Generalizing Nyquist Electronic Noise in the Hydrodynamic Regime

Emmanuel Baudin
Christophe Voisin, Bernard Plaçais

Laboratoire de Physique de l’Ecole Normale Supérieure, 24 rue Lhomond, 75005 Paris

baudin@lpa.ens.fr

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


Figure 1: Drift correction factor $\alpha$ 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 ($\alpha = 2.5$ for consecutive white lines). Noise fluctuations diverge when the drift velocity approaches the electronic sound velocity.s