DOPING IN NONCENTROSYMMETRIC CRYSTAL STRUCTURES

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Introduction

- Increasing demand for faster computers have forced approaching the limits of traditional MOSFET devices.
- One potential replacement technology requires magnetic semi-conductors.
- Two systems with non-centrosymmetric structures were studied here, $Ba_2CuGe_2O_7$ and $Ru_{1-x}Co_xGe$.
- Pure barium copper germanate is an insulator and already has magnetic phases.
- Neither $RuGe$, an insulator, nor $CoGe$, a metal, display magnetic ordering, but $Ru_{1-x}Co_xGe$ was discovered to be ferromagnetic. Thus, characterizing the nature of the magnetic structuring as a function of doping levels is of interest.

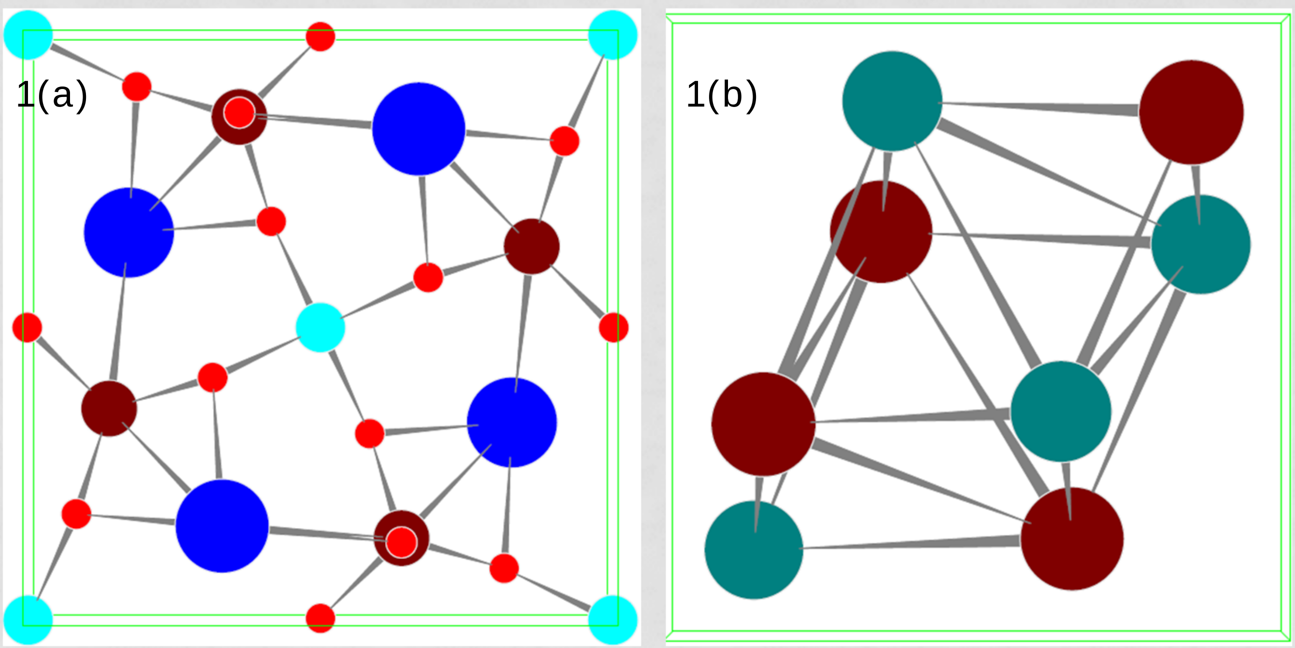
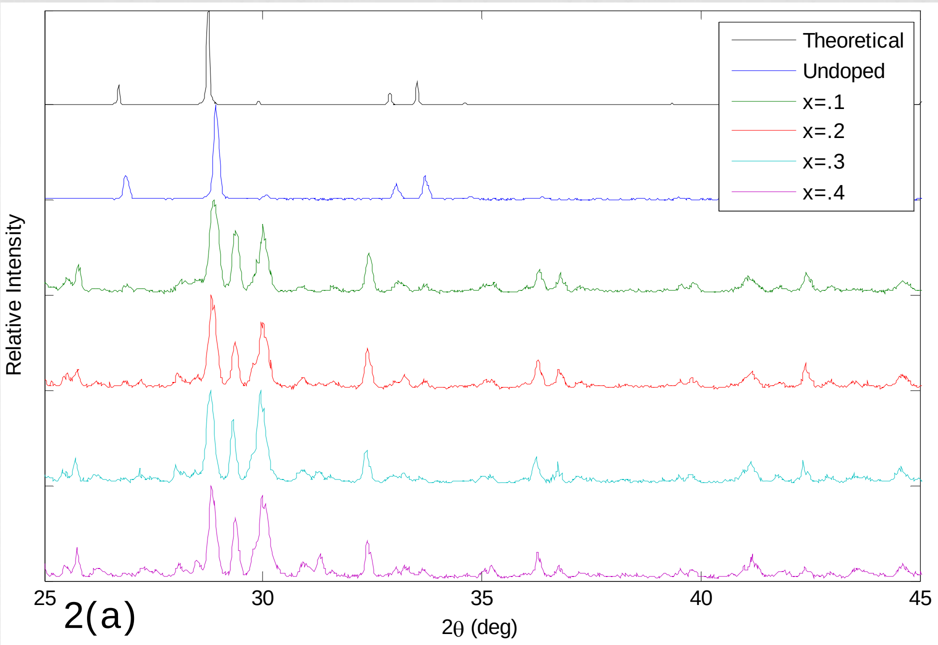


