

Synthesis, Refinement, and Magnetic Characterization of Heusler Compounds

Supervisor

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Mentor

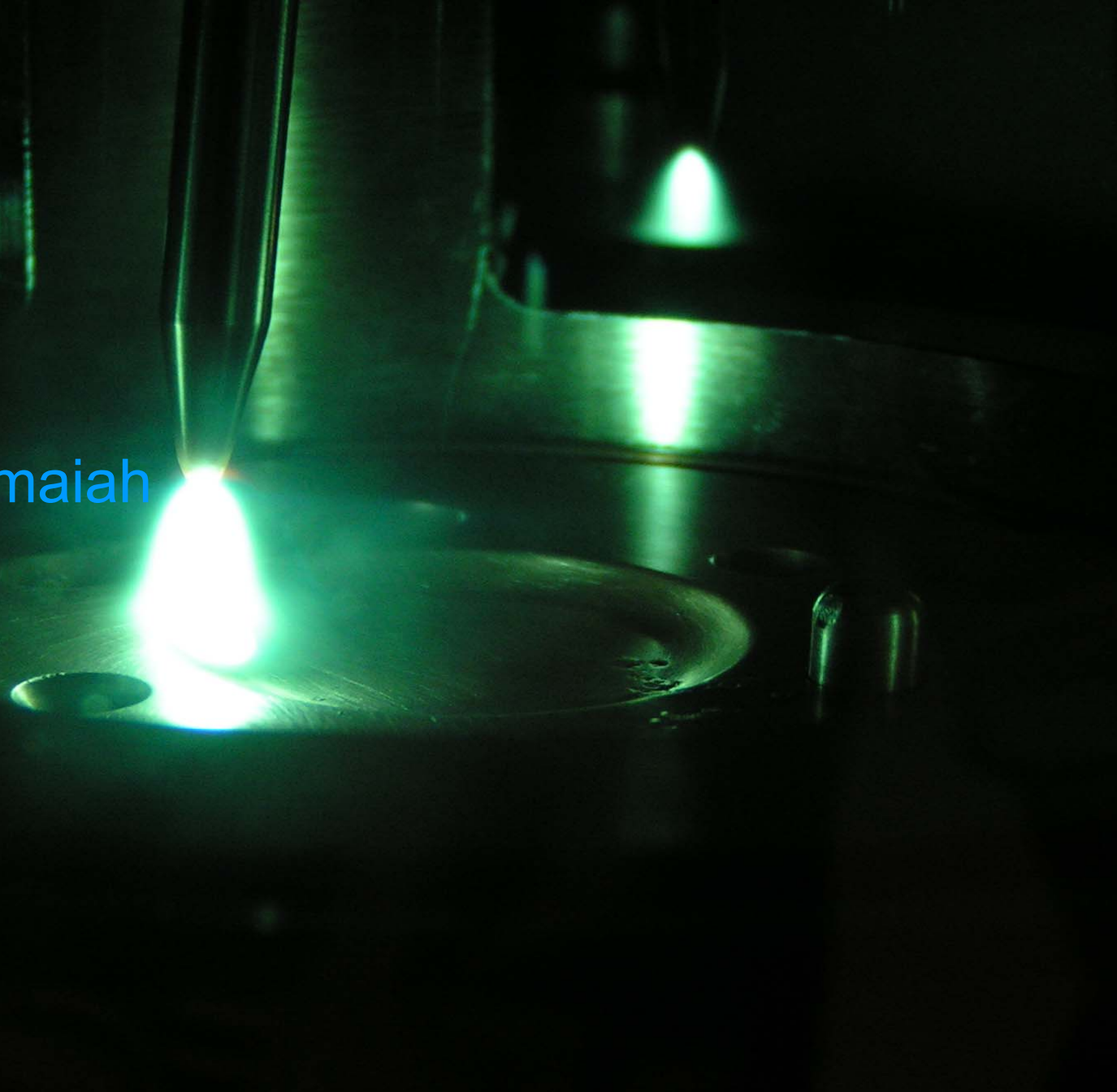
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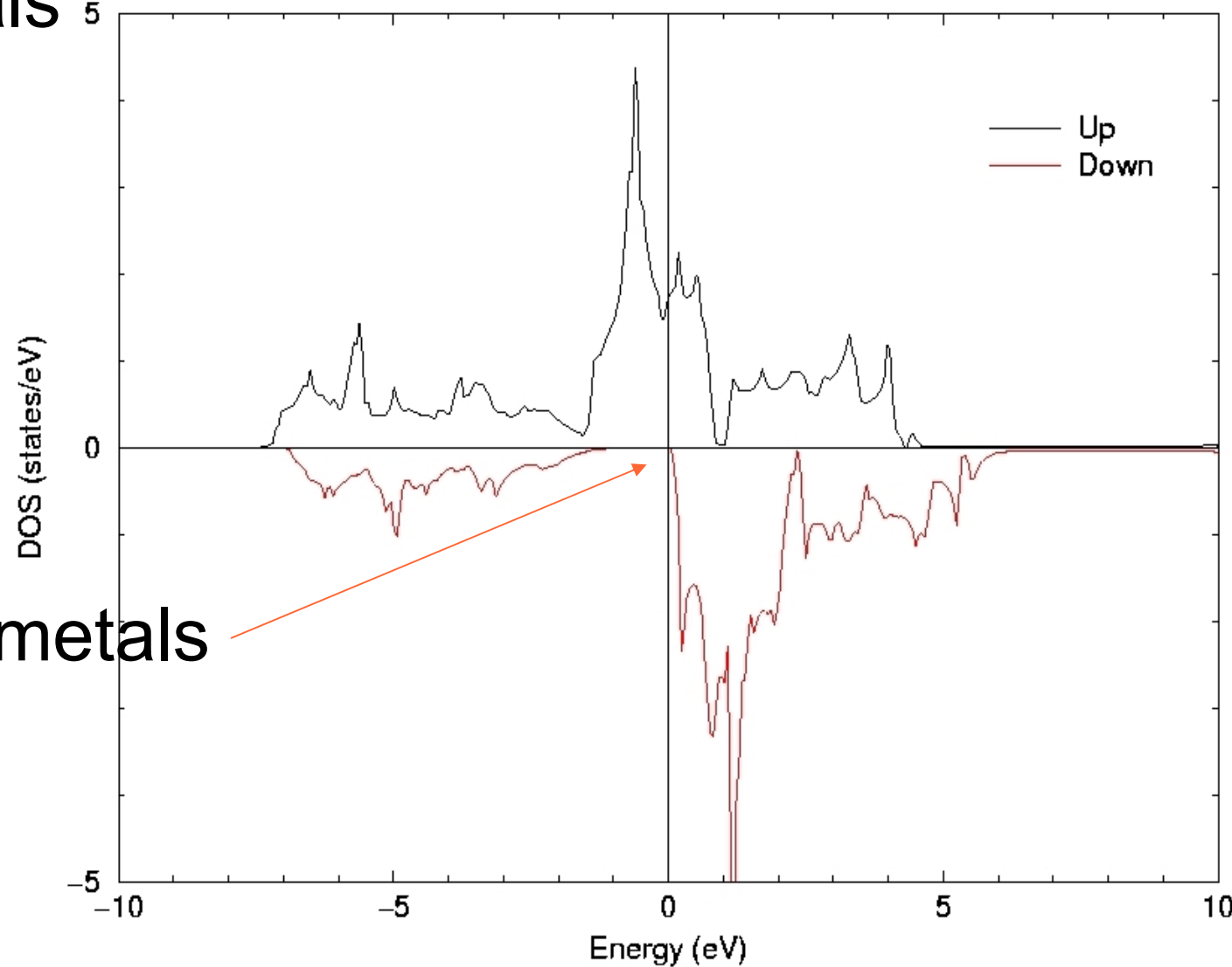
Funding

