

133/219 Projects list – Spring 2009

Papers' Databases:

prola.aps.org APS Physics Review online archive. For Condensed Matter select Phys. Rev. Lett., Phys. Rev., Phys. Rev. B, Rev. Mod. Phys..

xxx.lanl.gov/archive/cond-mat Condensed matter papers database.

scholar.google.com Google's papers search engine.

1. Ferromagnetism in HoRu₂

This is a Laves-phase family compound (RM₂ with R being a rare earth and M a non-magnetic transition metal). These materials are of particular interest because of the competition between crystal electric field (CEF) and exchange interactions.

This project will involve preparation of HoRu₂ polycrystals, X-rays characterization, M vs.H hysteresis study, M vs. T and R vs. T measurements, etc.

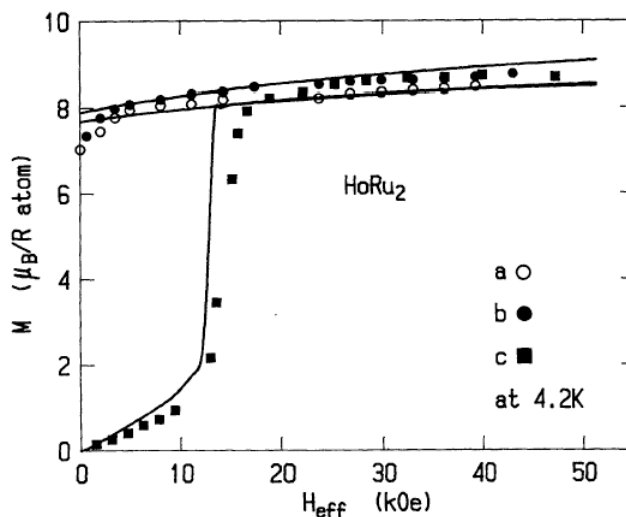


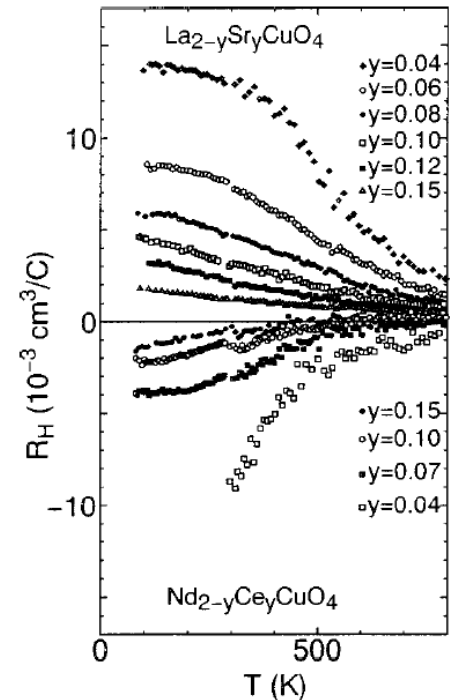
Figure 1 – HoRu₂ magnetization curves at 4.2 K.

2. L_{2-x}Ce_xCuO_{4-δ} (L=Pr, Nd, Sm, Eu, x ~ 0.15)

The charge carriers in all of the well-known layered copper oxide high-temperature superconductors (HTSC) are holes located in the CuO₂ planes, the common structural element of these systems (for example, the YBa₂Cu₃O_{7-δ} HTSC). Pr, Nd or Sm based compounds doped with Ce can produce a HTSC with electron carriers.

This project will involve preparation of NCCO, PCCO or SCCO polycrystals, X-rays characterization, T_c vs. X phase diagram, Hall measurements to determine the nature of the carriers ($R_{Hall} \sim 1/nq$ with q the charge of the carrier, negative or positive), etc.

Figure 2 – LSCO has positive Hall coefficient (hole-carriers), while NCCO has negative Hall coefficient (electron-carriers).



3. Effects of non-magnetic Zn impurities substitution in YBCO superconductor

It is well known that the substitution of magnetic materials in the highly studied cuprates destroys the superconductivity. Doping with other non-magnetic materials, such as Zn, has revealed a reduction in the T_c from 92 K to 60 K, for 3% Zn-doping, to no superconductivity at all for 10% Zn substitution.

This project will involve preparation of $YBa_2(Cu_{1-x}Zn_x)_3O_{7-\delta}$ polycrystals, X-rays characterization, measurement of the T_c vs. X phase diagram, etc.

