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Modeling the Griffiths Phase in Manganese Intercalated Tantalum Disulfide [Poster]

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Simulating Griffiths Phase Behavior

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Background

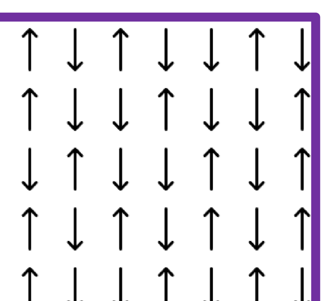
Paramagnetism:

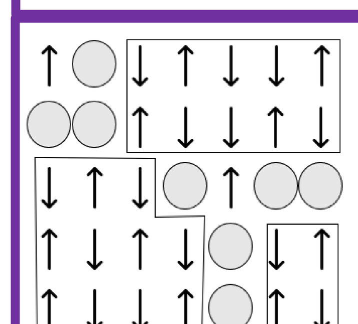
- The magnetic moments in a paramagnetic material are randomly oriented in the absence of a magnetic field and more aligned in the presence of one.
- Exhibited at high temperatures

Ferromagnetism:

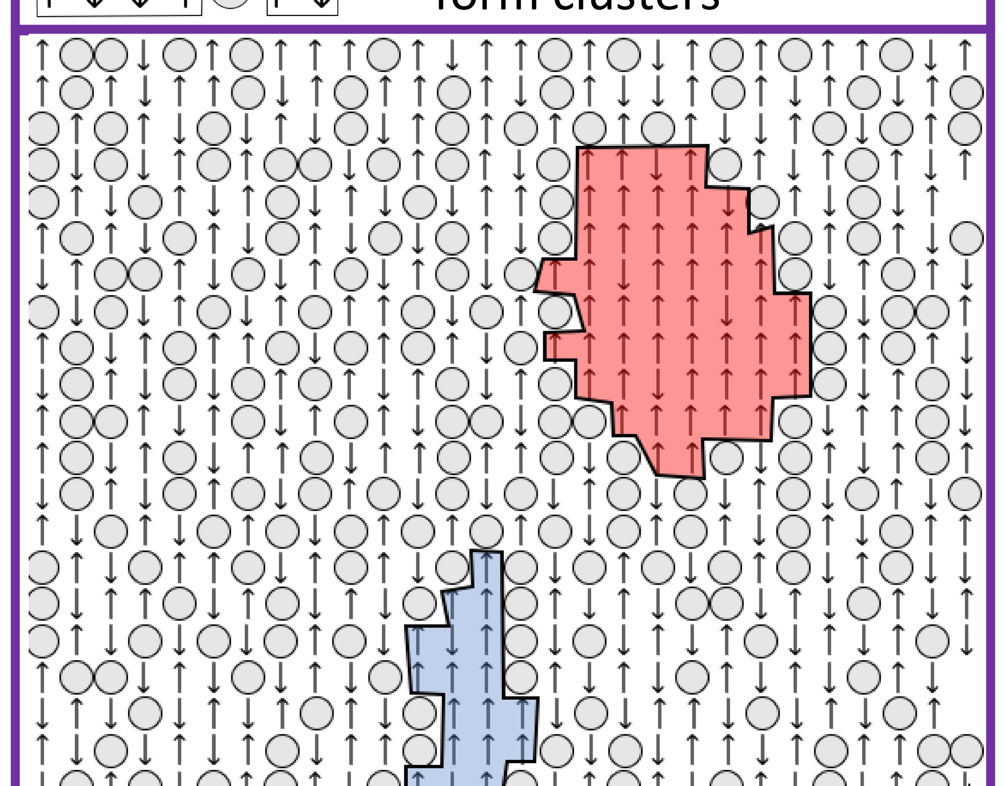
- Ferromagnetic materials have ordered magnetic moments even without an external magnetic field.
- Their moments in the domains align in a strong external magnetic field
- They produce their own magnetic field as a result