NSF



What Are Heusler Compounds?

- Contain 3 metals
- Full Heusler
 - ♦ Formula X_2YZ
- Half Heusler
 - Formula XYZ
- Magnetic
- Some are half-metals
 - Spintronics

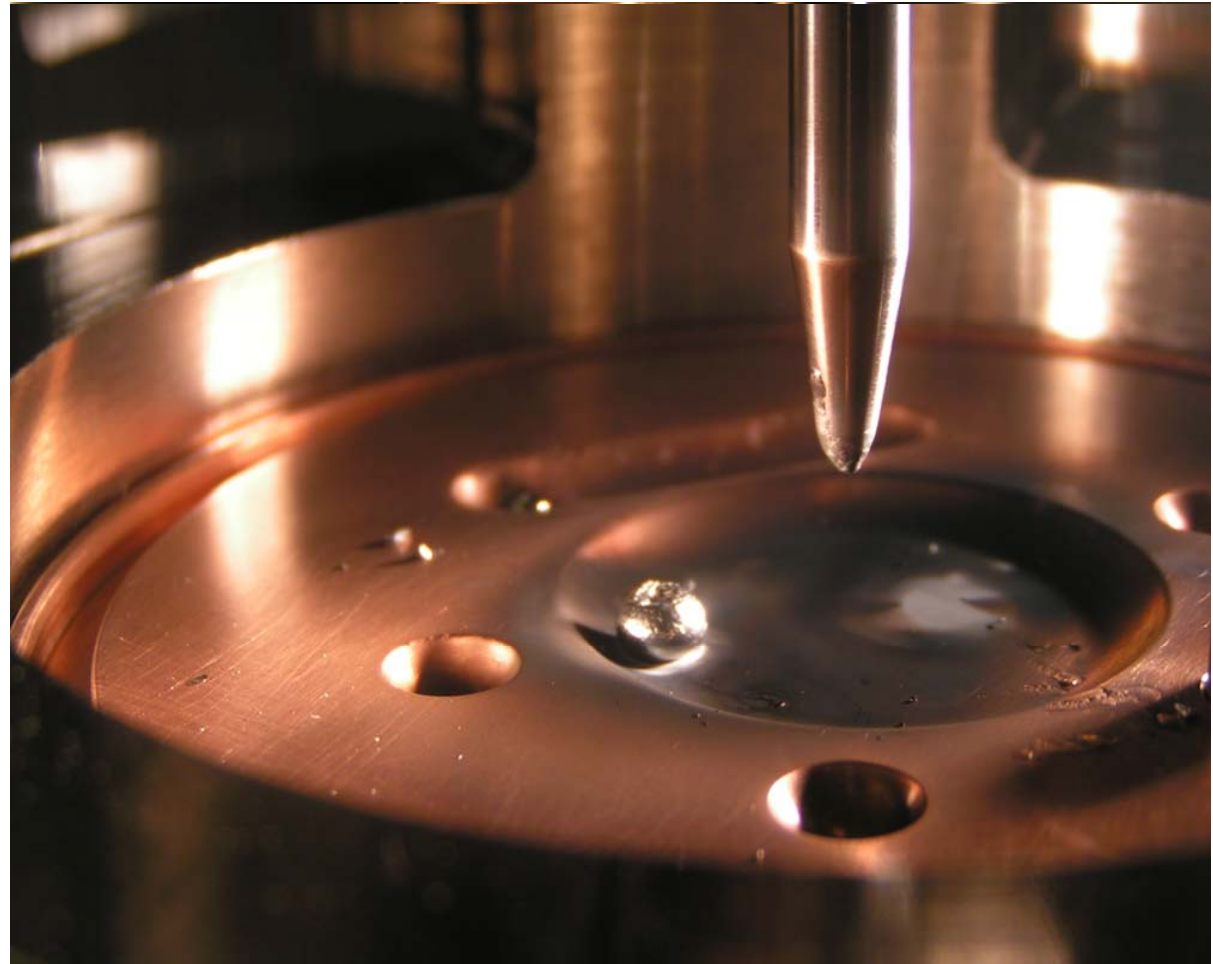
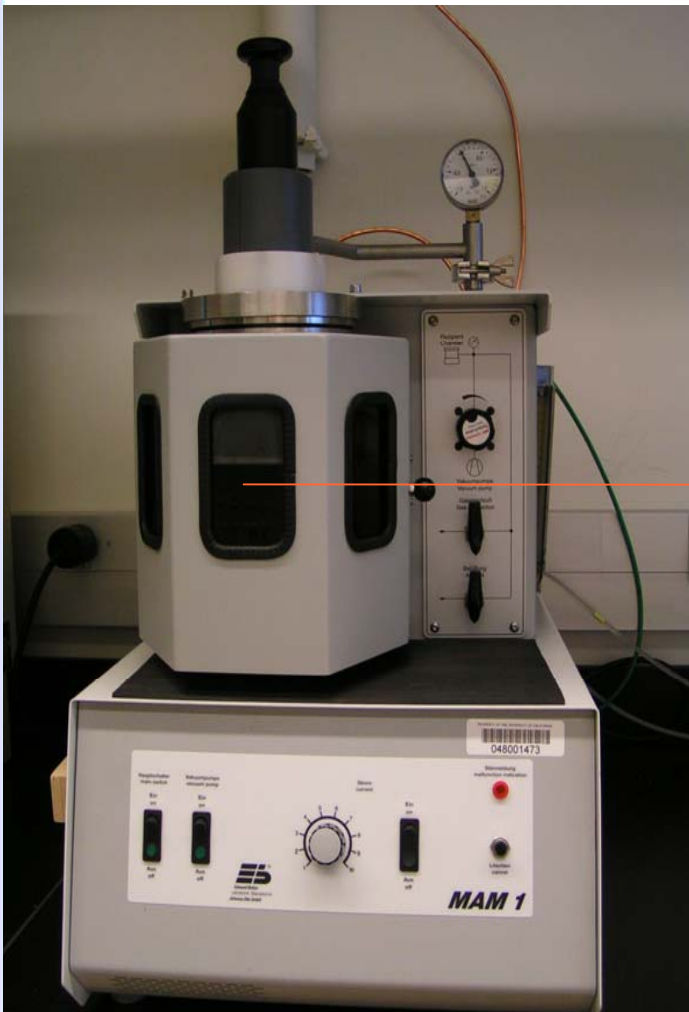


