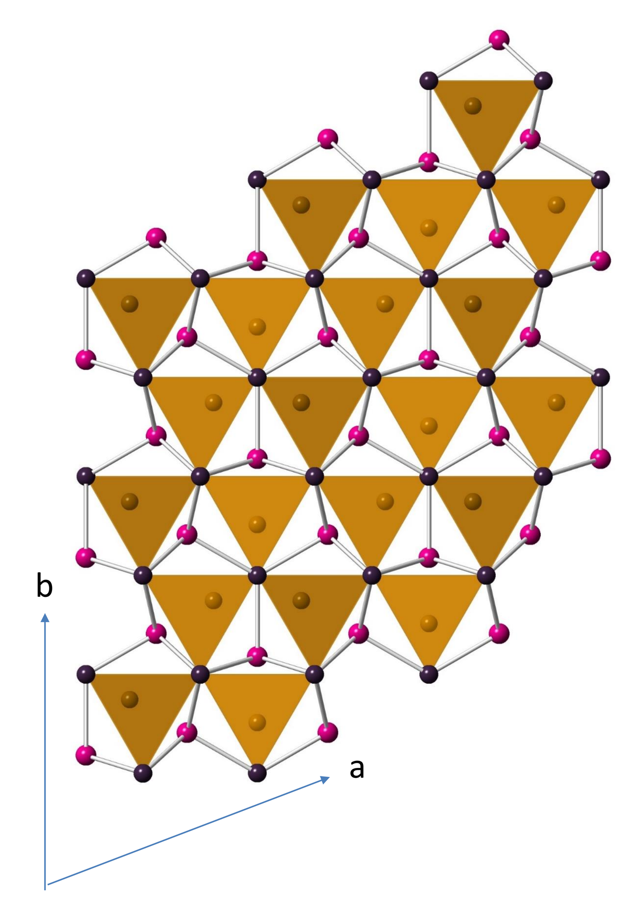
MnFeAs(1): Cu_2Sb

- Mn
- Fe
- As



MnFeAs(2): Fe_2P

- Mn
- Fe
- As



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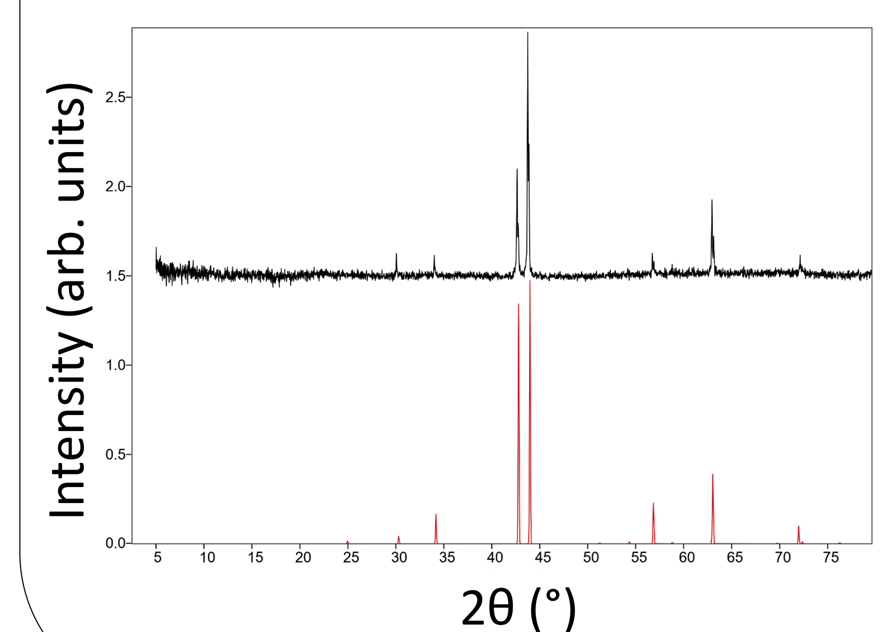
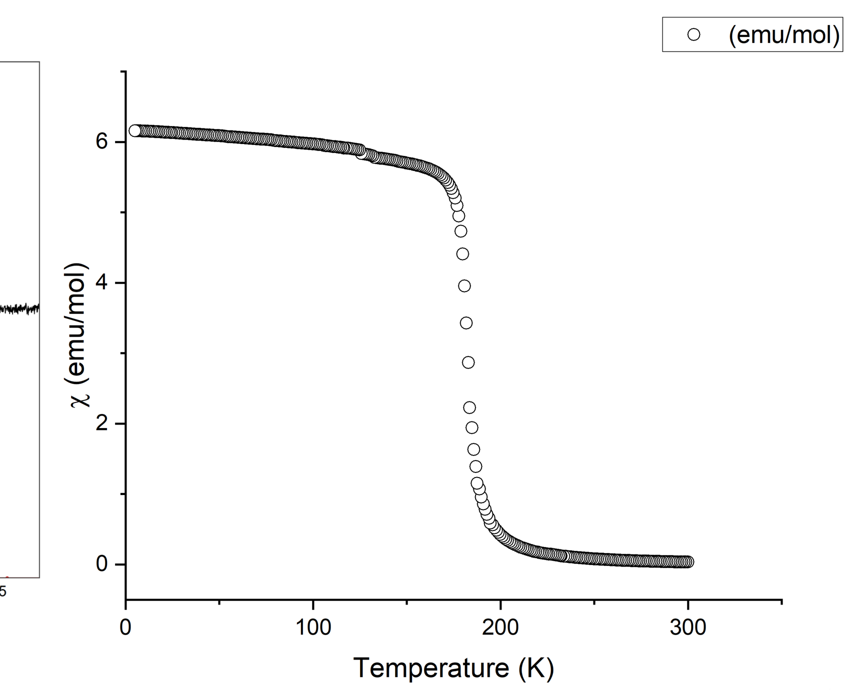
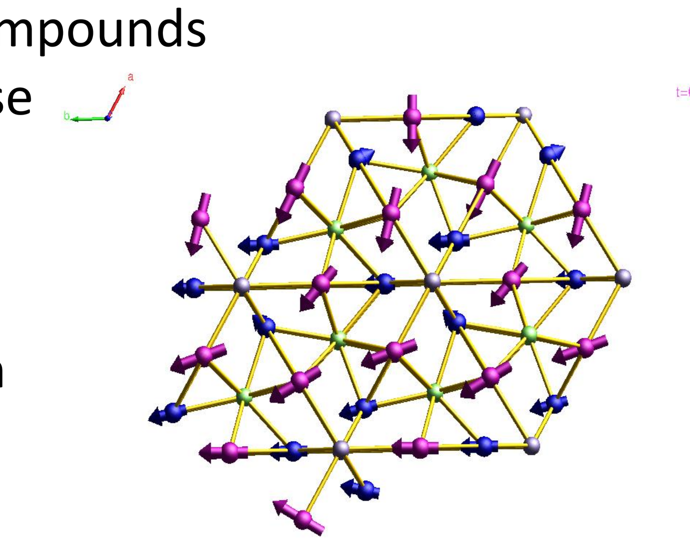
Results





Future Directions

- Synthesize MnFeAs alloy and test to understand the dynamics of the coexisting phases
- Collect magnetic susceptibility data on MnFeAs
- Expect interesting behavior to show up because of the lack of inversion symmetry in the Fe2P structure type
- Substitute As for Ge in the MnFeGe alloy to determine which structure type occurs in the intermediate phase of these two parent compounds
- Determine if a structural phase transition can be observed
- Almost no reports on the magnetic properties of the intermediate phases between two parent compounds



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