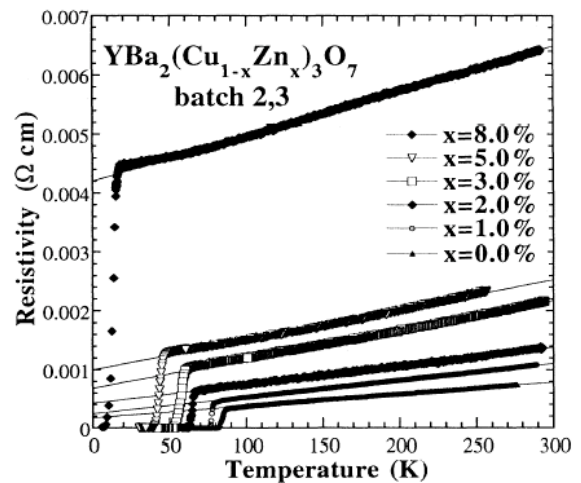


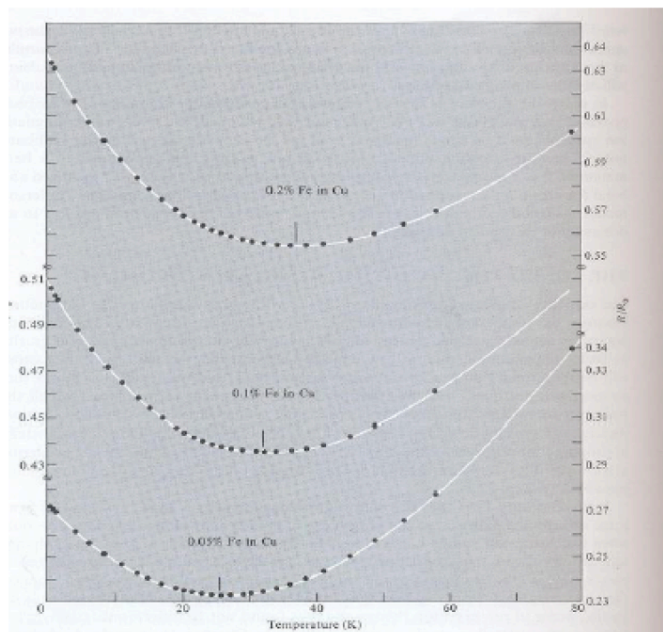
Figure 3 – Suppression of T_c with increasing Zn-doping.

4. Thin films and the Kondo effect.

The Kondo effect is due to the interaction of conduction electrons in a metal interacting with a magnetic impurity spin. Under certain conditions, a bound spin singlet state forms between conduction electrons and magnetic impurities and as a result the resistance of the material increases. The groups doing this will use

magnetron sputtering to grow thin films of a given material, characterize the sputtering growth rates using X-ray diffraction and do resistivity measurements to observe the Kondo effect.

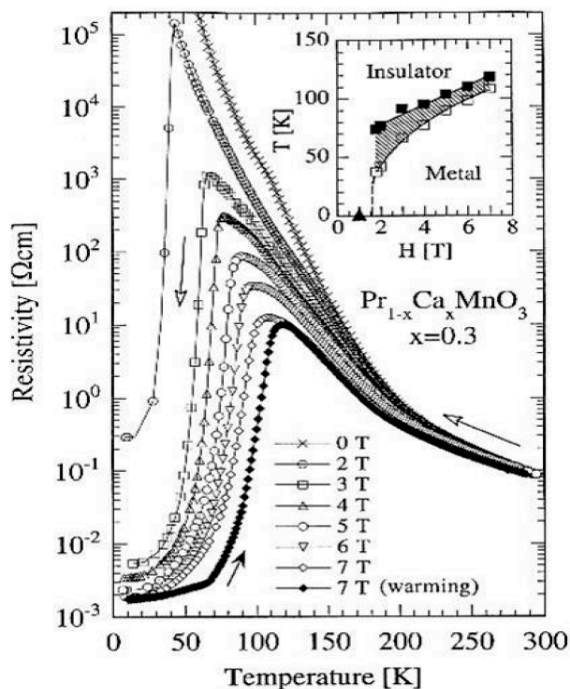
Figure 4 – Kondo behavior for various doping concentrations of Fe in Cu.



5. Manganites and Colossal Magnetoresistance.

One of the most active areas of research in condensed matter physics studies the origin of large magnetoresistance effects in particular materials. Among them, the Mn oxides (manganites) are much analyzed due to the existence of a phenomenon called colossal magnetoresistance (CMR), where the resistance of the sample changes dramatically once relatively small fields are turned on. An example project would be growing single crystals of $\text{La}_{1-x}\text{Sr}_x\text{MnO}_3$ over a range of x values and testing to see which x gives colossal magnetoresistance.