Experimental Methods

. Preparation

- Arc melter, furnace

3 metals \longrightarrow Arc melter

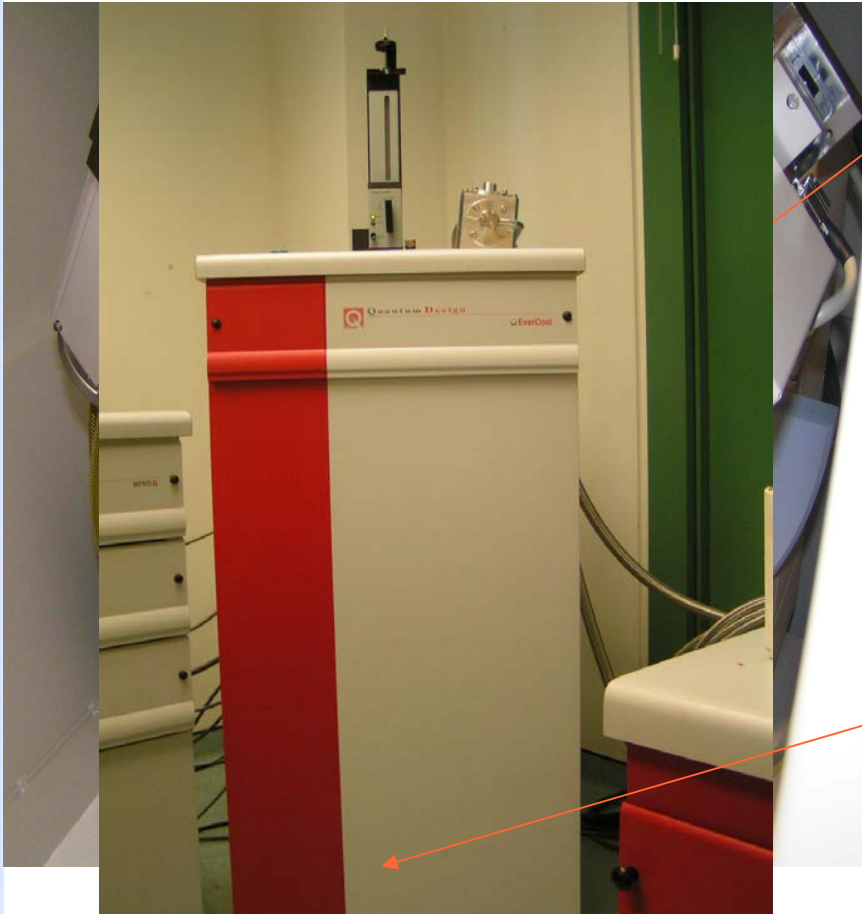


Experimental Methods

• Characterization

- X-ray powder diffractometer
- SQUID magnetometer

3 metals → Arc melter



Diffractometer ← Furnace
impure →

Pure

Rietveld Analysis

Heusler

SQUID magnetometer

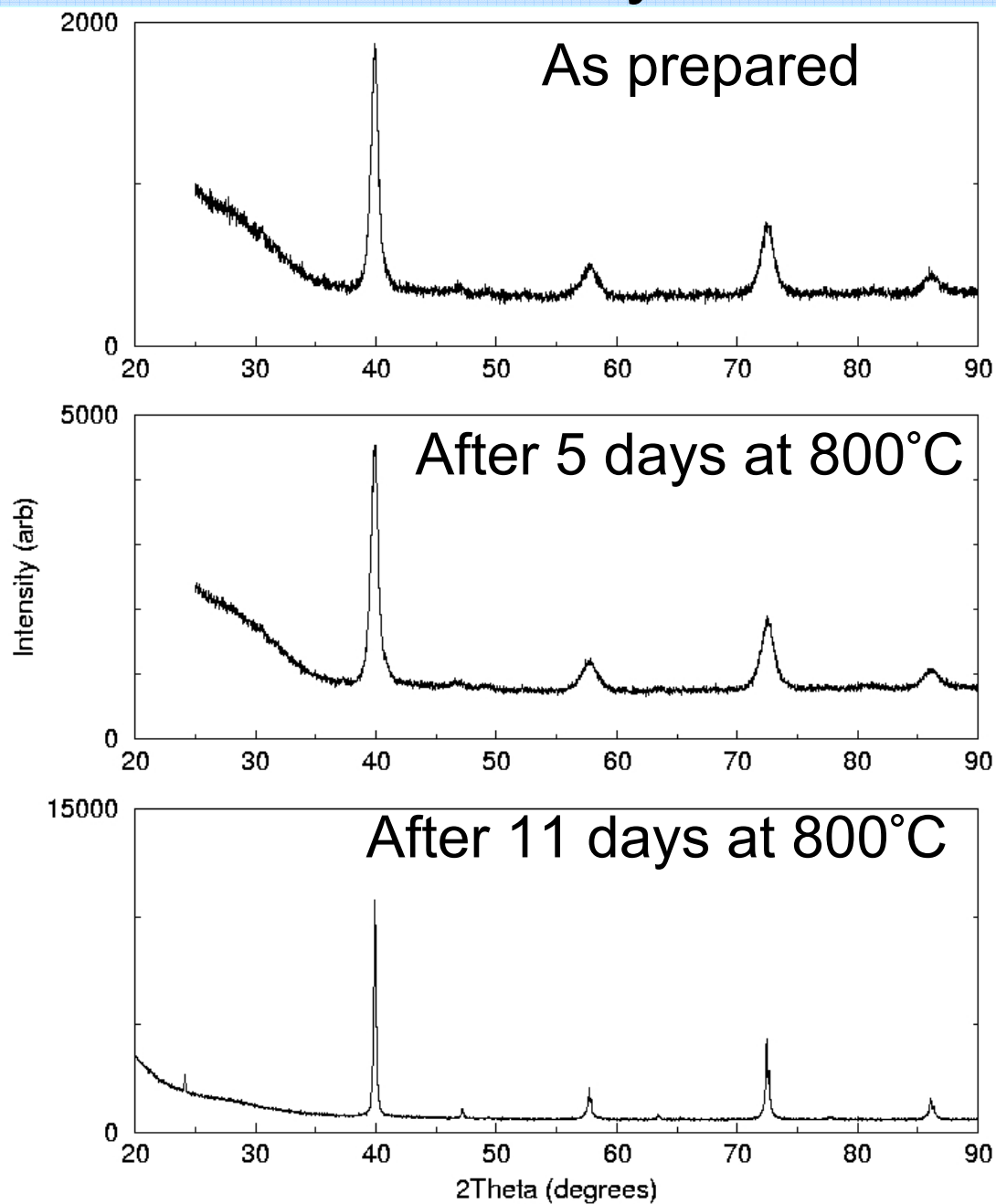
Results

#	Formula	Phase?	Magnetic Data?	Notes
1	Pd ₂ MnSn	Single	Yes	
2	Pd ₂ MnSi	Mix	No	Tried single crystal analysis
3	PdMnSi	Single	No	Contaminated during melting
4	PdMnSi	Mix	No	
5	Co ₂ NbSn	Single	Yes	Some small, extra peaks
6	CoNbSn	Mix	No	
7	Pd ₃ MnSi ₂	Single	Yes	Not Heusler
8	Nb ₂ TiAl	?	?	Could not crush
9	Pd ₂ TiAl	Mix	No	
10	Pd ₂ CrSn	Mix	No	
11	Cr ₂ NbSn	Mix	No	Not Heusler
12	CrNb ₂ Sn	Mix	No	
13	CrNb ₂ Si	Mix	No	
14	Co ₂ NbSn	Mix	No	Tried high temp. annealing