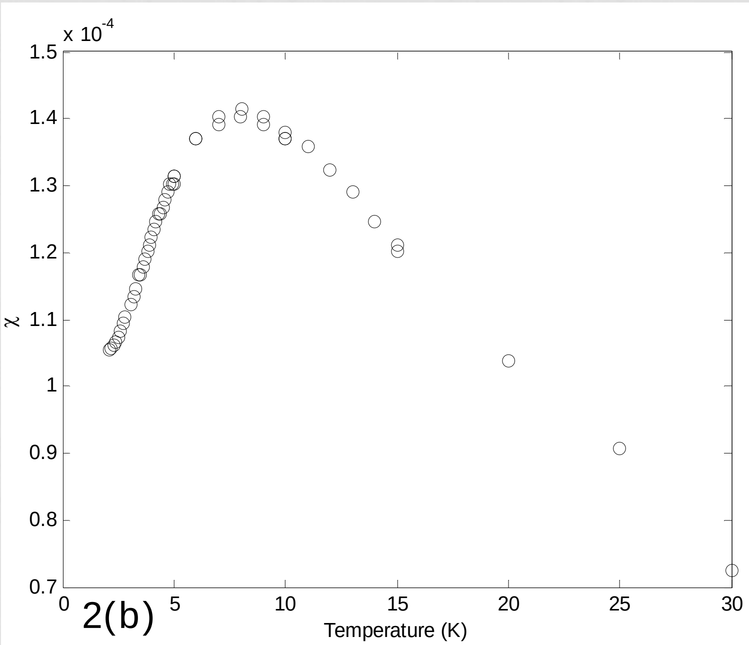
Figure 1(a): $Ba_2CuGe_2O_7$ Crystal structure, Space Group 113, $P\bar{4}2_1m$

