Topoligically induced Hall effects in graphene-based EX-SO-TIC van-der-Waals heterostructures

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Two-dimensional Van-der-Waals materials focus enormous attention due to a variety of electronic and magnetic properties that might be controlled by external fields. A special group of van-der-Waals materials are so-called *EX-SO-TIC* structures where one can turn the time-reversal symmetry on and off on demand by electric gating. This leads to the swap between an exchange (EX) and spin-orbit (SO) coupling. An example of such an ex-so-tic structure is bilayer graphene (GG) sandwiched by a 2D ferromagnet Cr2Ge2Te6 (CGT) and a monolayer of transition metal dichalcogenides, e.g., WS2. Swapping between the exchange and spin-orbit coupling in CGT/GG/WS2 is possible due to the interplay of gate-dependent layer polarization in bilayer graphene and short-range spin-orbit and exchange proximity effects affecting only the layer of graphene in contact with the sandwiching materials

We will present a theoretical study of topological transport properties of CGT/GG/WS2 based on an effective Hamiltonian derived from symmetry considerations and DFT study [1]. Within Green's function formalism we have derived numerical and analytical characteristics describing intrinsic (topological) anomalous, valley and spin Hall effects. Among others, we will expose the influence of certain parameters and external gate voltage on the changes in the band structure and, consequently, on the Hall effects (topological properties described by the Berry curvature). We will also present a potential Hall effects-based device grounded on this heterostructure.

[1] Klaus Zollner, Martin Gmitra, and Jaroslav Fabian. Swapping exchange and spin-orbit coupling in ex-so-tic 2D heterostructures, 05 2020

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