Results

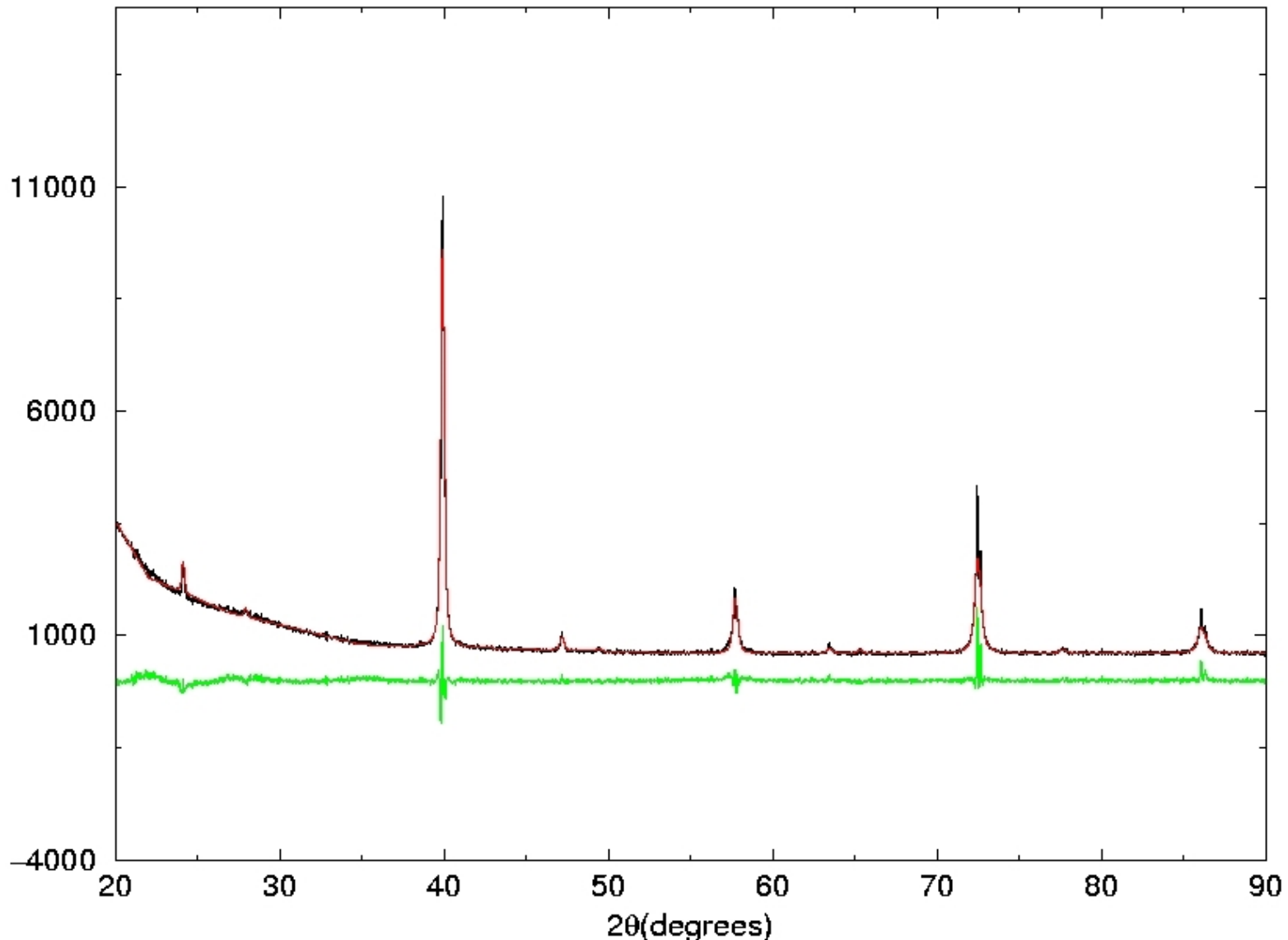
#	Formula	Phase?	Magnetic Data?	Notes
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8	Nb ₂ TiAl	?	?	Could not crush
9	Pd ₂ TiAl	Mix	No	
10	Pd ₂ CrSn	Mix	No	
11	Cr ₂ NbSn	Mix	No	Not Heusler
12	CrNb ₂ Sn	Mix	No	
13	CrNb ₂ Si	Mix	No	
14	Co ₂ NbSn	Mix	No	Tried high temp. annealing

Analysis of Sample 1: Pd₂MnSn X-Ray Diffraction Profiles



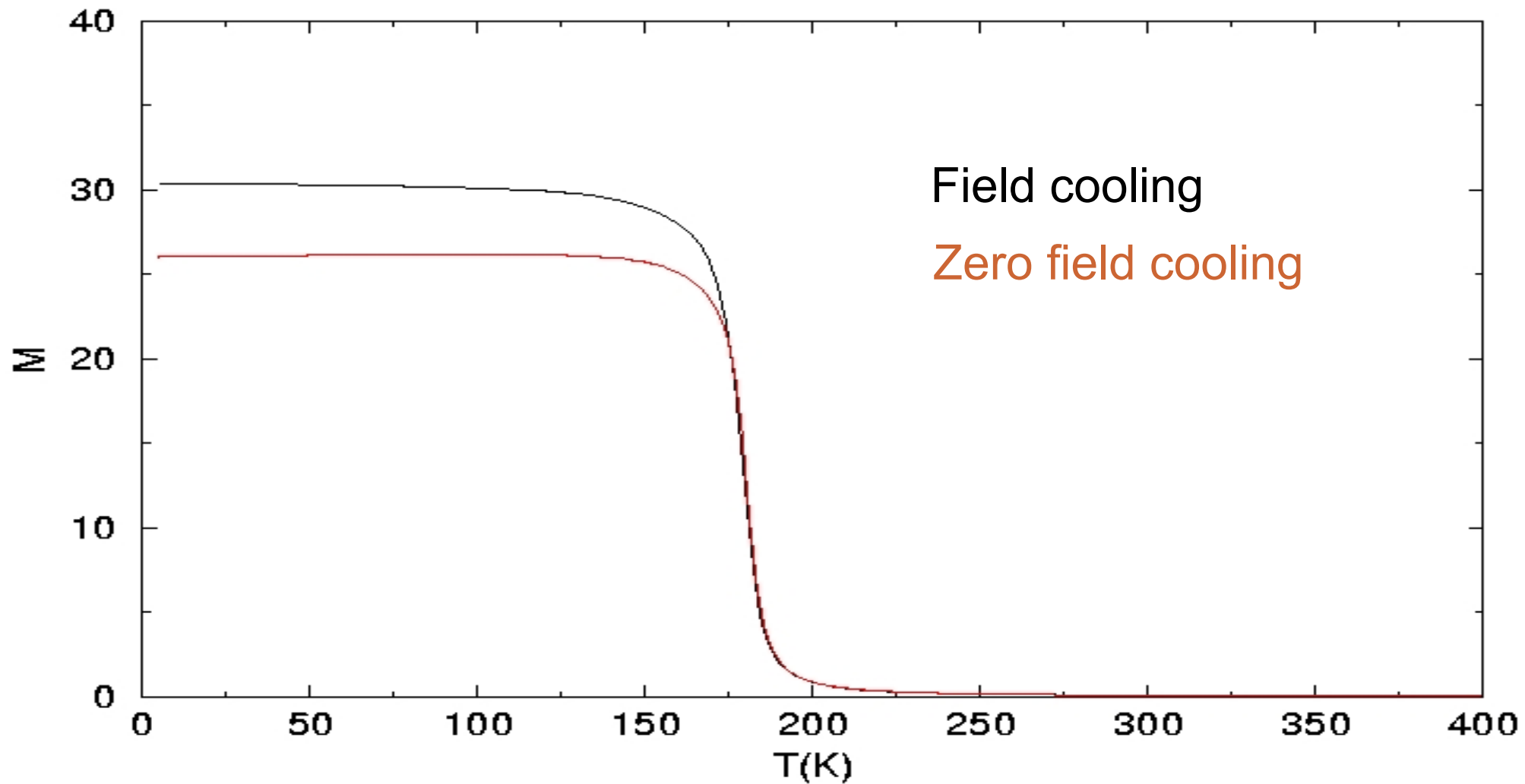
Analysis of Sample 1: Pd₂MnSn

- Rietveld refinement: $R_{\text{Bragg}} = 10\%$
 - The unit cell of the crystal measures 6.387(11) angstroms



