Strong magnon-magnon coupling and unidirectional exchange spin waves in magnetic nanostructures

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Magnons, the quanta of spin waves, are collective precessions of electron spins in magnetic materials, which do not involve charge motion during propagation, and thus can avoid Joule heating in information transmission, making them potential candidates for the next-generation of low-power electronic devices. In this talk, I will introduce the observation of strong interlayer magnon-magnon coupling in magnetic metal-insulator hybrid nanostructures. A large anticrossing gap up to 1.58 GHz is observed between the ferromagnetic resonance of the metallic nanowires and the in-plane standing spin waves of a low-damping yttrium iron garnet (YIG) film. Using this effect, we also experimentally observe the long-distance propagation of ultra-short-wavelength spin waves with wavelengths as low as 50 nm, and demonstrate the unidirectional behavior of such spin waves. A nanoscale magnonic interferometer can be designed based on the unidirectional spin waves. We also discuss the experimental observation of nonlocal three-magnon scattering between spatially separated magnetic systems. Above a certain threshold power, a CoFeB Kittel magnon splits into a pair of counter-propagating YIG magnons which can be detected by the inverse spin Hall effect. Our results demonstrate the nonlocal detection of two separately propagating magnons emerging from one common source that may enable quantum entanglement between distant magnons for quantum information applications.