Of Manganites and Magnetoresistance

William Ratcliff II, Jae-ho Chung, Owen Vajk
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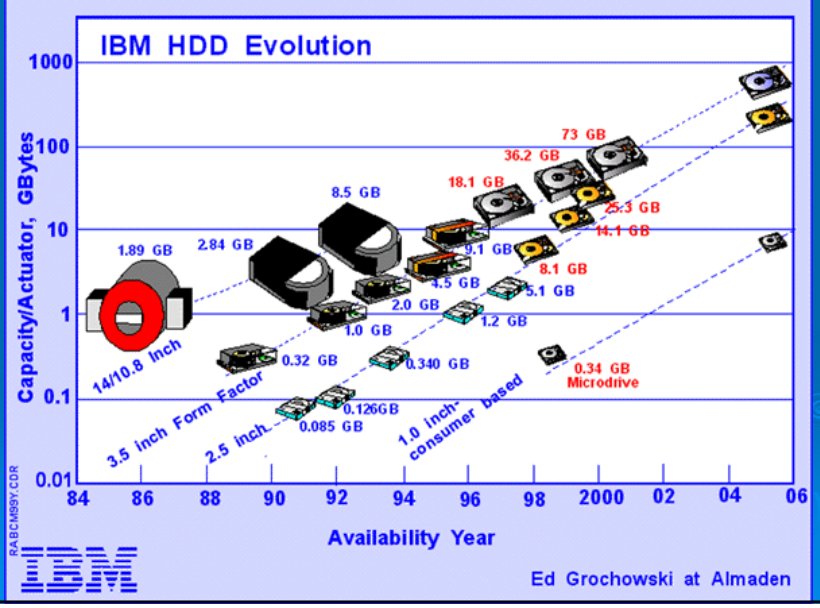
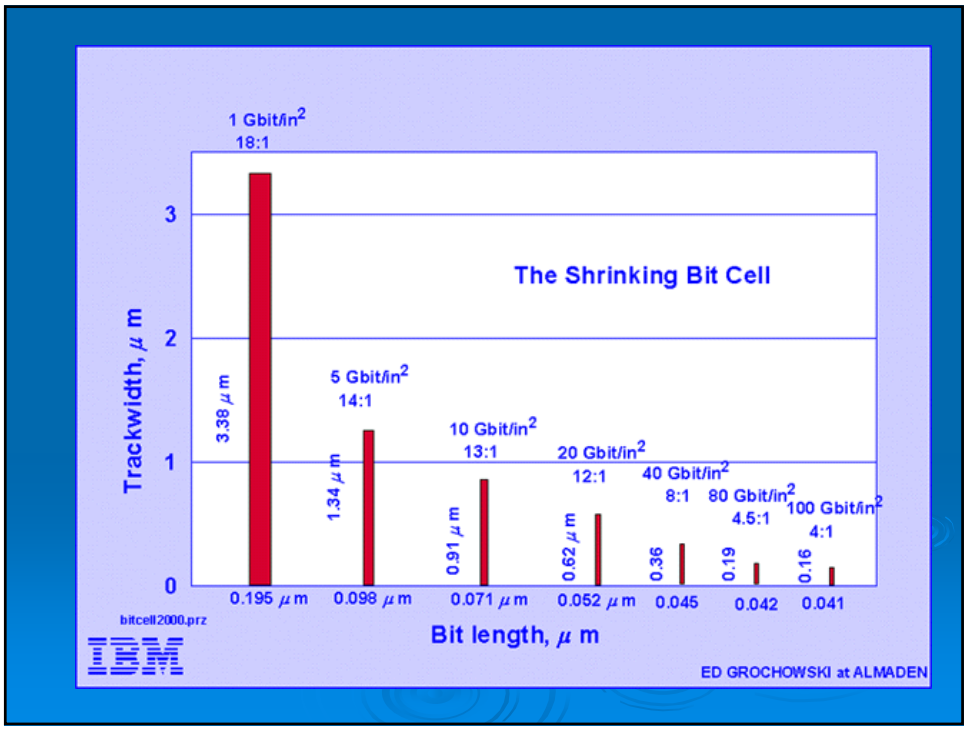
Overview

