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Intraband and interband spin-orbit torques in non-centrosymmetric ferromagnets

H. LI, KAUST, K. VYBORNY, T. JUNGWIRTH, Institute of Physics ASCR, H. GAO, J. SINOVA, Texas A&M University, A. MANCHON, KAUST — Experimental observations of the spin-orbit torque in non-centrosymmetric ferromagnets such as multilayered ferromagnetic metals and dilute magnetic semiconductors, have recently been reported [1]. Two scenarios have been invoked to explain the origin of these current-driven torques. In the first one, the spin orbit coupling generates an in-plane non-equilibrium spin density and exerts a field-like torque on the magnetization. In the second one, the torque originates from the spin Hall effect occurring in the normal metal placed below the ferromagnet. Recently, a large (anti-)damping-like torque has been observed in a single magnetic GaMnAs layer [3]. Obviously, the torque cannot be attributed to the spin Hall effect owing to the absence of the adjacent heavy metal. Such a torque might be attributed to the interband contribution to the non-equilibrium spin polarization in the linear-response Kubo formula. This intrinsic (scattering-independent) mechanism is related to (a specific type of) the Berry curvature and our calculations corroborate its link to actual experiments. Our numerical results show the parametric dependences of the different torque components, they exhibit similarities to the analytical results for the Rashba two-dimensional electron gas in the weak disorder limit and open new perspectives in the development of current-driven spin-orbit torques by structural design.[1] A. Chernyshov, et.al., Nat. Phys. 5, 656(2009). L. Liu et al. Science 336, 555 (2012) [2] H. Kurebayashi,et.al., Nat. Nano. 9, 211 (2014).

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