- In an ideal paramagnet, magnetic moments fully occupy every lattice point



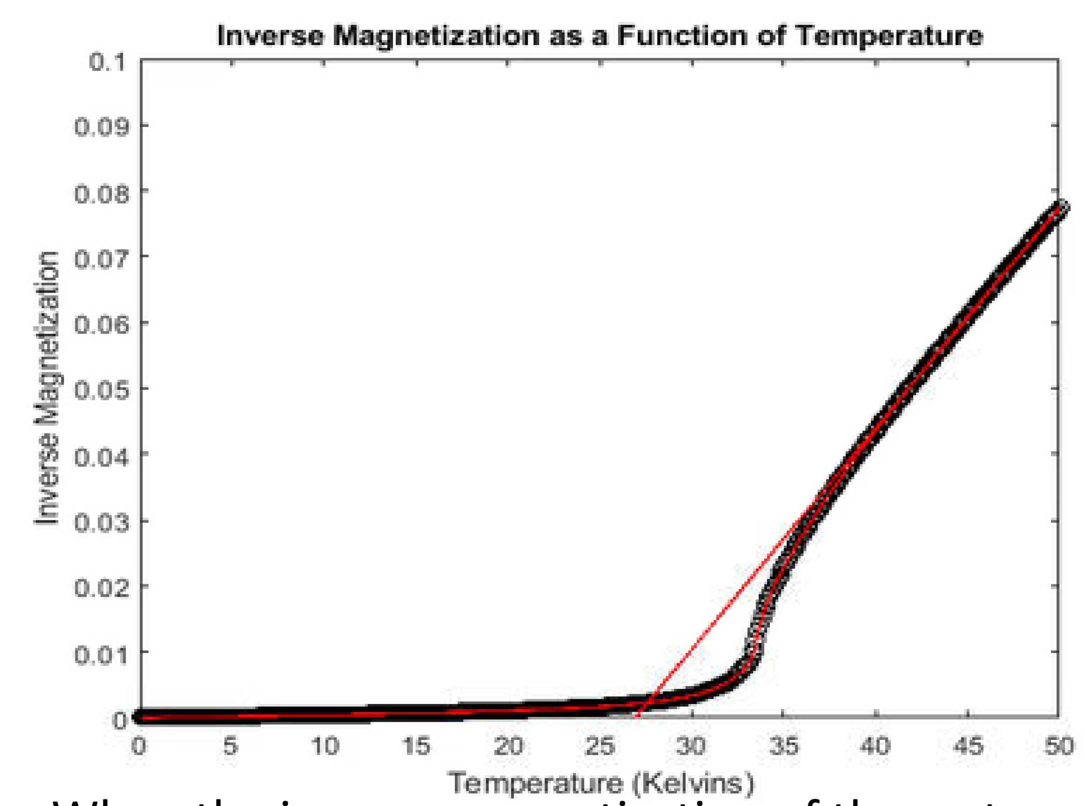


- As disorder is introduced, magnetic moments are removed and remaining moments form clusters



- Very large clusters (red) become very rare
- These clusters dominate the overall magnetization of the system due to their size

What is the Griffiths Phase?



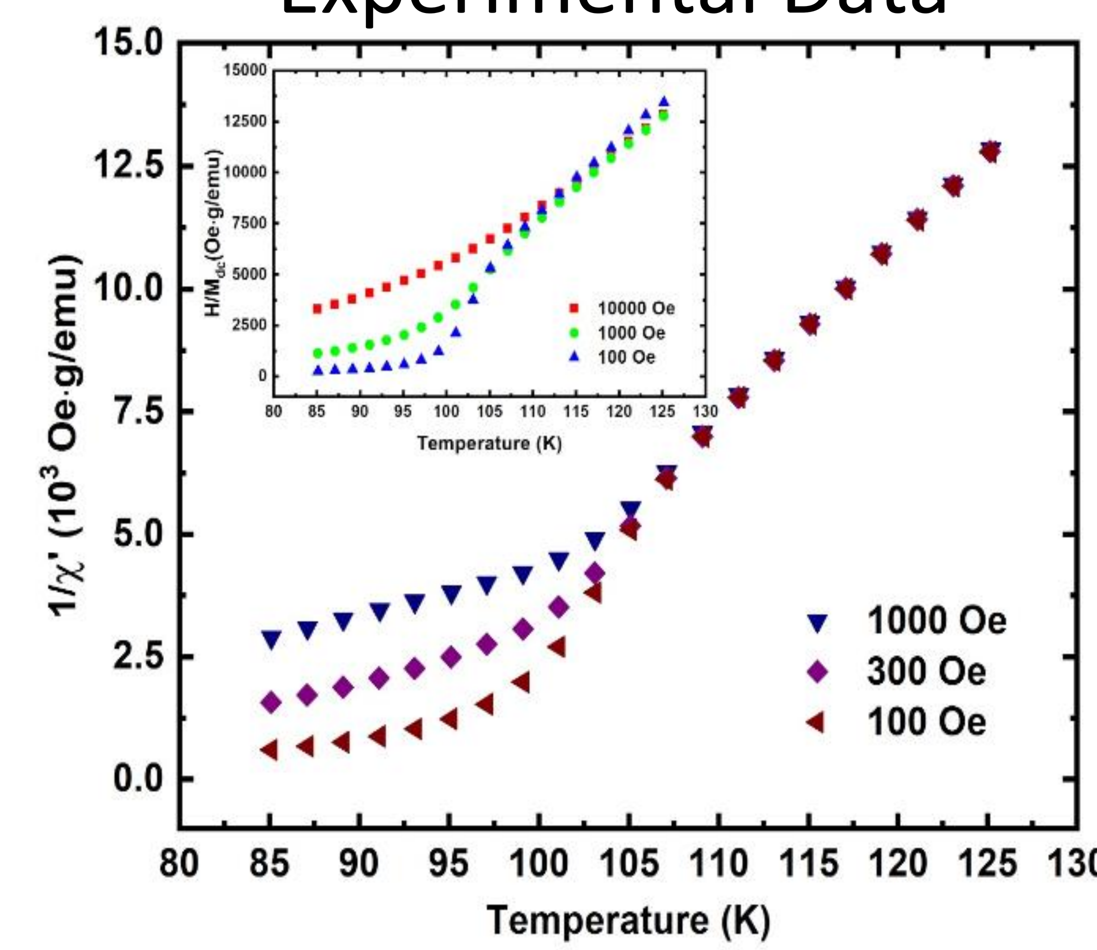
- When the inverse magnetization of the system deviates below the Curie-Weiss Line (as shown above)