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

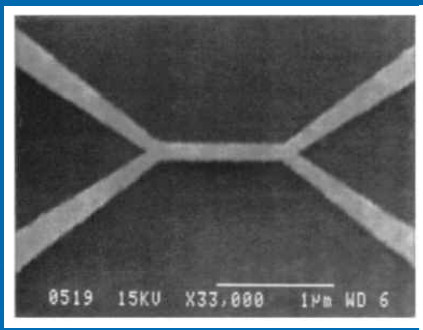
Hard Drives

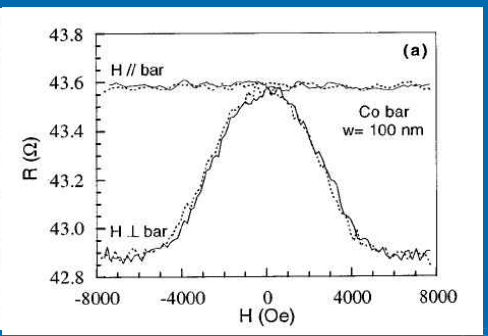

IBM HDD Evolution
Capacity/Actuator, GBytes
1000
100
10
1
0.1
0.01
84
86
88
90
92
94
96
98
2000
02
04
06
Availability Year
1.89 GB
2.84 GB
8.5 GB
73 GB
36.2 GB
18.1 GB
25.3 GB
14.1 GB
9.1 GB
8.1 GB
4.5 GB
5.1 GB
2.0 GB
1.2 GB
1.0 GB
0.32 GB
0.340 GB
0.34 GB
Microdrive
0.126GB
0.085 GB
14/10.8 Inch
3.5 inch Form Factor
2.5 inch
1.0 inch-
consumer based
RABCM99Y.CDR
Ed Grochowski at Almaden


The Shrinking Bit Cell
Trackwidth, μ m
3
2
1
0
1 Gbit/in2
18:1
3.38 μ m
0.195 μ m
5 Gbit/in2
14:1
1.34 μ m
0.098 μ m
10 Gbit/in2
13:1
0.91 μ m
0.071 μ m
20 Gbit/in2
12:1
0.62 μ m
0.052 μ m
40 Gbit/in2
8:1
0.36
0.045
80 Gbit/in2
4.5:1
0.19
0.042
100 Gbit/in2
4:1
0.16
0.041
Bit length, μ m
bitcell2000.prz
ED GROCHOWSKI at ALMADEN

Old Days

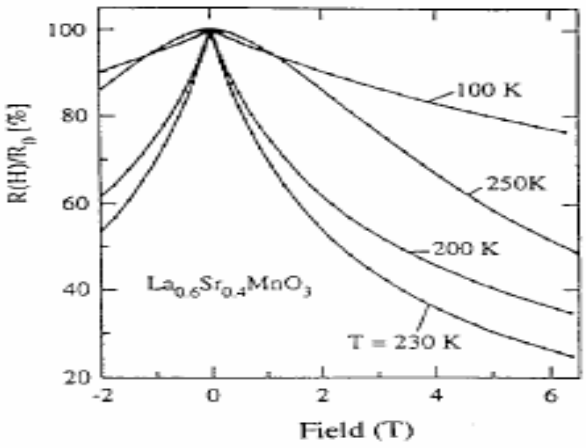
Anisotropic Magnetoresistance (AMR)





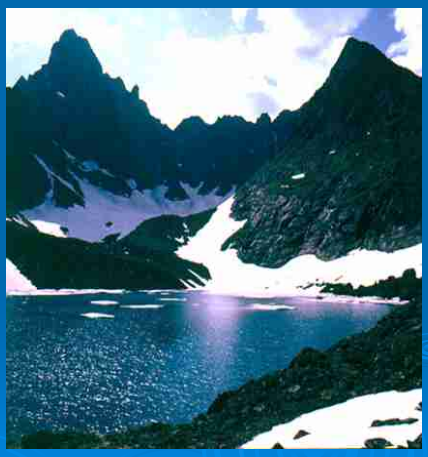
"Effect of bar width on magnetoresistance of nanoscale nickel and cobalt bars" J. Appl. Phys. 81(8) 1997