Figure1(b): $RuGe$ Crystal structure, Space Group 198, $P2_13$

$Ba_{2-x}La_xCuGe_2O_7$

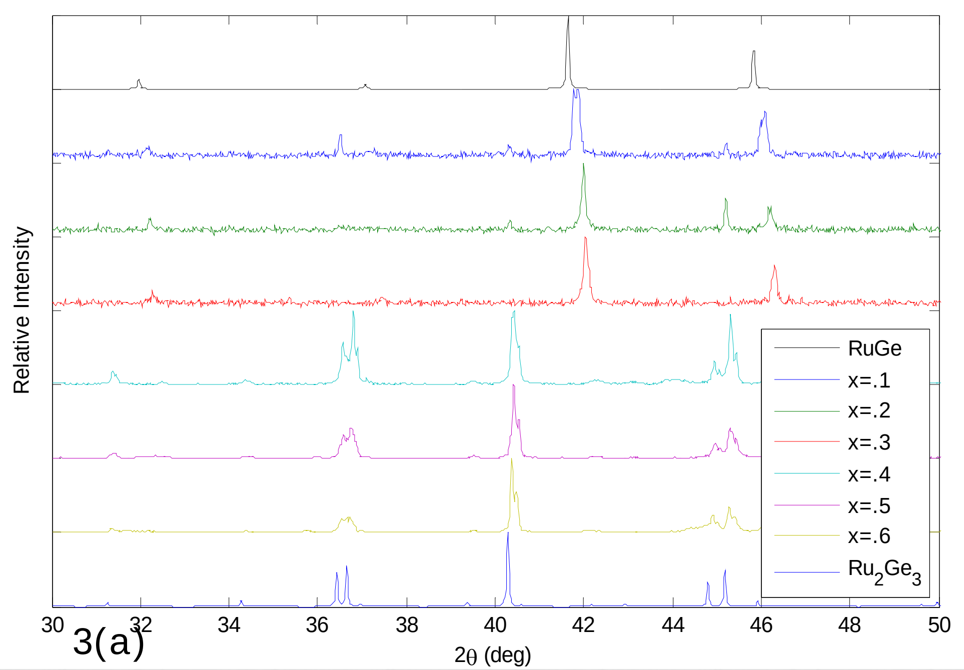
- This systems synthesis was not well reported.
- After system was grown successfully, we attempted to dope it to measure the electron transport properties.
- It was determined that attempted doping at the copper site would not be ideal, so we began with at the barium site.
- Lanthanum shown to be ineffective, as it produced undesirable phases. (Figure 2(a))
- Nondoped samples showed good agreement with literature.[1](Figure 2(b))



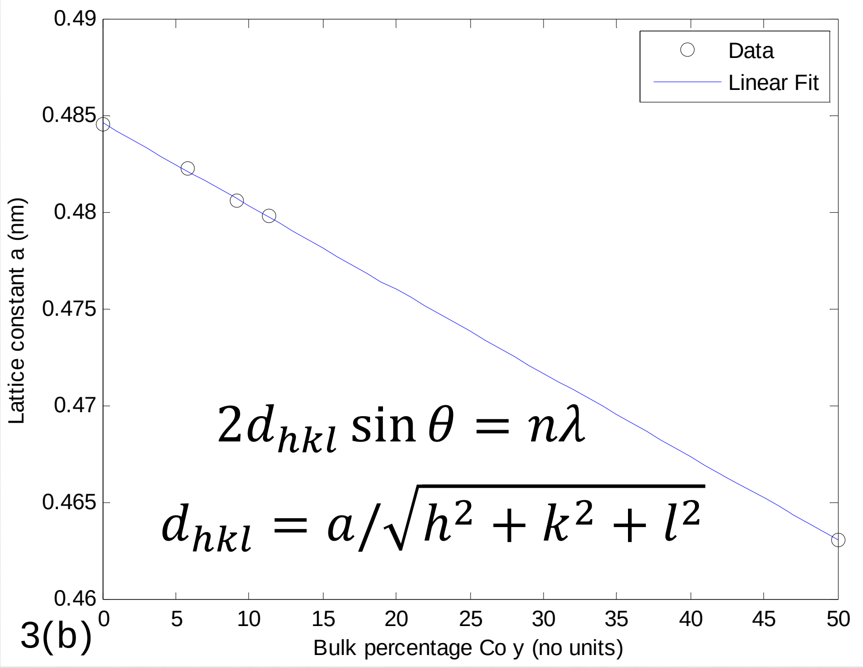


$Ru_{1-x}Co_xGe$

- Both $RuGe$ and $CoGe$ lack any magnetic ordering.
- The system that combines the two was discovered to have ferro-magnetic ordering at temperatures T < 20K
- Systematic study of the system for various levels of doping began with analysis of the purity of the polycrystalline samples produced, and the determination of the shift in lattice constant.
- XRD patterns were used to analyze purity (Figure 3(a)).
- Shift in lattice parameter appears linear (Figure 3(b)).
- Data on CoGe taken from reference [2]



3(a)



