Nonlocal magnetolectric effects in diffusive conductors with spatially inhomogeneous spinorbit coupling

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We present a theoretical study of non-local maanetoelectric effects [1] in diffusive hybrid structures with an intrinsic linear-inmomentum spin-orbit coupling (SOC) assumed to spatially which is be inhomogeneous. Our analysis is based on the SU(2)-covariant drift-diffusion equations from which we derive boundary [2] conditions (BC) at hybrid interfaces for SOC of any kind. We demonstrate that the extrinsic presence of sources of spin relaxation (ESR), such as magnetic impurities and/or a random SOC at nonmagnetic impurities, are present, the spin is no longer covariantly conserved, and spin Hall (SH) currents appear. We apply our model to describe a (2D) non-local spin valve with an interface separating two regions: one normal region without intrinsic SOC and one with a Rashba SOC [3] (see Fig. 1b). We first explore the inverse spingalvanic effect, i.e., a spin polarization induced by an electric field (see Fig. 1c). We demonstrate how the spatial behavior of such spin density depends on both, the direction of the electric field and the strength of the ESR rate. We also study the spin-to-charge conversion (see Fig. 1d), and compute the charge current and the distribution of electrochemical potential in

the whole system when a spin current is injected into the normal region. In systems with an inhomogeneous SOC varying in one spatial direction, we find an interesting non-local reciprocity between the spin density induced by a charge current at a given point in space, and the spatially integrated current induced by a spin density injected at the same point.

References

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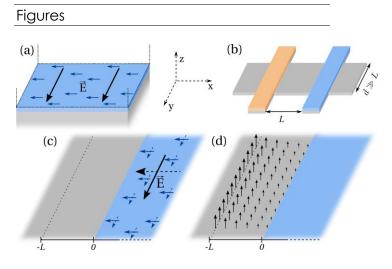


Figure 1: Different systems in which the magnetoelectric effects are usually studied. We focus in (2D) non-local spin valves (b), analyzing charge (c) and spin (d) injection. This study is based on the BC we develop at the interface between a normal (grey regions) and a Rashba (blue region) conductors.