CMR

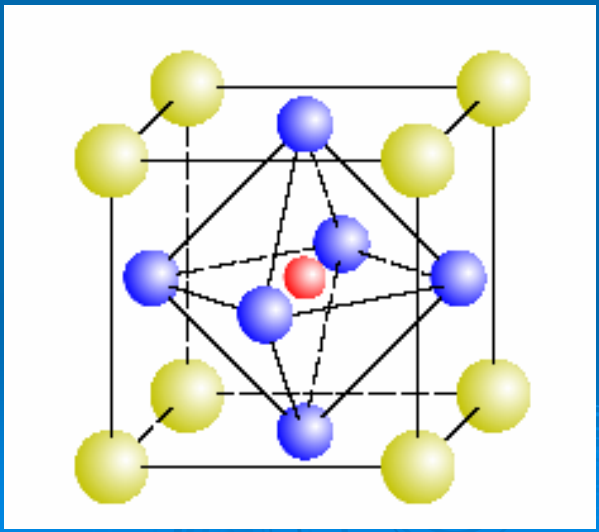


J.M.D. Coey et al. Adv. in Phys. (1999).

Perovskites



Crystal Structure

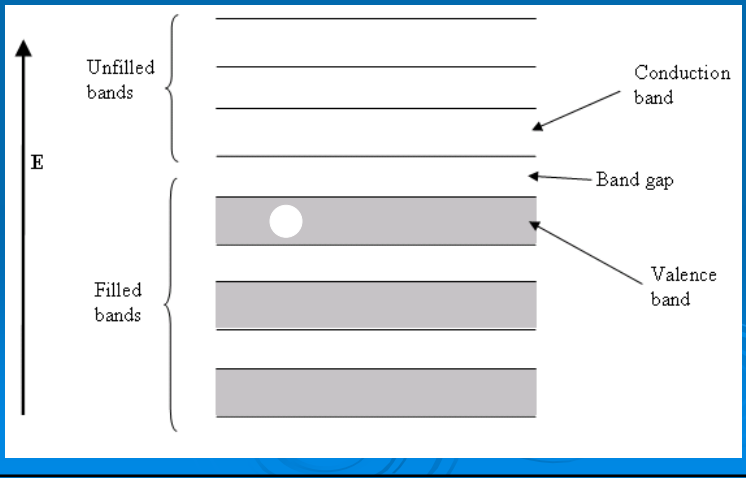


Carrier Doping

- 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

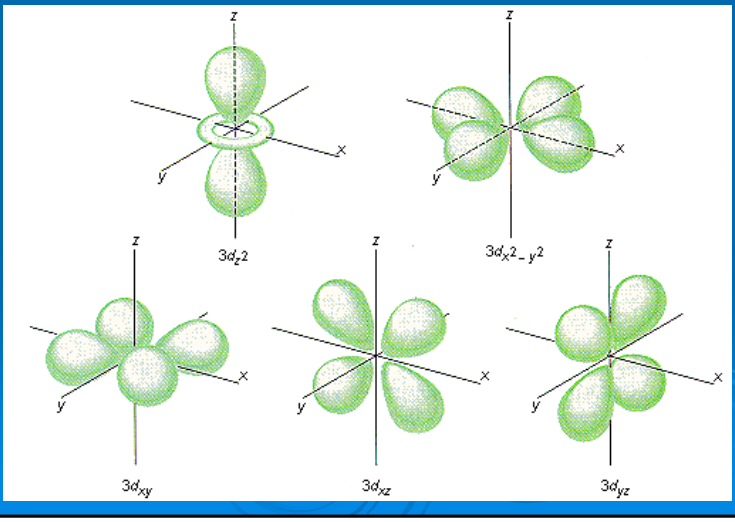
- In the manganites, we introduce holes, which give rise to Mn^{3+} and Mn^{4+} ions in the system. How do spins arrange themselves? Why?