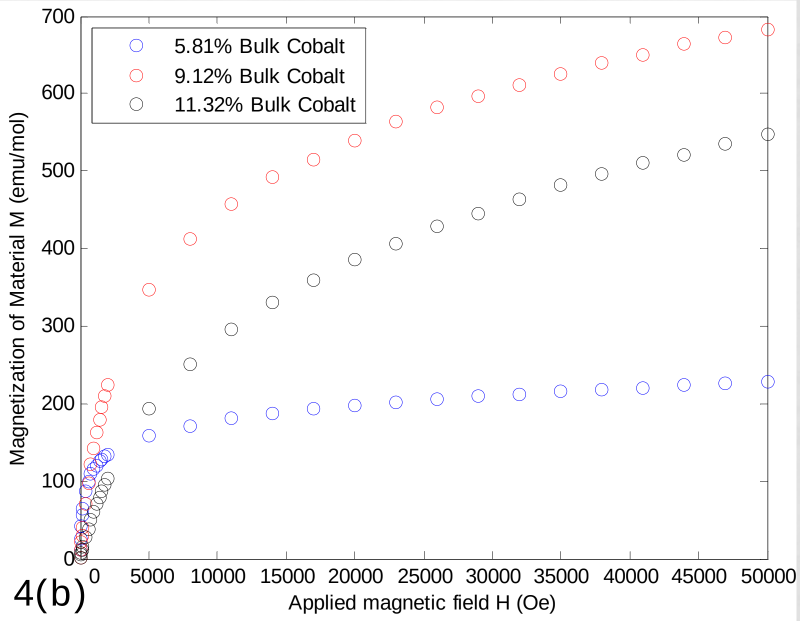
$$2d_{hkl}\sin\theta = n\lambda$$

$$d_{hkl} = a/\sqrt{h^2+k^2+l^2}$$

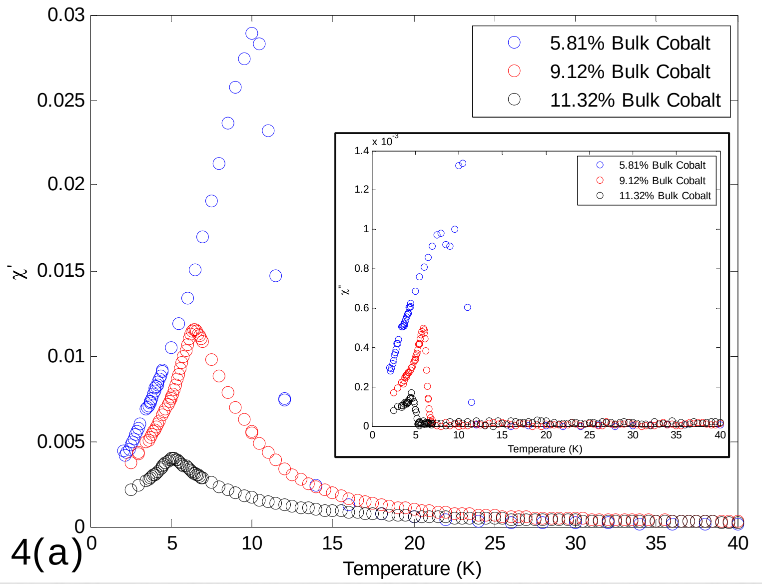
3(b)

Magnetic Characterization

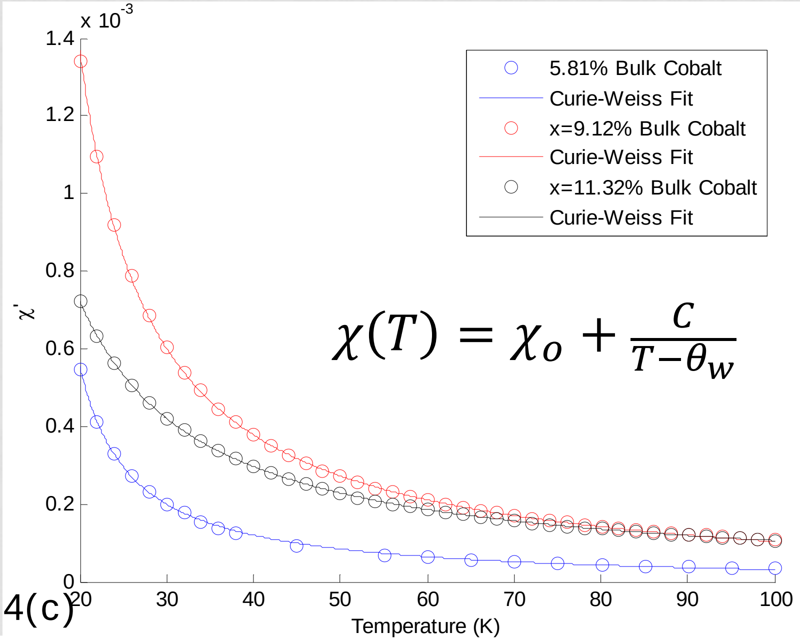
- We measured the magnetic properties in a SQUID Magnetometer.
- This gave a preliminary look at how characteristics like the Curie Temperature, the Weiss Temperature, the Curie Constant, and the Saturated Moment vary as a function of doping.



