Weak Localization vs. Weak Antilocalization in Graphene

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The understanding of quantum-transport phenomena in graphene-based materials is the current subject of great excitation. Indeed, low energy excitations can be formally described as massless Dirac Fermions exhibiting a linear dispersion relation together with an additional degree of freedom, namely pseudospin, which stems from the underlying sublattice degeneracy. In the presence of disorder, one of the predicted signatures of pseudospin is the change in sign of the quantum correction to the semiclassical Drude conductivity (1). This phenomenon, referred to as weak antilocalization (WAL), indeed results from complex quantum-interferences effects of charge carriers in a disordered potential landscape, and in grapheme these characteristics are markedly different from ordinary metals.

The effect of WAL has been recently observed experimentally with weak-field magneto-transport measurements in samples of high quality because the quantum-interference effects are preserved when the phase-relaxation length of the electrons is large enough. (2)

In this talk we present a numerical weak-field magneto-transport study of huge graphene samples and the influence of a realistic disorder potential describing charges trapped in the gate oxide causing long-range scattering potentials (3). Our simulations give clearly different magneto-conductance responses in different regimes which are fingerprint of either weak localization or WAL. Depending on the strength of the perturbing potential, the magneto-conductance can be tuned from positive to negative. The energy of the charge carriers as determined by the gate potential provides a second handle to modify these characteristics.

Our results therefore shed new light on experiments and unveil the possible origin of multiple crossovers from positive to negative magneto-conductance.

References

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Figures

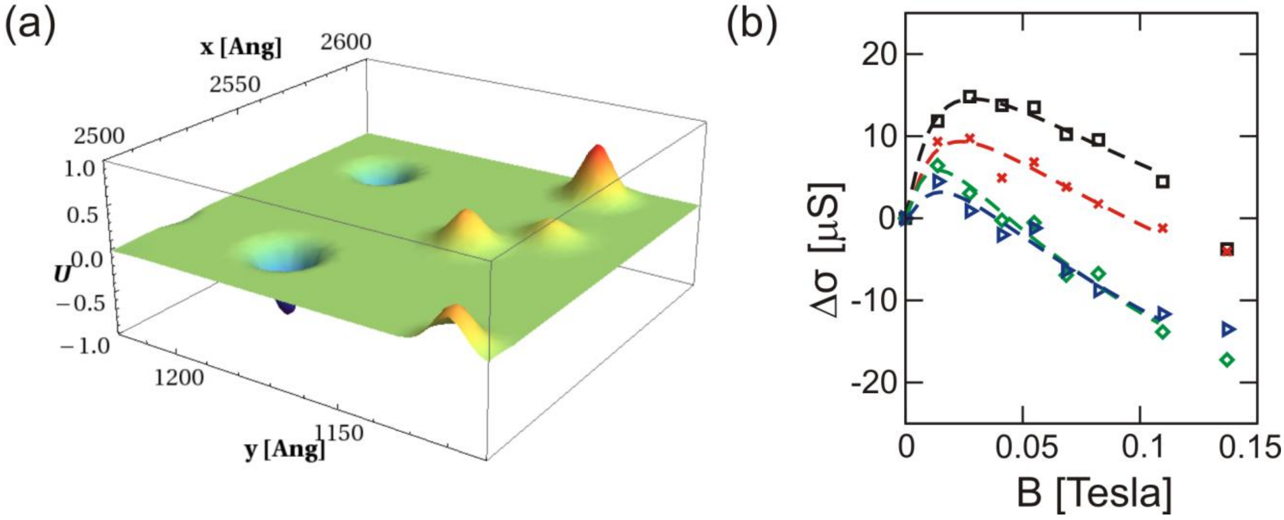

Figure 1: (a) Typical long-range disorder potential. (b) Magneto-transport response.