Charge-to-Spin Conversion in Low-Symmetry Topological Materials

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In this work, we theoretically show that the reduced symmetry of strong spin-orbit coupling materials such as MoTe2 or WTe2 enables new forms of intrinsic spin Hall effect that produce large and robust in-plane spin polarizations in coexistence with the traditional out-of-plane component. Through quantum transport calculations on realistic devices in the diffusive regime, we show that spin-charge interconversion can reach efficiencies of 80%, while also possessing long spin diffusion lengths (~100 nm). Such combination is largely superior to what is typically found in conventional SHE materials. These findings vividly emphasize how crystal symmetry governs the intrinsic SHE, and how it can be exploited to broaden the range and efficiency of spintronic functionalities. We also propose specific experimental guidelines for the confirmation of the effect.

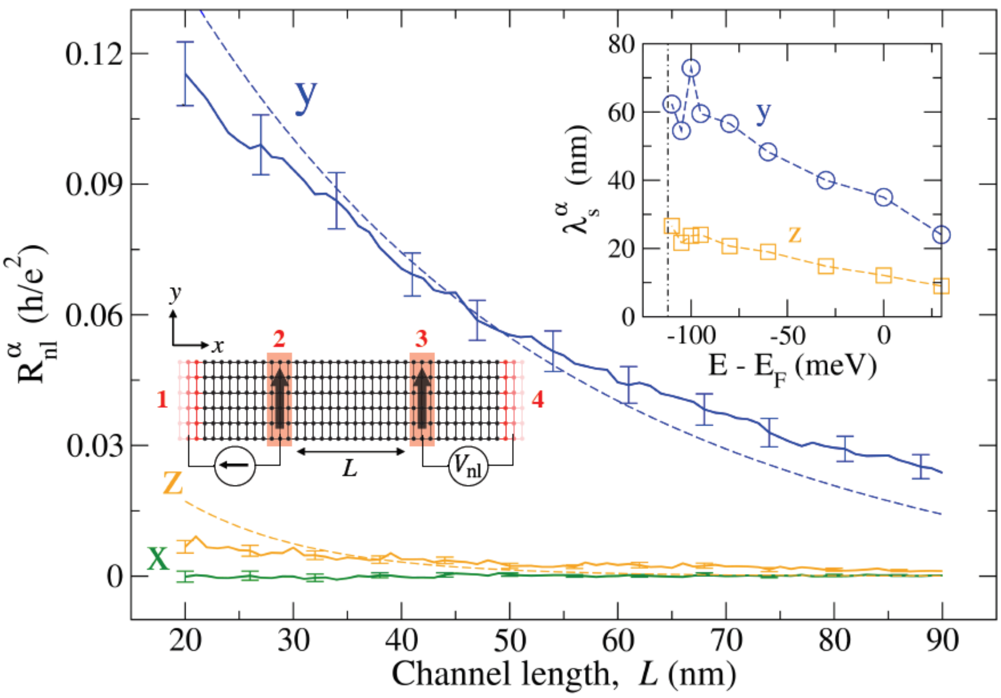

Figure 1: Nonlocal resistance (solid lines) as a function of channel length, L, for spins polarized along x, y and z. Error bars result from averaging over 150 disorder configurations (channel width is 50 nm). Dashed lines are fits using diffusive theory. Left inset: Diagram of the nonlocal spin valve. Black (red) regions denote the device (leads), with leads 2 and 3 being ferromagnetic. Current I0 flows from lead 2 to 1 and the nonlocal voltage is measured between leads 3 and 4. Right inset: Energy-dependence of the spin relaxation lengths for all spin components. The dot-dashed line marks the conduction band minimum of MoTe2