Proof of Half-metallicity by Electron Spin Dynamics: application to Fe_3O_4

M. Battiato[1], J. Minar[2], W. Wang[3], W. Ndiaye[4], M. C. Richter[4], O. Heckmann[4], J.-M. Mariot[5], F. Parmigiani[6], K. Hricovini[4], and C. Cacho[7]

[1]*ISSP, Vienna University of Technology, Vienna, Austria*
[2]*NTC, University of West Bohemia, Univerzitni 8, 306 14 Pilsen, Czech Republic,*
[3]*Department PBC,Linkoping University, SE-581 83 Linkoping, Sweden*
[4]*LPMS, Université de Cergy-Pontoise, F-95031 Cergy-Pontoise, France*
[5]*Sorbonne Université, UPMC Univ Paris 06, UMR 7614, F-75231 Paris, France*
[6]*CNR, Laboratorio TASC INFM, I-34012 Trieste, Italy*
[7]*Central Laser Facility, Rutherford Appleton Laboratory, Didcot, Oxon OX11 0QX, UK*

We propose a novel approach to investigate the bulk half-metallicity of a material by monitoring the spin-dependent electron dynamics at the Fermi level using time- and spin-resolved photoemission. Half-metallic materials are very promising candidates for spintronic devices with a potential for generating fully spin polarized currents or high spin filtering effects. Nevertheless the characterization of their bulk properties by photoemission remains very challenging due to surface reconstructions.

Taking Fe_3O_4 as archetype system, we numerically solve the Boltzmann equation where the density of states is obtained by first principles calculations. The results show that electrons thermalize at the same temperature in both spin channels but with two distinct chemical potential across the majority spin band gap. Consequently the hot population spin polarisation becomes thermalization dependent and leads to a decrease of the absolute Fermi level spin polarization.

Experimentally we performed time- and spin- resolved photoemission measurements in the vicinity of the Fermi level using 4.65 eV photon energy for the probe, 1.55 eV for the pump. We observe that the Fermi level spin polarization is reduced over the first picosecond delay. This evolution of the spin polarization is qualitatively predicted by our bulk and surface thermalization calculations and is a direct consequence of the presence of the gap in majority spin channel. We conclude that the combination of time- and spin- resolved photoemission is a powerful technique to test the half-metallicity in solids.