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Oliver E. Buckley Condensed Matter Prize Lecture: Transfer of spin momentum between magnets: its genesis and prospect

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Consider two nanoscopic monodomain magnets connected by a spacer that is composed of a non-magnetic metal or a tunnel barrier. Any externally applied electric current flowing through these three layers contributes tiny pseudo-torques to both magnetic moments (*J.S.* 1989). Such a weak spin-transfer torque (STT) may counteract and overcome a comparably small torque caused by viscous dissipation (*L. Berger* 1996; *J.S.* 1996). Any initial motion (e. g. excited by ambient temperature) of one moment (or both), may grow in amplitude and culminate in steady precession or a transient switch to a new direction of static equilibrium. In a memory element, the STT effect writes 0 or 1 in a magnetic-tunnel junction. Indeed, world-wide developments of memory arrays and radio-frequency oscillators utilizing current-driven STT today enjoy a nine-digit dollar commitment. But the fact that transfer of each half-unit of spin momentum $h/4\pi$ through a barrier requires the transfer of at least one unit of electric charge limits its efficiency. Arguably, STT should also arise from the flow of external heat, in either direction, between an insulating magnet, of ferrite or garnet (e. g. YIG) composition, and a metallic spacer (*J.S.* 2010). Whenever s-d exchange annihilates a hot magnon at the insulator/metal-spacer interface, it transfers one unit $h/2\pi$ of spin momentum to the spacer. Conduction electrons within the spacer will transport this spin momentum to the second magnet without requiring an electric current. Such a *thermagnonic* method, modestly powered by a Joule-effect heater, can substantially increase the efficiency of STT. Support for this prediction comes from (1) an estimate of the sd-exchange coefficient from data on spin relaxation in magnetically dilute (Cu,Ag,Au):Mn alloys; (2) a DFT computation (*J. Xiao et al* 2010); and (3) most persuasively, data from spin pumping driven across a YIG/Au interface by ferromagnetic resonance (*B. Heinrich et al* 2011; *C. Burrowes et al* 2012).