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Extracting exchange stiffness in thick films

Magnetic memories, including magnetic RAM (MRAM) require constant innovation of magnetic materials with new and favorable properties. Magnetic materials have three fundamental properties associated with them: saturation magnetization, M_s, magnetic anisotropy, K_{eff}, and exchange stiffness, A_{ex}. All these properties play a crucial role in magnetization dynamics, such as magnetic switching in MRAM devices, and so it is crucial to be able to quantify them for materials development and magnetic modeling. Saturation magnetization and anisotropy are both easily accessed at the film level by techniques such as SQUID magnetometry. There is not yet a reliable method to extract exchange stiffness at the film level. In this work, we present a novel method for measuring exchange stiffness using Brillouin light scattering (BLS) spectroscopy. We probe spin waves in both the Damon-Eschbach and backward volume geometries in thick (100 nm) permalloy films with different capping layers and extract the exchange stiffness by fitting a closed form of the spin wave dispersion relation. To examine the effectiveness of this method, we also measured standing spin waves via ferromagnetic resonance (FMR). Notably, when calculating the wave vector for each standing wave, we see up to a 10% difference in the calculated exchange depending on the division of the surface anisotropy between the top and bottom interfaces. This work demonstrates a novel, effective, time efficient technique for extracting exchange stiffness at the film level. This significantly streamlines the process of engineering and modeling new materials for MRAM technologies.

Short Bio

Jacob Wisser is a physicist in the Applied Physics Division at the National Institute of Standards and Technology in Boulder, CO. He works on several projects measuring both magnetic and thermal properties of materials using techniques such as Brillouin light scattering (BLS), micro-focused BLS, extreme ultraviolet radiation, and advanced nanofabrication techniques. Prior to joining NIST full time, he did an NRC postdoctoral fellowship at NIST using some of the same techniques. He did his PhD work with Yuri Suzuki at Stanford University on spin dynamics in complex oxide heterostructures.