Of Manganites and Magnetoresistance

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Overview

- Hard Drives
- Perovskites
- Metals
- Magnetism
- Spin waves
- Questions
Hard Drives

IBM HDD Evolution

The Shrinking Bit Cell

IBM
Old Days

Anisotropic Magnetoresistance (AMR)

“Effect of bar width on magnetoresistance of nanoscale nickel and cobalt bars” J. Appl. Phys. 81(8) 1997
CMR


Perovskites
Crystal Structure

Carrier Doping

- Parent Compound LaMnO$_3$
- Insulator
- How can we get carriers into the system?
Here there be Holes!

- Since for chemical reasons we can’t “dope” in electrons, instead we introduce “holes”

Hund’s Rules

- In the manganites, we introduce holes, which give rise to Mn$^{3+}$ and Mn$^{4+}$ ions in the system. How do spins arrange themselves? Why?

- Hint: The electronic configuration of Mn is $3d^54s^2$
Crystal Field Splitting

- Now that we know the spin states, we must realize that we have spins in a lattice, not isolated and the electrical fields of the ligands (oxygen) will split the degeneracy of the d-orbitals.

Remember
Answer

Double Exchange

\[ \text{Mn}^{4+} \quad \text{O}^{2-} \quad \text{Mn}^{3+} \]

\[ \text{d}^3 \quad \text{p}^5 \quad \text{d}^4 \]

\[ \text{Mn}^{3+} \quad \text{O}^{2-} \quad \text{Mn}^{4+} \]

\[ \text{d}^4 \quad \text{p}^6 \quad \text{d}^3 \]
Phase Diagram


Ising Model
Quasielastic Scattering

Heisenberg Model

\[ E = -2 \sum J_{ab} \cdot S_a \cdot S_b \]
Excitations?

Spin Waves
Real Spin Wave

For small $q$

$E \sim Dq^2$

Summary

- Transport is dependent on magnetic state in Manganites
- This magnetic state can be probed by neutrons
- Exploration of dynamics can constrain models of magnetism
Questions?