Computational Details

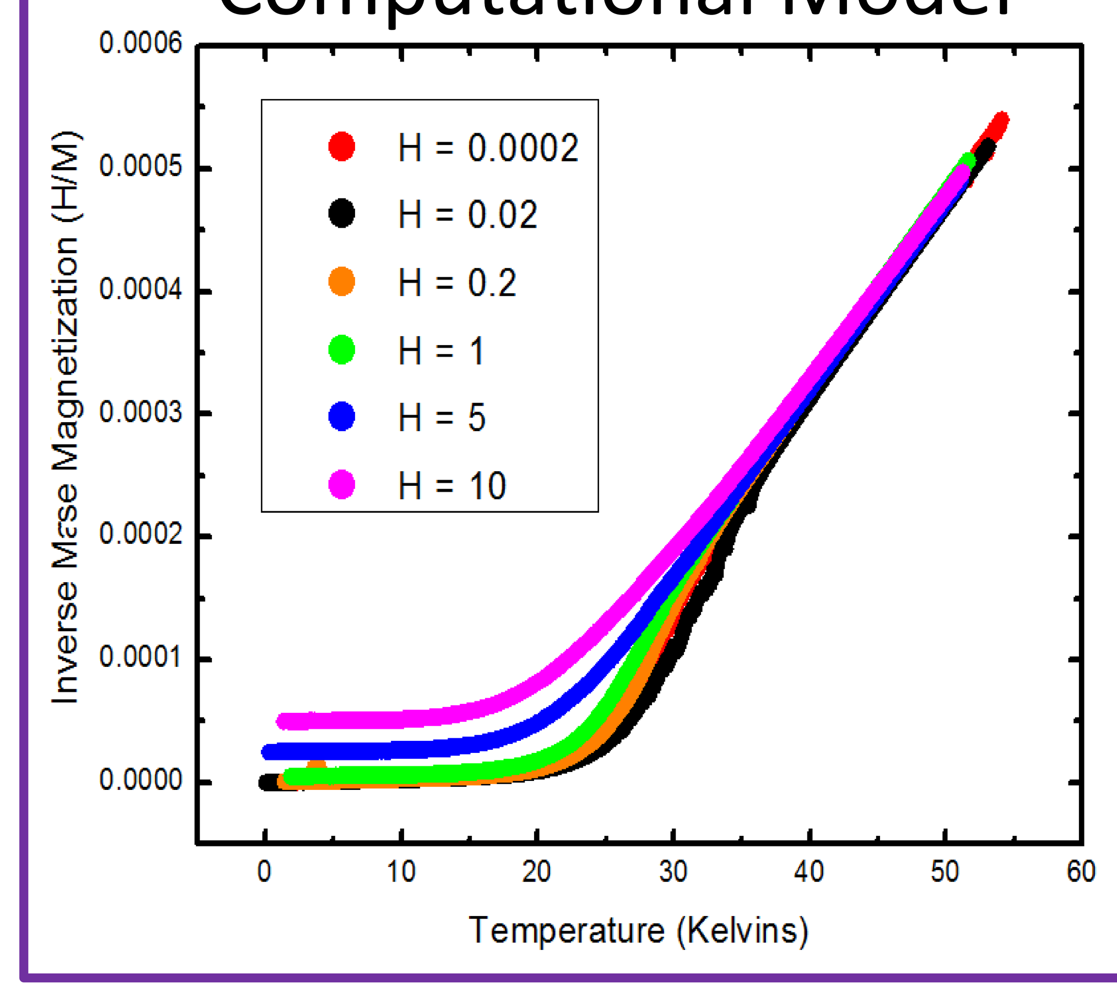
- Utilizing MATLAB, we were able to use the Langevin function to simulate the behavior of clusters and the resultant magnetization of that system.
- Interaction between magnetic moments was simulated via a molecular field taken to be proportional to the magnetization.
- A conditional segment of the code allowed us to account for values above and below the Curie temperature and calculate the overall magnetization.
- A secondary code was written to analyze the Curie-Weiss line and subsequent computational deviation from that line in a process that allowed us to quantitatively compare the affects that a changing magnetic field had on the Griffiths Phase, coined “Ratio of Departure”.

