EVIDENCE OF UNIVERSAL NOISE FLUCTUATIONS IN GRAPHENE

D. Cox, T. Elo and P. Hakonen

Low Temperature Laboratory, Department of Applied Physics, Aalto University, PO BOX 15100, 00076 AALTO, Finland
email: teemu.elo@aalto.fi

The conductance of a mesoscopic sample has sample-to-sample variation known as universal conductance fluctuations (UCF) [1], observed as the change of measured conductance as a function of chemical potential or external magnetic field. These fluctuations seem to be random in nature, although the pattern is completely reproducible. The amplitude of these fluctuations is on the order of a conductance quantum, $G_0 = 2e^2/h$. Similarly, universal noise fluctuations (UNF) are seen in shot noise power of a biased diffusive sample [2], whose dimensions are smaller than the phase coherence length.

Our samples are mechanically exfoliated, natural monolayer graphene flakes with dimensions ranging from 0.5×1.5 to 6×1 μm^2 in different samples. The flake is contacted with Cr/Au electrodes, while doped silicon substrate forms a back-gate. A simplified schematic of the low-temperature parts of the measurement system is shown in Fig. 1 (a). The sample is mounted at 50 mK temperature in a dry dilution refrigerator. Our setup utilizes home-made HEMT amplifiers operating around 750 MHz with a noise temperature of 7 K [3] and digital capture of the down-converted signal at 180 MS/s with data processed on a GPU in real time. The first observation of UNF is presented in Fig. 1 (b), showing the magnitude of UNF from gate voltage sweep as a function of applied bias voltage. The fluctuations follow the theoretical predictions at intermediate bias where random noise or hot electron effects are not dominating.

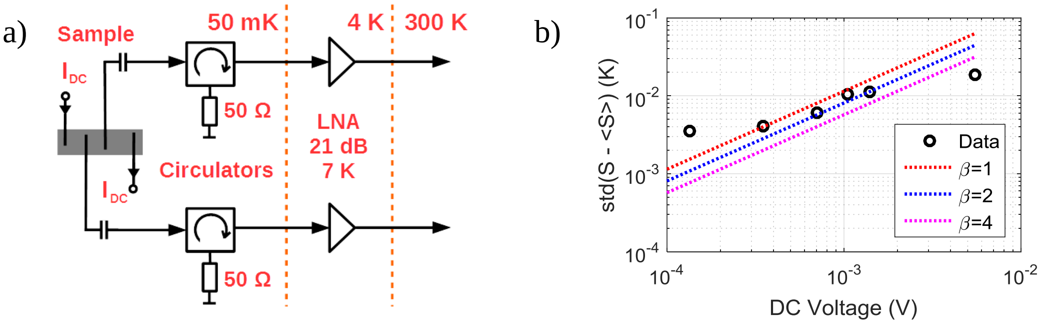

Figure 1: (a) Schematic of the low-temperature parts of the measurement system, showing the sample, DC leads and noise measurement lines. (b) Measured UNF from gate voltage sweep as a function of bias voltage and theoretical curves for different regimes.

[1] P.A. Lee and A.D. Stone, Phys. Rev. Lett. 55, 1622 (1985).
[2] M.J.M. de Jong and C.W.J. Beenakker, Phys. Rev. B 46, (1992).
[3] T. Nieminen, P. Lähteenmäki, Z. Tan, D. Cox, and P.J. Hakonen, Rev. Sci. Instrum. 87, (2016).