Gate Bias Dependence of Flicker Noise in Graphene as a Result of Carrier Statistics

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Flicker noise in graphene has been investigated by several authors and a variety of behaviors of its power spectral density have been observed as a function of the backgate bias. In particular, in bilayer graphene, but also in a few samples of monolayer graphene, a minimum of flicker noise has been observed at the Dirac point, and several explanations have been proposed. An interesting theory [1] exploited screening of a trapped carrier and the peculiar properties of the graphene bandstructure to explain the observed features of flicker noise. We have developed a different approach [2] that leads to analogous results starting from the mass-action law and from the observation that the prevalent components of flicker noise are slow compared to the generation-recombination times of carriers. Here we further develop such a model and apply it to a wider range of situations.

We rely on the preservation of the electric neutrality of the conductor and, as a result of the mass-action law, of the product of electron and hole concentrations. A direct consequence of these two constraints is that near the Dirac point a trapping event leads to screening by both types of carriers (electrons and holes) and to no net variation of the total available number of carriers. As a result of the symmetry between the transport properties of electrons and holes in graphene, the preservation of the total number of carries leads to the disappearance of generation-recombination noise (which is at the basis of flicker noise, that can be interpreted as a superposition of Lorentzian generation-recombination spectra) in this circumstance. On the other hand, far away from the Dirac point a trapping event leads to a variation of the number of carriers by one unit, as in ordinary doped semiconductors, thereby without any suppression of flicker noise. If we perform a numerical calculation of the flicker noise power spectral density as a function of the carrier concentration, we obtain a good match with the experimental data for bilayer graphene. The observed behavior for monolayer graphene, which does not usually exhibit a minimum at the Dirac point, can be retrieved taking into consideration a disorder model resulting from the presence of randomly located impurities.

[1] B. Pellegrini, Eur. Phys. J. B 86, 373 (2013).
[2] B. Pellegrini et al., J. Stat. Mech. 2016, 054017 (2016).

Fig. 4: Same as Fig. 3 but for AB-stacked vdW heterojunction.

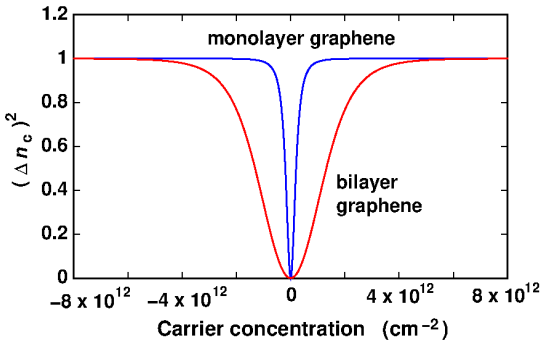

Fig.1: Behavior of the square of the carrier number fluctuation as a function of carrier concentration for monolayer and bilayer graphene.

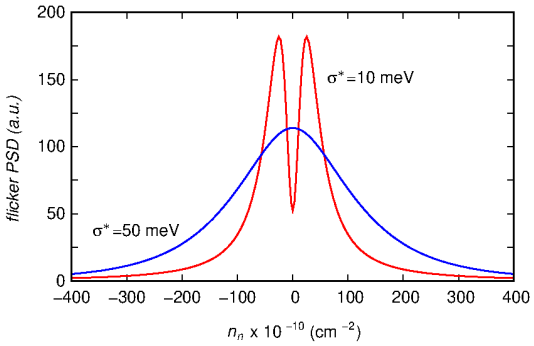

Fig.3: Power spectral density of flicker noise in the presence of disorder, for monolayer graphene.

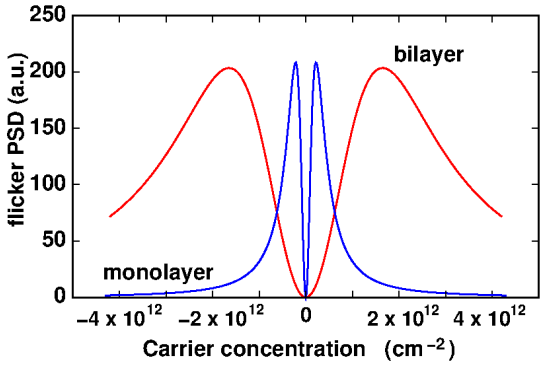

Fig.2: Power spectral density of flicker noise fluctuations as a function of the carrier concentration for monolayer and bilayer graphene.

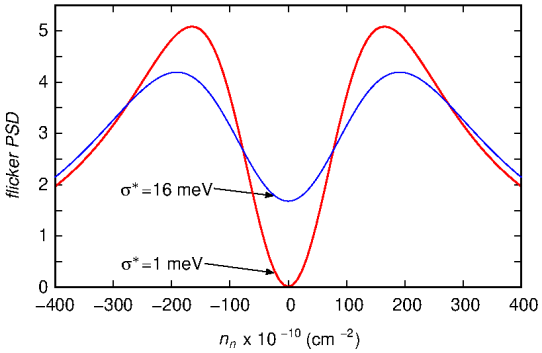

Fig.4: Power spectral density of flicker noise in the presence of disorder, for bilayer graphene.