- Hint: The electronic configuration of Mn is $3d^5 4s^2$

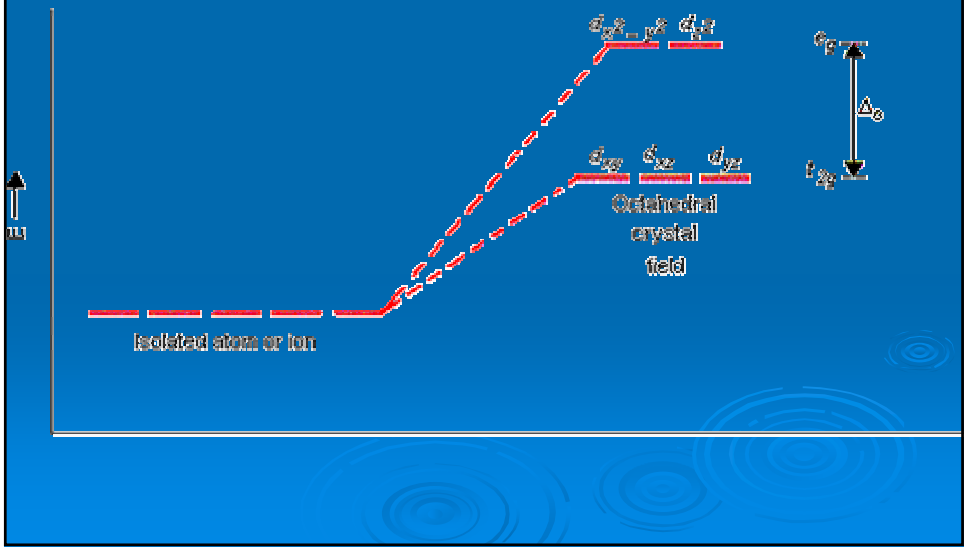
Crystal Field Splitting

- 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

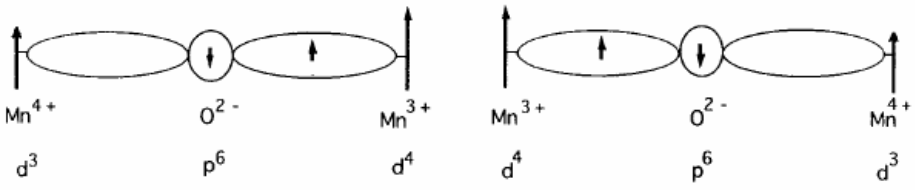
Remember



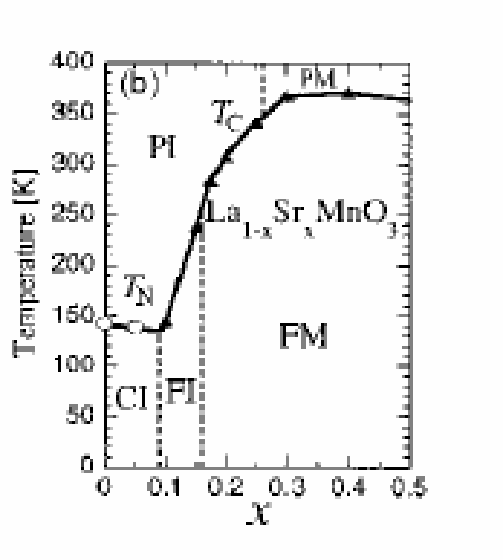
Answer



Double Exchange

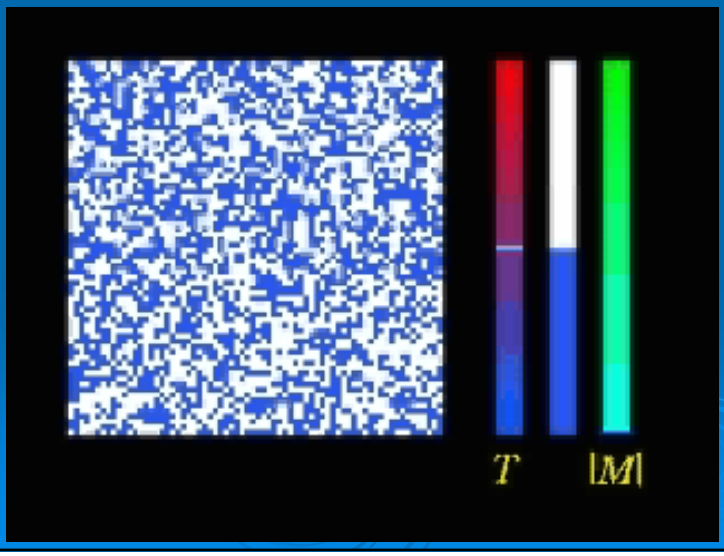


Phase Diagram

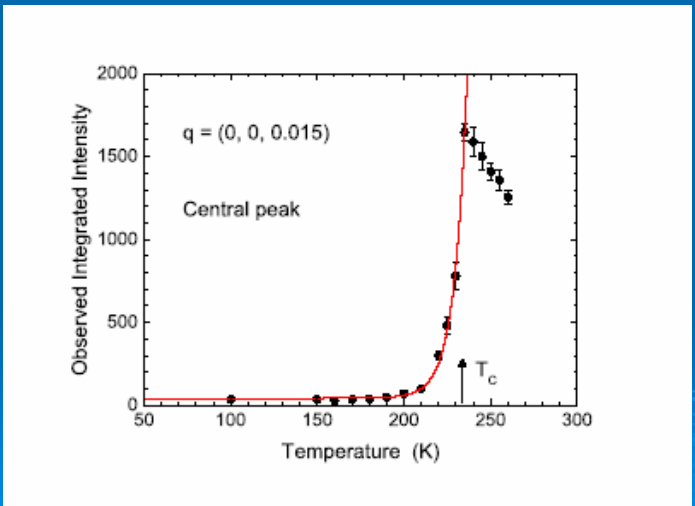


