THz spin dynamics and magnon torques

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Magnons, the quasiparticles of spin waves, are the elementary low-energy collective excitations in magnetic materials. Antiferromagnetic insulators (AFMIs) can host THz frequency magnons to carry angular momentums without moving charges. We examine the high-frequency optical mode of α-Fe_2O_3 and report that Dzyaloshinskii-Moriya (DM) interaction generates a new type of torque on the magnetic resonance [1]. The ability to electrically manipulate antiferromagnetic magnons, essential for extending the operating speed of spintronic devices into the THz regime, remains a major challenge. We demonstrate the electrical manipulation of sub-THz magnons in the α-Fe_2O_3/Pt heterostructure using spin-orbit torques [2]. In the α-Fe_2O_3/Pt heterostructure, the bilinear magnetoelectric resistance (BMER) is triggered from the asymmetric spin accumulation via modulation of the efficiency of magnon excitation, which can be utilized to electrically read the in-plane orientation of the Neel vector of α-Fe_2O_3 [3]. We present the direct observation of chiral damping of magnons through Brillouin light scattering (BLS) spectroscopy [4]. The resulting linewidths exhibit odd symmetry with respect to the magnon wave vector, confirming the presence of chiral damping. Our study introduces a novel methodology for quantifying chiral magnons.

We also detect THz spin resonance in an antiferromagnetic NiO heterostructure by employing both low-wavenumber Raman and continuous-wave THz spectroscopy techniques. Then, we demonstrate the electrically tunable THz spin resonance in antiferromagnetic NiO by applying charge currents along the adjacent metal layer [5]. The involvement of moving charges in electron-mediated spin torques leads to inevitable Joule heating and corresponding energy dissipation. This issue can be circumvented by magnon torques [6]. The field-free magnon torque switching of CoFeB can be observed utilizing z-spins in $PtTe_2$/WTe_2/NiO/CoFeB heterostructures [7], which suggests the existence of out-of-plane anti-damping magnon torques. In addition, we report the direct time-domain measurement of the velocity (up to 650 km/s) of antiferromagnetic magnons in NiO with optical-driven THz emission [8]. Our observation suggests the prospects of energy-efficient nanodevices using AFMIs considering finite dissipation in real materials.

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Biography

Hyunsoo Yang is a Professor in the Department of Electrical and Computer Engineering, National University of Singapore (NUS), working on various magnetic materials and devices for spintronics applications. He worked at C&S technology and Intelligent Fiber Optic Systems, California. He received his Doctorate from Stanford University. From 2004-2007, he was at IBM Almaden Research Center. He has authored more than 260 journal articles, given 200 invited presentations, and 20 patents. He was a recipient of the Outstanding Dissertation Award from the American Physical Society (GMAG), IEEE Magnetics Society Distinguished Lecturer, Minister of Science ICT award, Mid-Career Award of the IEEE Magnetics Society, AAIA Fellow, and IEEE Fellow.