Figure 5 – Resistivity vs. temperature for different applied magnetic fields.



6. Spin Glasses and the Kondo Effect.

The Kondo effect is due to the interaction of conduction electrons in a metal interacting with a magnetic impurity spin. At low impurity concentrations, a bound spin singlet state forms between conduction electrons and magnetic impurities and as a result the resistance of the material increases. At larger impurity concentrations, the magnetic impurities begin to interact with each other (e.g. via conduction electron spin or directly) in such a way that their orientations become randomly orientated (due to the system's inability to simultaneously minimize the competing interaction energy between its components). This project would involve growing a material over a range of magnetic impurity disorder levels, and attempting to pin down at which level the material goes over from exhibiting Kondo behavior and spin glass behavior.

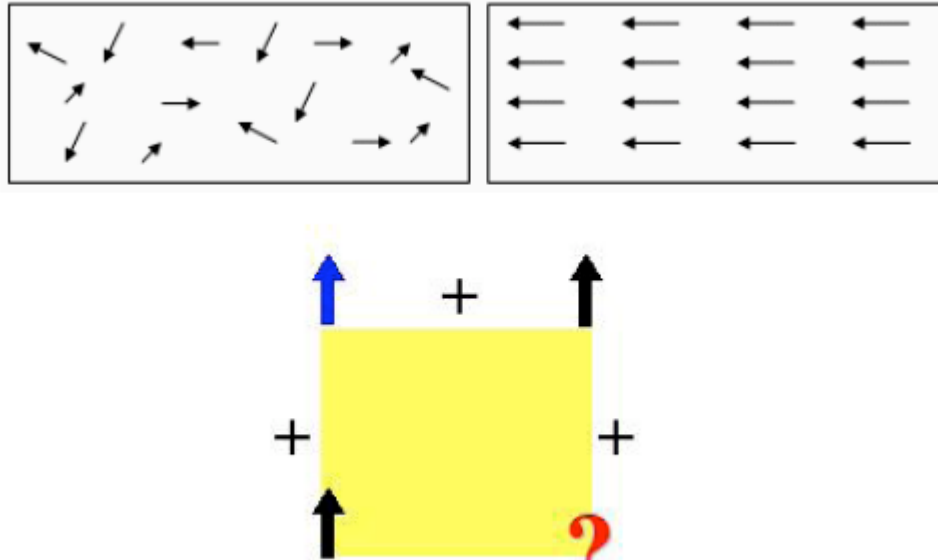


Figure 6 – If we initially have a ferromagnetic material, once the impurity spins are added, the original spins will interact with the impurities and become "frustrated", i.e. they won't "know" which way to align themselves.

7. Intercalated Graphite Compound YbC₆.

Graphite intercalation compounds are made up of graphite layers with guest molecules or atoms inserted between them. Not every layer is necessarily occupied by guests. A "stage 1" graphite intercalation compound consists of alternating graphite and guest atom layers while a "stage n " graphite intercalation compound consists of n layers of graphite alternating with 1 layer of guest atoms.

The stage 1 compound YbC₆ has the second highest superconducting critical temperature ($T_c \sim 6$ K) among the graphite intercalation compounds. The nature of the superconducting state in these materials is still under debate and remains a topic of considerable interest.

This project will consist of growing single crystals of YbC₆ using a vapor transport technique, characterizing the crystal structure via x-ray diffraction and measuring the superconducting critical temperature using a SQUID magnetometer. If time permits, it may be possible to measure the anisotropy of the superconducting upper critical field.

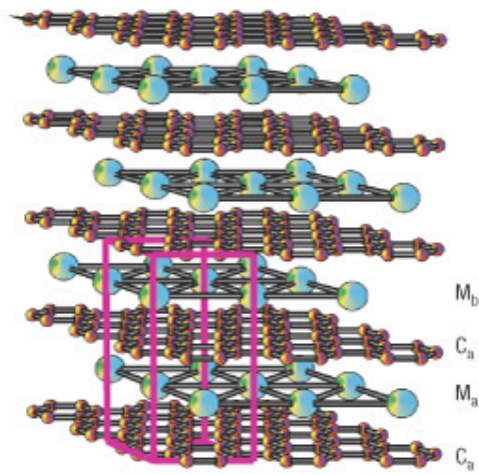


Figure 7 - Crystal structure of YbC₆ showing alternating layer of graphite and ytterbium metal guest atoms.

8. Growth and transport study of Oxypnictides.

Study the magnetic and superconducting properties of several oxypnictide materials (LaFePO). Using varied growth parameters study the effects on yield and properties of material.