Tunable spin-polarized edge transport in inverted quantum well junctions

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Topological insulators (TI) are bulk insulator materials with spin-degenerated metallic edges/surface states. In 2D, the topological behavior manifests itself as the quantum spin Hall (QSH) effect, arising due to a strong spin-orbit coupling and time reversal symmetry. In the QSH regime, the edge states are helical: electrons with different spins travel in opposite directions. Such behavior is a manifestation of a novel quantum state of matter, theoretically proposed in 2006 and experimentally verified on HgTe/CdTe quantum wells in 2007. Although widely studied in recent years, several questions remain regarding their electronic and transport properties. This work aims to study the spectrum and electronic transport in TIs, using finite-difference and recursive Green's functions methods. The system was modeled by the BHZ effective Hamiltonian, obtained by applying the kp method to Dirac's equation and spin-orbit coupling theory. We use a finite differences' method, in which the Hamiltonian was discretized into a lattice, where each site holds four states: electron/hole with spin up/down. Specifically, we have studied the material's local conductance in a set-up with a gated central region, forming a "n-TI-n junction", which have been recently realized in experiments. We find regimes in which the edge states carry spin polarized currents in the TI region even in the presence of a small magnetic field. Moreover, the transition between quantum spin Hall and ordinary quantum Hall effect was analyzed.