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Magnetotransport in disordered graphene at charge neutrality

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It is now reasonably well understood that for Dirac fermion systems including both graphene and topological insulators, close to charge neutrality the energy landscape becomes highly inhomogeneous, forming a sea of electron-like and hole-like puddles, that determine its properties at low carrier density [1]. The formation of these puddles and the corresponding electronic properties of the Dirac point provide an intriguing example of how the competing effects of disorder, electron-electron interactions, and quantum interference conspire together to give a surprisingly robust state whose properties can be described using semi-classical methods [2]. In the present work we study how this balance is altered in the presence of a moderate magnetic field. The limits of both strong magnetic fields and weak magnetic fields are somewhat understood: a large magnetic field forms quantized Landau levels and the corresponding quantum Hall effect; and in weak magnetic fields, a two-channel model has been effectively used to understand experiments [3]. However, the regime of intermediate magnetic fields has remained an enigma including the experimental observation of unusual insulating states at densities close to the Dirac point. We address this problem by studying three distinct effects of a magnetic field: (i) The magnetic field dependence of the polarizability function within the Random Phase Approximation; (ii) The magnetic field induced change in transmission across the Klein tunneling barrier formed at the boundary between the electron and hole puddles; and (iii) The generalization of the Landauer-Bruggeman effective medium theory for magnetotransport within the puddles. We find that the latter two effects contribute significantly to the transport properties in the presence of a magnetic field, and we compare our theory with available experimental data.

References:

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