4(b)



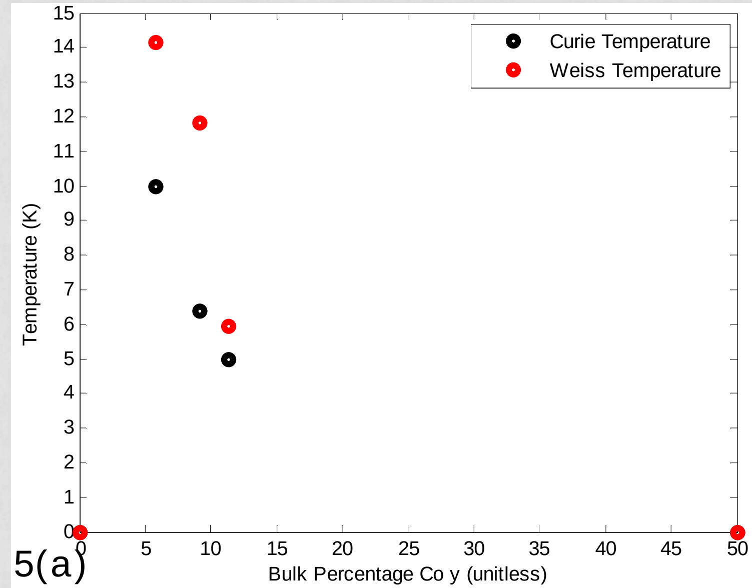
4(a)

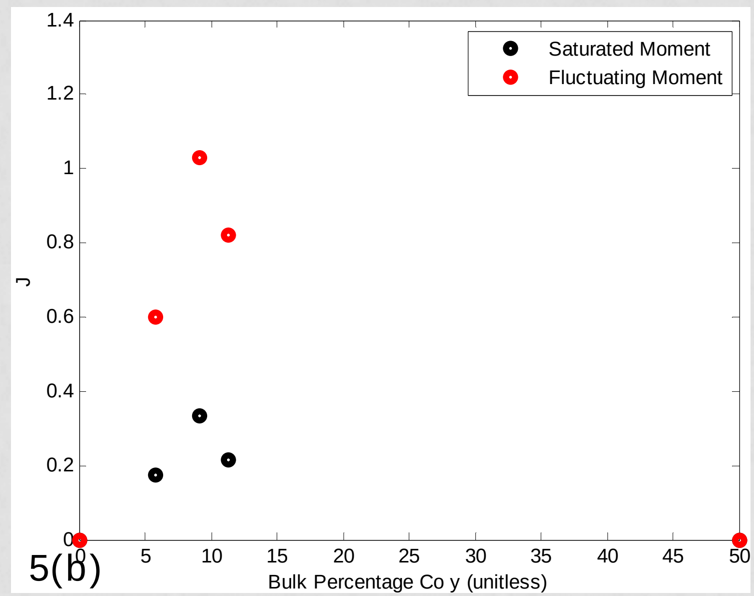


4(c)

Results

- The Curie Temperature was take to be the temperature of the highest measurement of the magnetic moment.
- The Saturated magnetic moment was taken from Magnetization at 5T and the equation $M = \eta g \mu_B J$
- The Weiss Temperature and Curie constant were taken from a fit of the data to the Curie-Weiss law.
- The Fluctuating moment was taken from the definition of the Curie Constant, $C = \frac{(g\mu_B)^2}{3k_B}\eta J(J+1)$
- Results indicate an itinerant mechanism, as well as decreases in the Curie and Weiss temperatures, with an apparent rapid increase at low doping levels.





Questions?

References:

[1] H Hohl, A.P Ramirez, C Goldmann, G Ernst, E Bucher, Transport properties of RuSi, RuGe, OsSi, and quasi-binary alloys of these compounds, Journal of Alloys and Compounds, Volume 278, Issues 1–2, 1 August 1998, Pages 39-43, ISSN 0925-8388, http://dx.doi.org/10.1016/S0925-8388(98)00584-2. (http://www.sciencedirect.com/science/article/pii/S0925838898005842)

[2]"*Exploring the magnetic, thermodynamics, and electrical transport properties of MnGe and CoGe having the noncentrosymmetric B20 crystal structure*" J. F. DiTusa, *et al.*, (Preprint)