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Manifestation of electron-hole pairing in screening behavior of a two-layer graphene system

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The realization of the electron-hole pairing and exciton superfluidity in two-layer graphene systems and topological insulator thing films is a challenge task [1-4]. One can expect that it is a two-step process and the pairing takes place at temperatures larger than the superfluid transition temperature T_s. At $T<T_s$ the pairing should reveal itself in a nondissipative flow of oppositely directed electric currents in the layers. We propose an alternative approach for the observation of the pairing suitable both below and above T_s. It is based on the study of screening.

The screening of the electric field of a test charge by a two-layer graphene system is considered. At zero concentration of the carriers the graphene layers mimic the effect of the dielectric medium: the electric field is reduced by a constant factor. At nonzero concentration of carriers the screening is much stronger. The screened electric field decays by the law $1/r^3$, where r is the distance to the test charge. The electron-hole pairing is realized under the electron doping of one graphene layer and the hole doping of the other layer at equal concentrations of the electrons and holes. It is shown that the pairing suppresses the screening. At r much larger than some r_s the electric field of the test charge approaches to the unscreened value. The quantity r_s depends on the carrier density and on the order parameter for the electron-hole pairing Δ. The value Δ can be evaluated from the measured dependence of the electric field on r.

The effect of screening is also analyzed with reference to a two-layer system where the monolayer graphene is replaced with the bilayer graphene.

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