

Mie-enhanced micro-focused Brillouin light scattering with wavevector resolution

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Magnonics investigates magnetic excitations (spin waves) for both fundamental condensed matter physics studies and low-power, THz-frequency computing [1]. Despite the availability of various experimental techniques, a significant “blind spot” remains for wavenumbers between 30 and 300 rad/ μm , where established methods fail to resolve spin waves.

Here, we introduce a method that bridges this gap by combining a standard tabletop micro-focused Brillouin light scattering (μBLS) setup with periodic dielectric structures fabricated directly on the magnetic sample. These structures enhance the scattering process via Mie resonances, enabling access to the previously unattainable magnon wavenumber range (Mie-enhanced μBLS). While our earlier work using dielectric disks demonstrated strong signal enhancement [2,3], the key advancement here is achieving wavevector resolution through the added periodicity. Using state-of-the-art electron-beam lithography, we fabricated dielectric gratings on a permalloy thin film with periodicities as small as 150 nm, successfully detecting magnons with wavenumbers determined by multiples of $2\pi/A$ (A being the grating period) up to 200 rad/ μm , corresponding to a wavelength of around 30 nm [4].

This technique closes a long-standing gap in magnon detection, enabling new studies of spin-wave physics across the entire Brillouin zone and facilitating the imaging of nanoscale spin-wave devices. Our results provide a robust way to characterize nanoscale spin waves in space, wavenumber, and frequency with unprecedented resolution, supported by both experimental data and theoretical modeling. Beyond magnonics, this approach is applicable to other excitations, such as phonons, opening new possibilities in areas ranging from ultrafast magnetism to mechanobiology.

References:

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