Using Higher Energy X-rays and Spin Detection To Go After Non-magnetic Electron Correlation, Half-metallic Ferromagnetic Behavior and Magnetic Ordering

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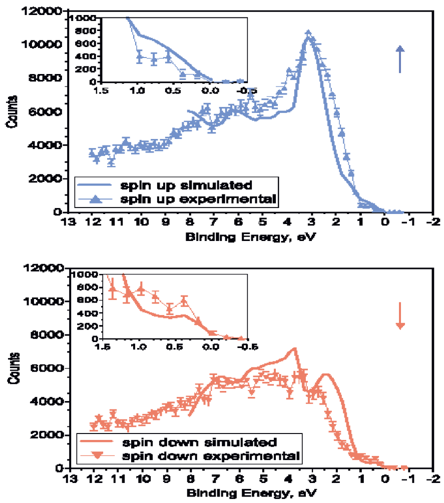
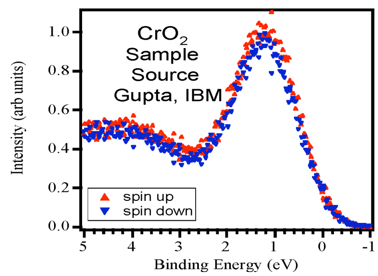
1. Half-Metallic Ferromagnets and Dilute Magnetic Semiconductors

Ex situ Prepared Samples: Fe_3O_4 worked (somewhat) but CrO_2 did not



To the right: Fe_3O_4 Sample Source – Schuller *et al*
At hv = 160 eV, Pol (E_F) = - 40%
S.A. Morton, G.D. Waddill, S. Kim, I.K. Schuller, S.A. Chambers, and J.G. Tobin, Surface Science Letters **513**, L451 (2002).

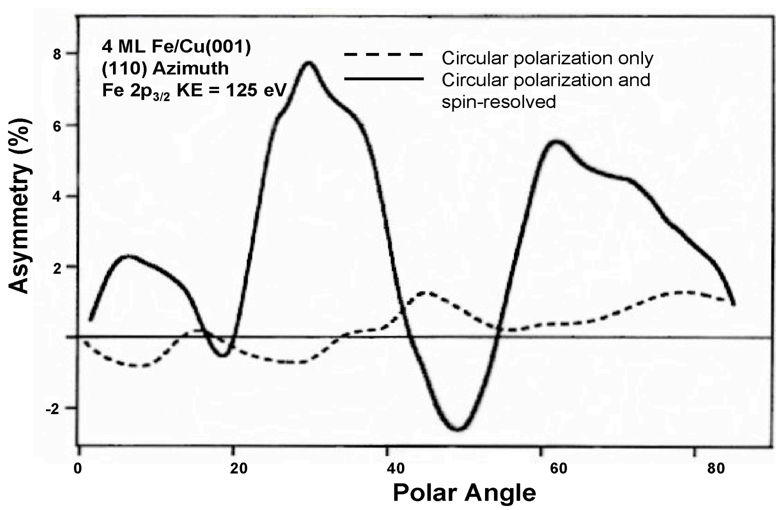


But even the Fe3O4 result was limited by surface effects: we need more bulk sensitivity and well behaved matrix elements!!! Higher hv!!!!

2. Double Polarization and Magnetic Ordering

Spin-Polarized Photoelectron Diffraction: Double Polarization

Theory says that Double-polarized photoelectron diffraction (circularly polarized excitation and true spin detection) will give larger effects.



- With spin-resolution sensitivity to magnetic effects increases 5-10 fold
- Determination of local magnetic structure
- Ultimately imaging magnetic spins with atomic resolution

G.D. Waddill *et al.*, PRB **50**, 6774 ('94); S.Y. Tong *et al.*, PRB **54**, 15356 ('96).

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3. Double Polarization and Electron Correlation in Non-Magnetic Systems

Using the Fano Effect to Probe Electron Correlation in Non-Magnetic Systems

Electron Correlation in Ce

- **Much of the controversy revolves around the interpretation of the Ce photoemission structure in terms of a modified Anderson Impurity Model, first put forth by Gunnarsson and Schoenhammer (PRL and PRB 1983). Here, in this correlated and multi-electronic picture, semi-isolated 4f states (at a nominal binding energy of 1 eV) are in contact with the bath of spd valence electrons, generating spectral features at the Fermi Level and at a binding energy corresponding to the depth of the bath electron well, about 2 eV below the Fermi Level in the case of Ce.**
- **To the right, a revisitation to the issue, from Kotliar and Vollhardt, Physics Today, March 2004.**

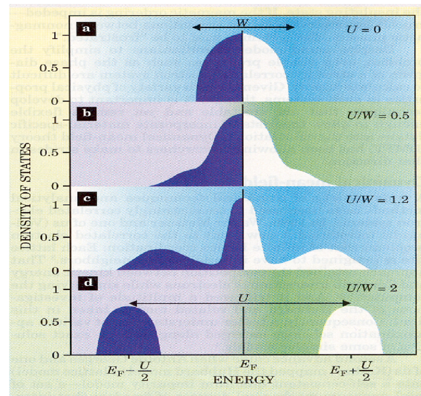

Illustration of the origin of the quasiparticle (at the Fermi Level, E_F) and t he Hubbard Bands (at $\pm$ U/2, relative to the Fermi Level). W is the band width and U is the correlation strength. Case c, third from the top, is the case closest to Ce.

Ultimately, we'd like to extend these measurements to Pu.

Conclusions: the advantages of higher energies

- **Half-Metallic Ferromagnets and Dilute Magnetic Semiconductors**
  - **Eliminate surface effects to get a bulk polarization**
- **Double Polarization and Magnetic Ordering**
  - **Increase the effect to 10% - 20%…Image 3d magnetic structure with 2p electrons**
- **Double Polarization and Electron Correlation in Non-Magnetic Systems**
  - **New probe of electron correlation in nonmagnetic systems, with bulk sensitivity**

Acknowledgements

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