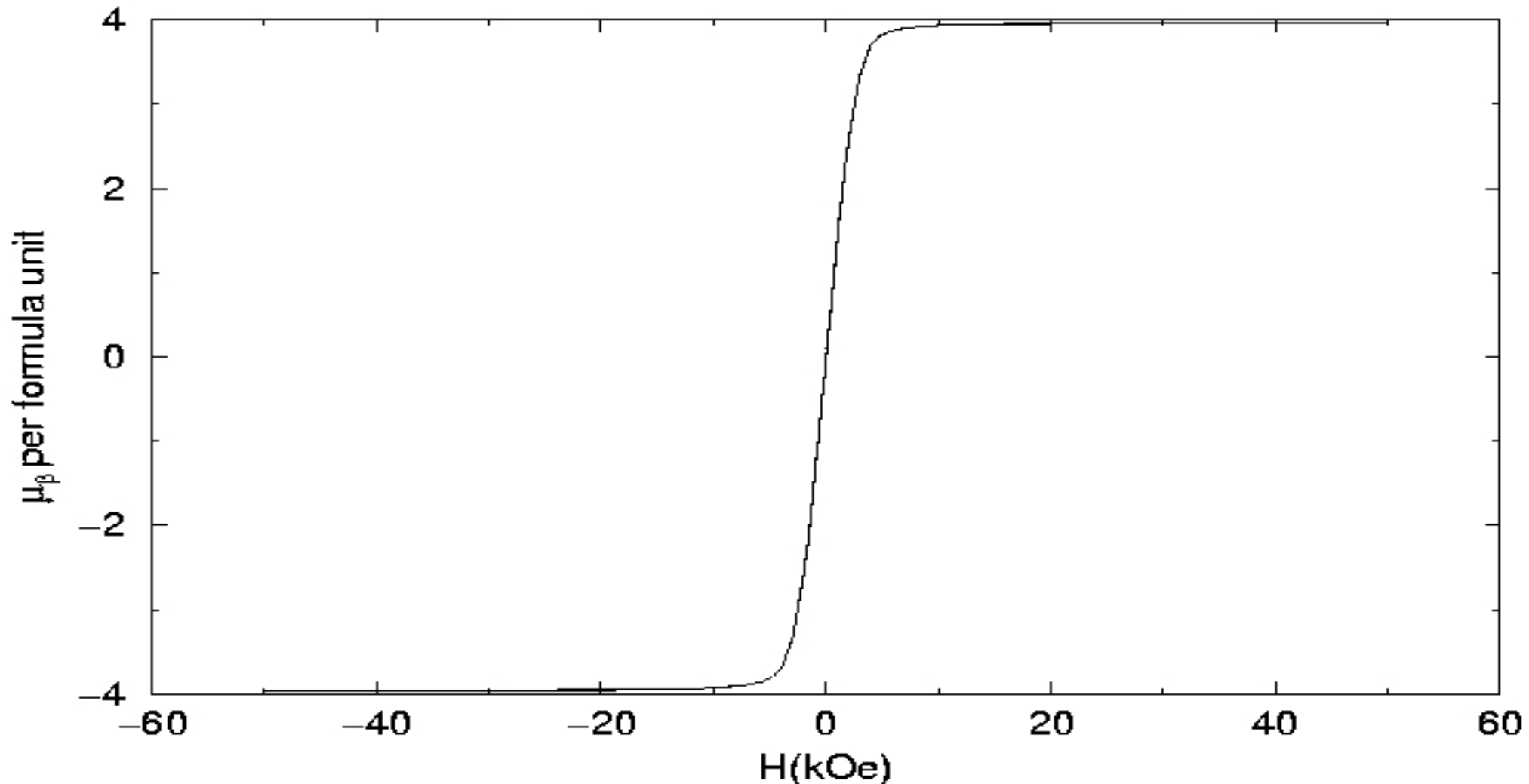
Analysis of Sample 1: Pd₂MnSn

- Magnetic measurements: magnetization vs. temperature (K)
 - The Curie temperature is 180 K



