# Non-linear screening of charged impurity by graphene

Mahmoudreza Ghaznavi, Zoran L. Miskovic* and Frank O. Goodman,

*Department of Applied Mathematics, University of Waterloo, Waterloo, Ontario, Canada N2L 3G1*

Ever since graphene was isolated in the laboratory [1], its peculiar electrical transport properties have attracted a great deal of interest [2]. In particular, graphene's conductivity in the regime of zero doping, or close to the so-called neutrality point still presents a challenge for theoreticians [3].

It is believed that the main contribution to the residual electron conductivity at the neutrality point comes from the scattering of charge carriers in graphene by the potential due to charged impurities, which are ubiquitous in the graphene's environment, either as chemisorbed species or charges trapped in the nearby insulating substrate. While using the ordinary Born approximation to calculate scattering rates in the Boltzmann theory of electron transport seems to suffice for calculating the conductivity of graphene, the problem of electrostatic screening of external charges presents a challenge when considered close to the neutrality point. Namely, because of the peculiar band-structure of graphene, which is a zero-gap semiconductor, the standard linear response theory of graphene's screening breaks down in the limit of zero doping [4].

In that respect, we solve a fully non-linear, Thomas-Fermi type model for screening of an external point charge by graphene [4], which takes into account the effects of variable doping levels (by both holes and electrons), non-zero temperature, and different dielectric constants of the substrate [5]. Our results for the effective non-linearly screened potential show a strong asymmetry with respect to the sign of the external charge and to the type of doping, as well as a strong reduction of the screening length as the temperature increases.

We expect that our results for the screened potential of an external charge, when used in the calculations of the electron scattering rates, will shed more light on the problem of the residual conductivity of graphene at the neutrality point.

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*zmiskovi@uwaterloo.ca