Results

Experimental Data

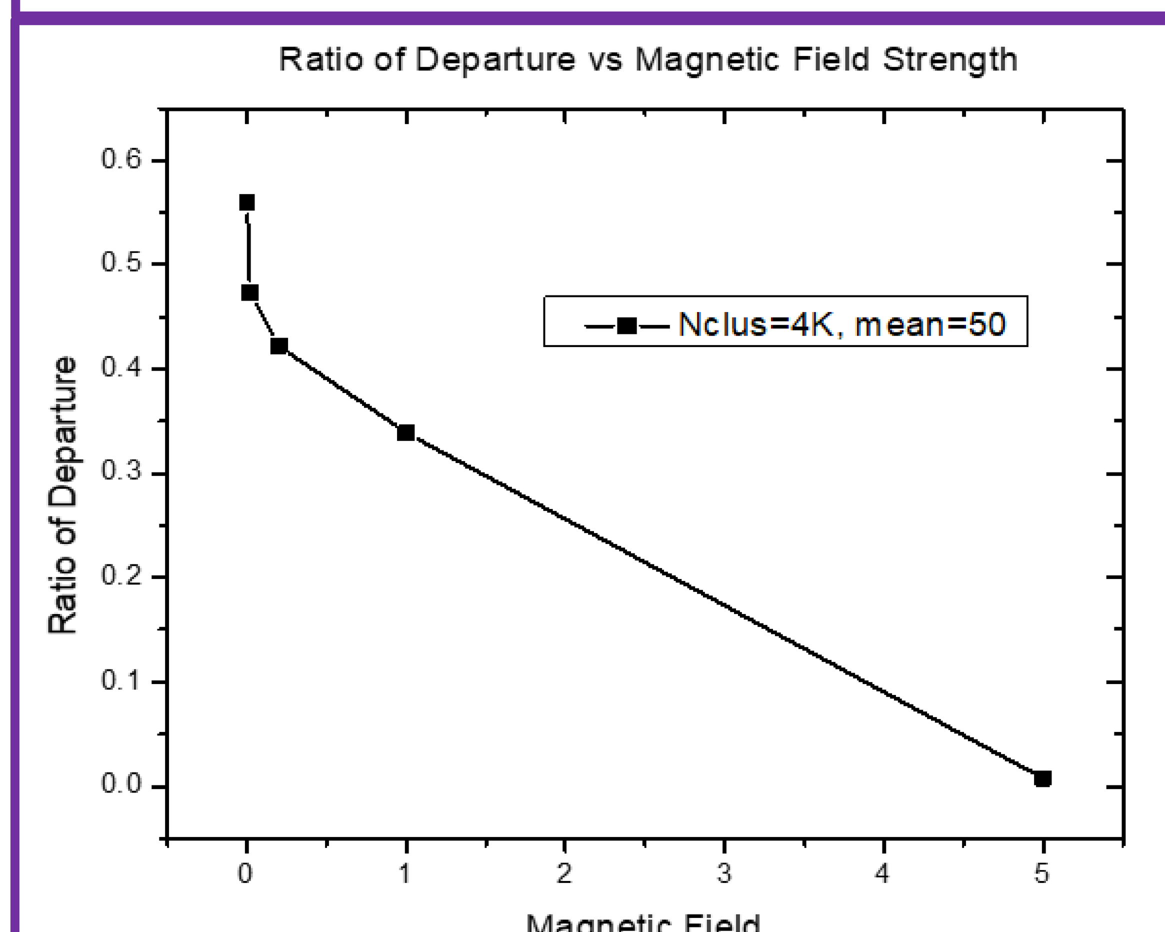


Computational Model



Effect of the External Magnetic Field on the Griffiths Phase

Quantifying the maximum ratio between the Curie-Weiss Line and computational data points allowed us to examine the strength of the Griffiths Phase as we modified variables.



Conclusion

The Griffiths Phase is a result of a spontaneous increase in the overall magnetization of the system primarily influenced by the rare, large clusters transitioning to a ferromagnetic state at the Curie Temperature. We were able to create a MATLAB program that exhibits this trend by using the Langevin function to simulate clusters. Comparing the two graphs, above, the trends of the computational model follow the behaviors of the experimental data as the external magnetic field is increased.

Future Work

Going forward, we would use this program to explore more variables and distribution types of the data in an attempt to better understand the Griffiths Phase.

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