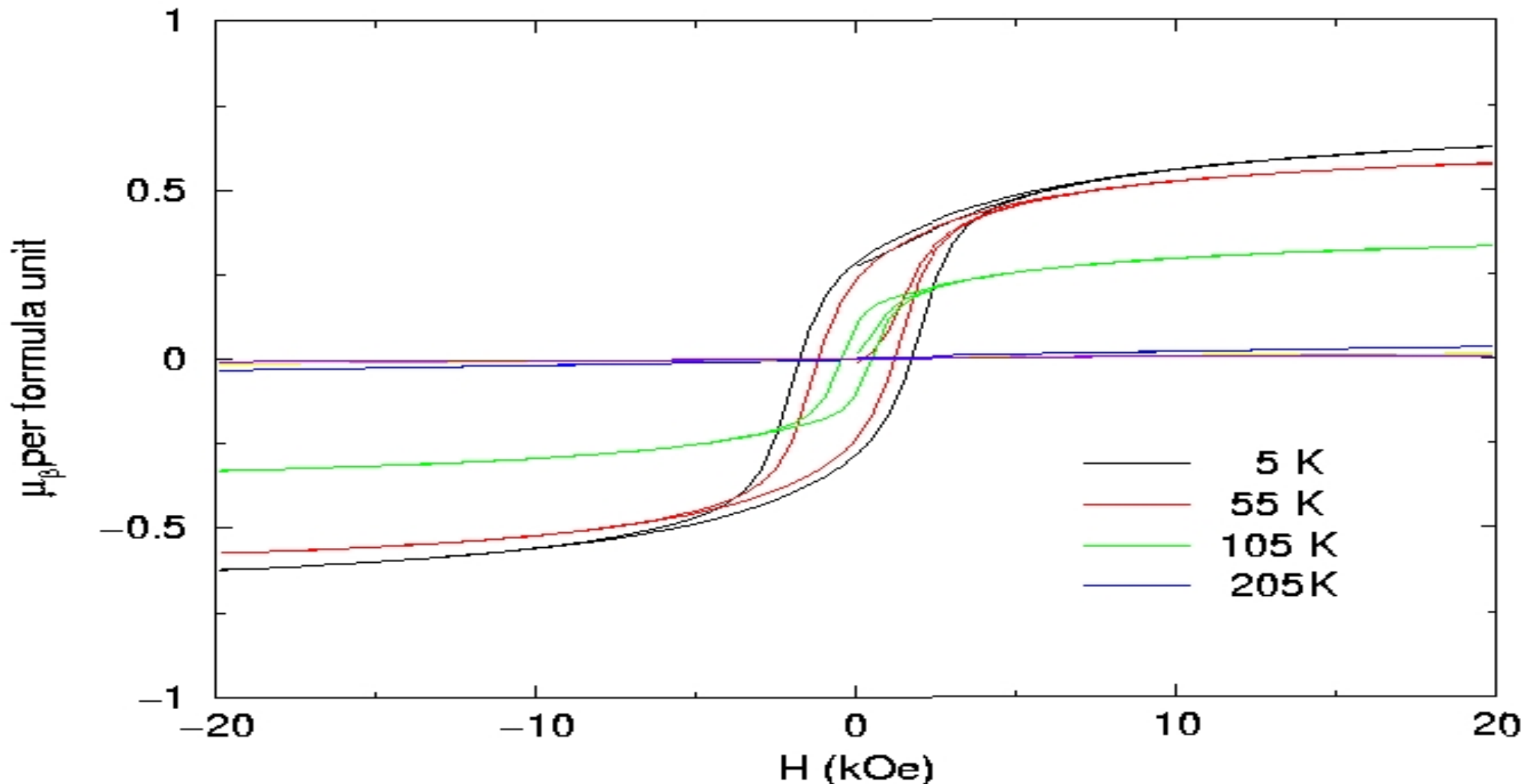
Analysis of Sample 1: Pd₂MnSn

- Magnetic measurements: magnetization (Bohr magnetons per formula unit) vs. magnetic field (kiloOersted) at 5 K
 - It is not a half-metal
 - It is a soft magnet



Analysis of Sample 5: Co_2NbSn

- Magnetic measurements: magnetization (Bohr magnetons per formula unit) vs. magnetic field (kiloOersted)
 - It is not a half-metal
 - It is a *hard* magnet

