Experimental Separation of Spin Hall and Orbital Torques in FM/HM/Light-Metal Heterostructures

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Recent advances in orbitronics have demonstrated that light metals and oxides can generate sizable orbital currents that can be converted into spin currents in adjacent magnetic layers, giving rise to efficient current-induced torques [1]. However, separating spin currents originating directly from the spin Hall effect from those arising via orbital-to-spin conversion remains an experimental challenge [2].

Here, we present a systematic and quantitative study of current-induced torques in ferromagnet/heavy-metal/light-metal multilayers, including Co-, Ni-, and NiFe-based heterostructures incorporating Pt and W as conversion layers, topped with Al and Cu layers. Using a combination of ferromagnetic resonance, anomalous and planar Hall effect measurements, as well as first- and second-harmonic Hall analysis, we extract both damping-like and field-like torque components across a broad set of samples with controlled layer composition and thickness, including dedicated reference heterostructures used to quantify the orbital contribution. This allows us to quantitatively disentangle orbital-current-induced torques from conventional spin Hall contributions.

References:

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