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Spin Transport by Collective Spin Excitations

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We report studies of angular momentum transport and magnetic dynamics in diverse insulating materials. We have shown that spin transport is exponentially suppressed by insulating diamagnetic barriers, but we find that collective spin excitations in various materials can enable robust spin transport in insulators. We present studies that reveal efficient spin transport in Yttrium Iron Garnet (YIG) even in the presence of magnetic-field defined barriers that require inter-conversion between magnons of dissimilar energy. Optical detection of Ferromagnetic Resonance (FMR) in YIG by means of nitrogen-vacancy (NV) defect centers in diamond reveals the role of spin waves in this dipole-mediated spin transfer process and presents a powerful approach to broadband, spatially resolved FMR detection for these and related studies. We find that fluctuating antiferromagnetic (AF) spin correlations also enable efficient spin transport having decay lengths approaching 10 nm in insulating antiferromagnets. While the spin decay length increases with the strength of the AF correlations, AF magnon spin transport is robust against the absence of long-range order. This research performed in collaboration with F.Y. Yang, V.P. Bhallamudi, C.H. Du, R. Adur, H.L. Wang, C.S. Wolfe, A.J. Berger and S.A. Manuilov, and is supported by the U.S. DOE through Grant DE-FG02-03ER46054, by the NSF MRSEC program through Grant 1420451 and by the Army Research Office through Grant W911NF-16-1-0547.

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