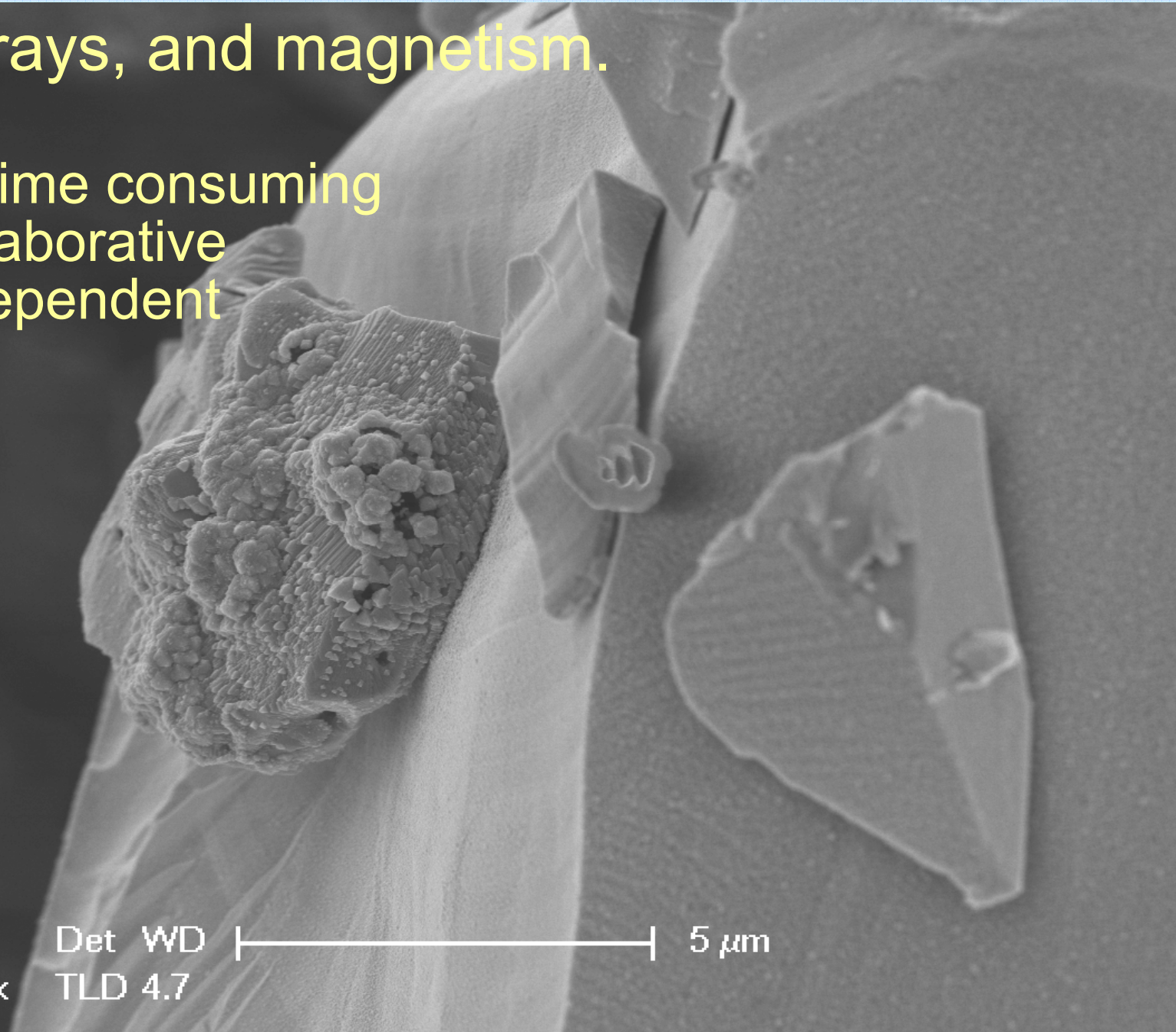


Summary

#	Formula	Lattice parameters	Curie Temperature	Magnetization (μ_{β} /formula unit)
1	Pd ₂ MnSn	6.387(11) Å	180 K	4.0
	Literature ₁	6.380 Å	188 K	4.2
5	Co ₂ NbSn	6.1538(3) Å	116 K	0.6
	Literature ₂	6.142 Å	105 K	0.69
7	Pd ₃ MnSi ₂	a=6.508(1) Å c=3.4575(3) Å	> 400 K	2.4
	Literature ₃	a=6.490(5) Å c=3.465(6) Å	498 K	2.12

What I Learned

- Crystals, x-rays, and magnetism.
- Research
 - Slow and time consuming
 - Highly collaborative
 - Highly independent



