Quantum Hall Effect in Graphene with Interface Induced Spin-Orbit Coupling

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Abstract:
Graphene is a non-magnetic material with very weak spin-orbit coupling (SOC). Since its discovery, there were several proposals to introduce spin-dependent properties in graphene, either by inducing magnetism or spin-orbit coupling.

Recently, there has been a significant progress in engineering those properties by proximity effect, which allows introducing spin-dependent features while preserving its high electronic mobility [1,2]. Even though there are signatures of SOC and magnetic exchange in the electronic properties of graphene, it is difficult to extract their characteristics and strength from transport measurements [2].

In this work, we consider a general effective model for graphene with interface induced spin-orbit coupling [3] and calculate the quantum Hall effect in the low energy limit. We perform a systematic analysis of the contribution of the different terms of the effective Hamiltonian to the quantum Hall effect for different couplings. By analyzing the spin-splitting of the quantum Hall states (see figure 1) in function of the magnetic field and gate-voltage, we obtain different scaling laws that can be used to characterize SOC in experiments (see figure 2). Furthermore, we perform numerical calculations for the effective tight-binding Hamiltonian to investigate the effect of disorder.

References

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Figures

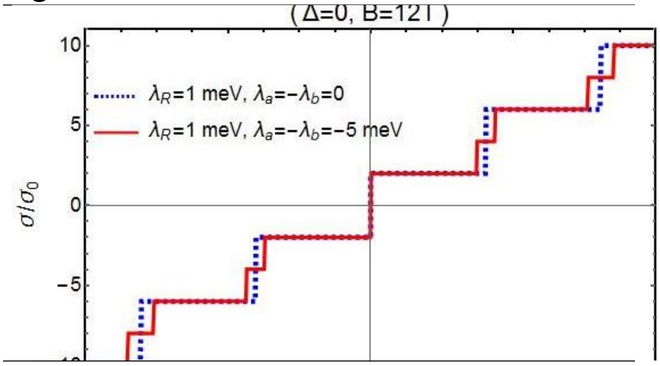

Figure 1: Landau fan diagram of the energy spectra as a function of gate voltage and magnetic field for graphene with interface induced spin-orbit coupling

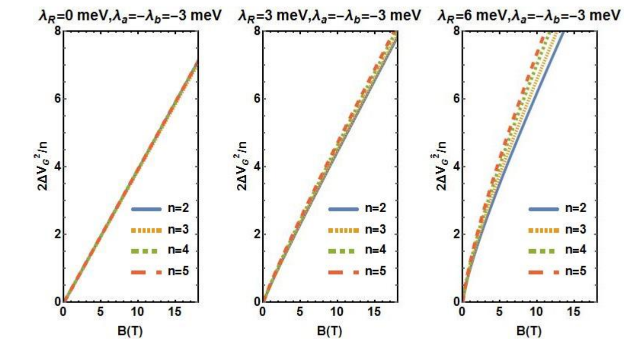

Figure 2: Deviation of the scaling law with progressive enhancement of Rashba coupling