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Testing Reciprocity of Spin Pumping and Spin Transfer Torque in Ferromagnet/Spin-Orbit Metal Heterostructures CARL BOONE, SATORU EMORI, TIANXIANG NAN, NIAN SUN, Northeastern University — Spin pumping from a ferromagnet (FM) to a normal metal (NM) and spin transfer torque (STT) generated in a FM from an injected spin current should be reciprocal processes governed by the spin mixing conductance. The same should be true for the spin Hall effect (SHE) and inverse SHE, which are used to generate and measure spin currents. Past experiments on multilayer thin films involving FM and NM interfaces have measured only spin pumping or spin injection, and have utilized incomplete modeling that results in different effective values for the same parameter such as the spin mixing conductance or spin Hall angle. This gives rise to a large range of values reported in the literature. Here we develop a complete model for spin flow in the FM/NM system including SHE, spin diffusion and spin pumping that allows us to determine the true values of the spin transport parameters. To explore the physcis we use STT-ferromagnetic resonance (FMR) experiments of NM/FM/NM trilayers, and FMR spectroscopy of FM/NM bilayers where we simultaneously measure damping changes due to spin pumping, voltage generated by the inverse SHE, and STT generated by the SHE. These experiments, combined with the complete modeling, allow us to test the reciprocity of spin pumping and STT plus the SHE and its inverse.

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