Generalizing Nyquist Electronic Noise in the Hydrodynamic Regime

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Electronic noise thermometry is a well-established technique to access the temperature of electrons. This technique is rooted in the fluctuation-dissipation relation relating the current fluctuations to the electronic conductivity. The fluctuation-dissipation theorem assumes quasi-thermal equilibrium of electrons, a hypothesis which is not met under large bias in graphene where drift velocity u can reach a fraction of the Fermi velocity v_F. [1-3]

I will show that Nyquist formula can be extended to large drift velocity cases in the hydrodynamic electronic transport regime. This regime is naturally met in high-mobility graphene field-effect transistors under large bias because the electron gas self-heating leads to the dominance of electron-electron collisions over competing collision mechanisms. [4] In this regime, the Nyquist formula of noise is corrected by a multiplicative factor which depends on drift velocity and band structure. [5]

References

[1] I. Meric et al., Nat. Nanotechnol. **3** (2008) 654
[2] V.E. Dorgan et al., Appl. Phys. Lett. **97** (2010) 082112
[3] W. Yang et al., Nat. Nanotechnol. **13** (2018) 47
[4] A. Lucas et al., J. Phys.: Condens. Matter **30** (2018) 053001
[5] E. Baudin et al., in prep.

Figures

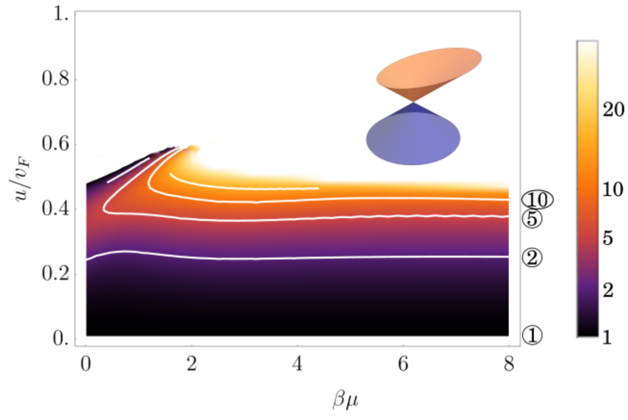

Figure 1: Drift correction factor α to the Nyquist noise formula for monolayer graphene function of the reduced chemical potential $\mu/k_B T$ and the reduced drift velocity u/v_F. At null drift velocity, $\alpha = 1$, and it increases with drift velocity ($\alpha = 2{,}5{,}10$ for consecutive white lines). Noise fluctuations diverge when the drift velocity approaches the electronic sound velocity.s