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Effective spin Hall properties of a mixture of materials with and without spin-orbit coupling: Tailoring the effective spin-diffusion length[1]
YUE ZHANG, MEGAN PRESTGARD, ASHUTOSH TIWARI, MIKHAIL RAIKH, Univ of Utah — We study theoretically the effective spin Hall properties of a composite consisting of two materials with and without spin-orbit (SO) coupling. In particular, we assume that SO material represents a system of grains of radius, a, and density, n, in a matrix with no SO. We calculate the effective spin Hall angle, θ_{eff}^{SH}, and the effective spin diffusion length, λ_{eff}, of the mixture. Our main qualitative finding is that, if the bare spin diffusion length, λ, is much smaller than a, then λ_{eff} is strongly *enhanced*, well beyond $\lambda/(na^3)^{1/2}$, which can be expected from purely "geometrical" consideration. The physical origin of this additional enhancement is that, with small diffusion length, $\lambda \ll a$, the spin current mostly flows *around the grain* without suffering much loss. We also demonstrate that the voltage, created by a spin current, is sensitive to a very weak magnetic field directed along the spin current, and even reverses sign in a certain domain of fields. The origin of this sensitivity is that the spin precession, caused by magnetic field, takes place outside the grains where SO is absent.

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