Mode and size dependent damping in magnetic nanostructures
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Abstract: An outstanding question in the broad field of spin dynamics with ferromagnets is whether the damping of gyromagnetic precession is in actuality subject to finite size effects at the nanometer length scale. We demonstrate that the effective damping in nanomagnets depends strongly on the excited spin-wave mode and on the size of the nanomagnet. The damping increases by up to 40 % compared to the thin film. The damping constant \( \alpha \) is a critical parameter for spintronics devices, e.g., spin-torque-transfer magnetic random access memory (STT-MRAM), since the switching current \( I_c \) is proportional to the damping and the required power depends on \( I_c^2 \). Optical measurements of the magnetization dynamics are particularly challenging when the diffraction-limited laser spot is much larger than the size of the nanomagnet. We developed a novel heterodyne magneto-optical microwave microscope (H-MOMM) to measure ferromagnetic resonance in individual, well-separated nanomagnets by use of heterodyne detection of magneto-optical signals at microwave frequencies. We find that the damping for the spin-wave mode that is distributed throughout the nanomagnet, a.k.a. the “center-mode”, increases with decreasing nanomagnet size, whereas damping for the two “end-modes” that are strongly localized at the ends of the nanomagnet show the opposite trend [1]. The experimental results are in good agreement with calculations based on the theory of dissipative transverse spin-currents internal to a conductive magnetic film, where the spin-currents are proportional to the spatial curvature of the excited mode [2].

Bio: Hans T. Nembach is a Research Associate at the National Institute of Standards and Technology (NIST) in Boulder, Colorado. He received his PhD in physics from the Technical University Kaiserslautern, Germany in 2006, where he worked in the group of Prof. Burkhard Hillebrands. His thesis focused on magnetization dynamics in thin magnetic films studied by time-resolved magneto-optical Kerr effect magnetometry and by Brillouin Light Scattering Spectroscopy. He began work at NIST in 2006 under the auspices of a DAAD postdoctoral fellowship. His research interests are magnetization dynamics in thin films, multilayers and magnetic nanostructures.