ULTRA-LOW MAGNETIC DAMPING IN METALLIC AND HALF-METALLIC MATERIALS FOR DATA-STORAGE AND MRAM

Justin M. SHAW[1§], Martin SCHOEN[1], Danny THONIG[2], Eric EDWARDS[1], Hans NEMBACH[1], Tom SILVA[1], Michael SCHEIDER[1], Matt PUFALL[1], Charlie KARIS[2], Olle ERIKSSON[2]

1) Quantum Electromagnetics Division, National Institute of Standards and Technology, Boulder, Colorado 80305, USA

2) Department of Physics and Astronomy, University of Uppsala, S-75120 Uppsala, Sweden

§justin.shaw@nist.gov

The phenomenology of magnetic damping is of critical importance to devices which seek to exploit the electronic spin degree of freedom since damping strongly affects the energy required and speed at which a device can operate. However, theory has struggled to quantitatively predict the damping, even in common ferromagnetic materials. This presents a challenge for a broad range of applications in data storage, magnonics, spintronics and spin-orbitronics that depend on the ability to precisely control the dynamics of a device. Complicating the situation is the need to simultaneously control many other magnetic properties, such as anisotropy and saturation magnetization, that may or may not be independent of the damping.

I will discuss our recent work to precisely measure the intrinsic damping in several metallic and half-metallic material systems and compare experiment with several theoretical models.[1-7] This investigation uncovered a metallic material composed of Co and Fe that exhibit ultra-low values of damping that approach values found in thin film YIG.[8-10] Such ultra-low damping is unexpected in a metal since magnon-electron scattering dominates the damping in conductors. However, this system possesses a distinctive feature in the bandstructure that minimizes the density of states at the Fermi energy $n(E_F)$. This behavior can be seen in Figure 1 which shows the compositional dependence of the intrinsic damping in Fe-Co alloy system. $n(E_F)$ is also included in the figure and exhibits a proportionality with the damping. These findings provide the theoretical framework by which such ultra-low damping can be achieved in metallic ferromagnets and may enable a new class of experiments where ultra-low damping can be combined with a charge current.

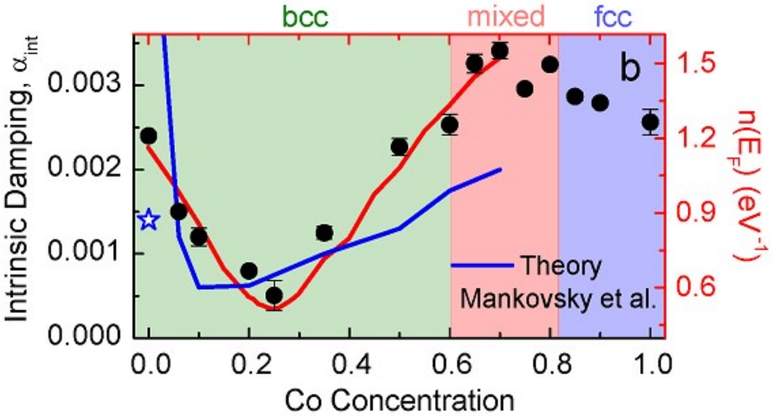

Figure 1. The intrinsic damping parameter (black circles) and density of states (red line) at the Fermi energy as a function of the Co concentration. [8]

Half-metallic Heusler compounds by definition have a bandgap in one of the spin channels at the Fermi energy. This feature can also lead to exceptionally low values of the damping parameter as a result of the reduced number of scattering channels. Co_2MnGe is a particularly promising Heusler material for applications in MRAM due to its low ordering temperature.[11] We show that an intrinsic damping parameter as low as 0.0008 can be achieved in B2 ordered, polycrystalline Co_2MnGe films. Our results show a correlation of the damping with the order parameter and resistivity in Co_2MnGe.

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