M. Imada et al. Rev. Mod. Phys. (1998)

Ising Model

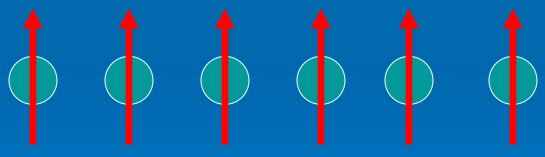


Quasielastic Scattering

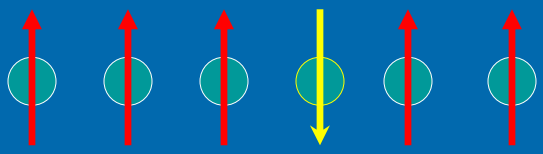


Heisenberg Model

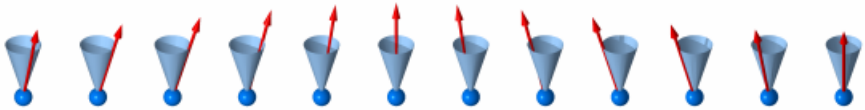
$$E = -2 \sum J_{ab} \cdot S_a \cdot S_b$$



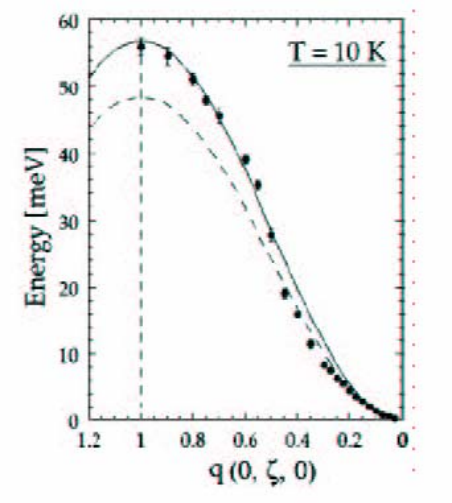
Excitations?



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?