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The Spin Hall Effect, Spin Currents and Spin Orbit Torques in Ferromagnetic/Normal Metal Multilayer Nanostructures

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In the spin Hall effect (SHE) the passage of a charge current through a non-ferromagnetic metal (NM) film generates a transverse pure spin current that when it impinges onto an adjacent ferromagnetic (FM) film will exert both a damping-like torque and a field-like torque on the FM, with the former arising from the absorption of the transverse component of the incident spin current and the latter due to spin rotation during the reflection of a portion of the incident spin current. Certain NMs (e.g. Pt, Ta, and W) have been found to exhibit a strong SHE and the damping-like torque that can be exerted in this manner on thin film magnetic materials has significant potential for spintronics in that it has been demonstrated to be capable of reversibly switching the magnetization direction of both in-plane and out-of-plane magnetized nanomagnets, to induce persistent microwave magnetic oscillations, and to facilitate the high-speed manipulation of domain walls in magnetic nanostrips. I will report some recent results from our SHE studies, including investigations into the fundamental role that the interfacial spin-mixing conductance plays in determining the effectiveness of the SHE for exerting strong anti-damping spin torques on the adjacent ferromagnet, and experiments which demonstrate that both the damping-like torque and a strong field-like torque can arise from the "bulk" SHE.

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