Anomalous growth of the thermoelectric power in gapped graphene[1]

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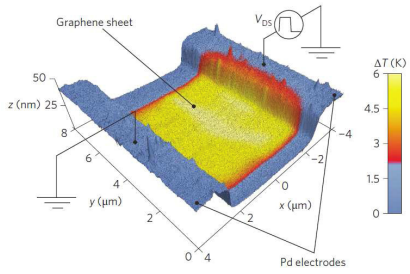
The experiments[2] indicate that thermo-electric effect in graphene accounts for up to one-third of the contact temperature changes (Fig. 1) and thus it can play significant role in cooling down of nano-devices based on graphene technology. At the same time other experiments indicate that at certain conditions, like an appropriate substrate, a gap Δ of the order of 10 meV can be opened at the Dirac points of a quasi-particle spectrum of graphene.

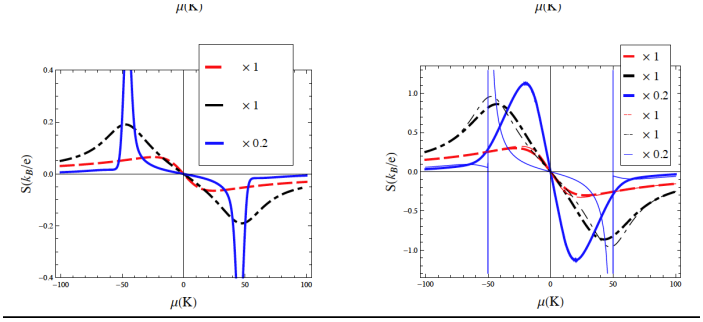


We analyze behavior of conductivity and thermopower in such system accounting for quasi-particle scattering from impurities with the model potential in self-consistent scheme. Reproducing the existing results for the case of gapless graphene we demonstrate a failure of the simple Mott formula in the case under consideration. We demonstrate that opening of such a gap in graphene spectrum can result in appearance of the fingerprint bump of the Seebeck signal $\mathcal{S}(\mu)$ when the chemical potential μ approaches the gap edge. A magnitude of the bump can be **up to one order higher** than already large value of the thermopower occurring in graphene. Such a giant effect, accompanied by the non-monotonous dependence on the chemical potential, is related to the emergence of a new channel of quasi-particle scattering from impurities with the relaxation time τ strongly dependent on the energy ε:

$$\tau^{-1}(\varepsilon) = \tau_0^{-1}\left(\frac{|\varepsilon+\mu|}{\mu} - \frac{\Delta^2}{|\mu||\mu+\varepsilon|}\right)\theta\left[(\varepsilon+\mu)^2-\Delta^2\right]$$

The specifics of thermopower consists of its sensitivity to derivative of the scattering rate. This is why presence of the step function in $\tau(\varepsilon)$ produces much stronger effect on $\mathcal{S}(\mu)$ behavior in the vicinity of gap $\mu \approx \Delta$ than a relatively slow energy dependence of relaxation time which could appear from the screened Coulomb potential.

The found dependency of Seebeck coefficient of gapped graphene on chemical potential is presented at the Fig. 2. The left pannel is for T=1 K while the right one is for T=5 K. The dashed (red) curves correspond to the gapless case with constant scattering



[1] S. G. Sharapov and A. A. Varlamov Phys. Rev. B 86, 035430 (2012)
[2] K. L. Grosse, M. H. Bae, F. Lian, E. Pop, and W. P. King, *Nature Nanotechnology* 6, 287 (2011).