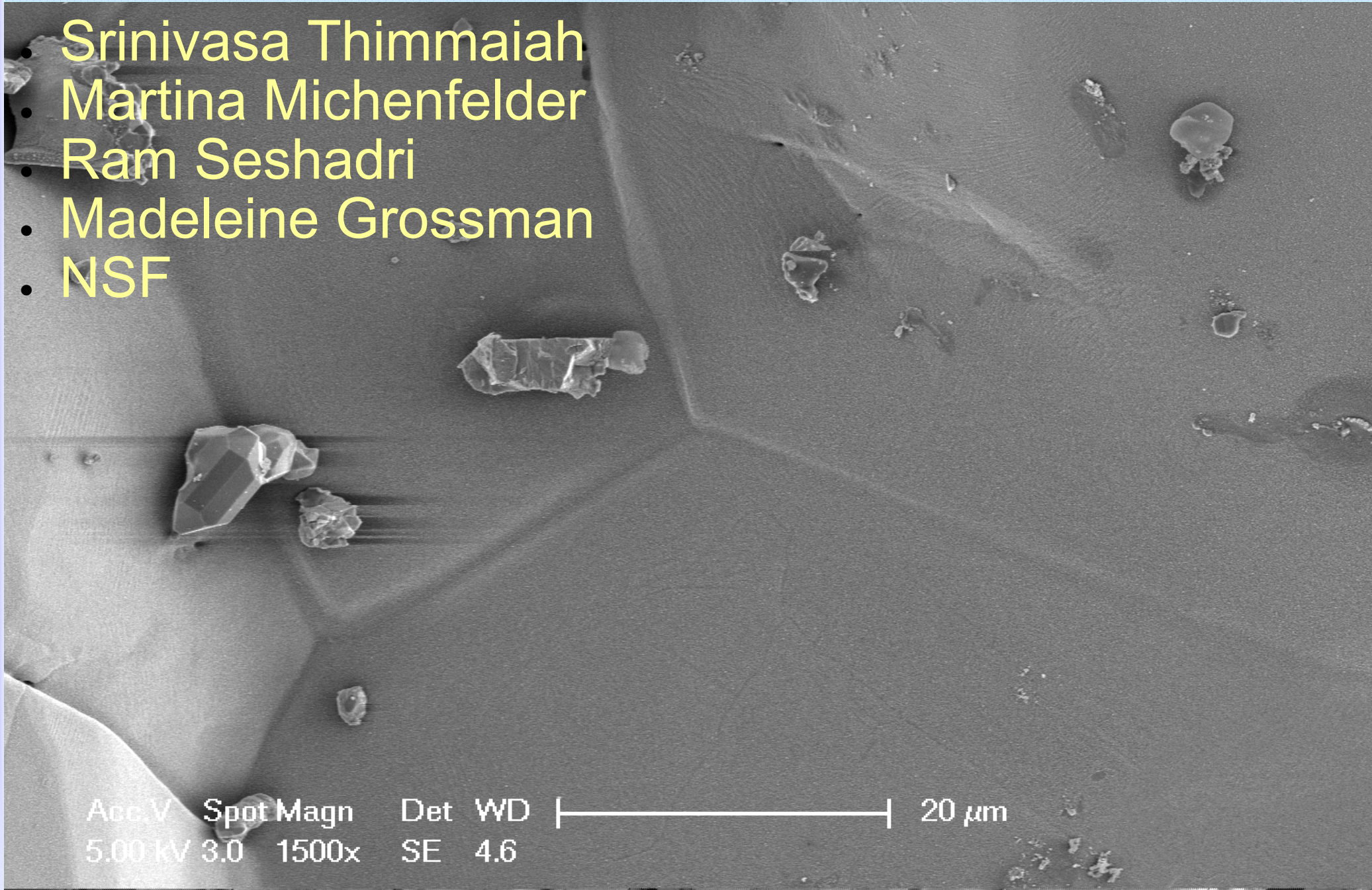
Acc.V Spot Magn
5.00 kV 3.0 5805x

Det WD
TLD 4.7

5 μm

Special Thanks to

- Srinivasa Thimmaiah
- Martina Michenfelder
- Ram Seshadri
- Madeleine Grossman
- NSF



References

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- 2. P.G. Van Engen and K.H.J. Buschow, *J. Magnetism and Magnetic Materials*. 30 (1983) 374-382.
- 3. W. Bazela, *J. Less-Common Metals*. 100 (1984) 341-346.

Acc.V Spot Magn Det WD |-----| 500 μ m
5.00 kV 3.0 65x SE 4.7