Electronic structure of graphene hybrid systems: Screening and interactions

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Abstract

We consider the effect of adsorbates and substrates on the electronic screening and electron-electron interactions in graphene. First, resonant scatterers such as hydrogen adatoms can strongly enhance the low-energy density of states in graphene. We study the impact of these impurities on electronic screening and find a two-faced behavior: Kubo formula calculations reveal an increased dielectric function $\varepsilon$ upon creation of midgap states but no metallic divergence of the static $\varepsilon$ at small momentum transfer $q \to 0$. This bad metal behavior manifests also in the dynamic polarization function and can be directly measured by means of electron energy loss spectroscopy. A new length scale $l_c$ beyond which screening is suppressed emerges, which we identify with the Anderson localization length [1].

We then address the question of how strong Coulomb interactions in graphene derived materials are: Free standing graphene is shown to feature simultaneously strong local ($U/t \sim 3.3$) and non-local Coulomb interaction terms [2]. Based on the Peierls-Feynman-Bogoliubov variational principle we show that the non-local Coulomb interactions can effectively screen the local interactions and stabilize the Dirac electron sea in graphene [3]. Interestingly, the ratio of the local to the non-local Coulomb interaction can be controlled by a metallic substrate, which efficiently screens non-local Coulomb terms.

References


Figures

(a) Effective Coulomb interactions in graphene: Contribution to the static dielectric function in graphene due to the $\sigma$-bands, which controls the effective interactions strength of the $\pi$-electrons. From [2]