Presenting Author: Kazi Rafsanjani Amin(1)
Co-Authors: Samriddhi Sankar Ray (2), Nairita Pal (1), Rahul Pandit (1), Aveek Bid (1)

(1) Department of Physics, Indian Institute of Science, Bangalore, Karnataka, India 560012.
(2) International Centre for Theoretical Studies, Tata Institute of Fundamental Research, Bangalore, Karnataka, India 560089.

Contact E-mail: kazi@physics.iisc.ernet.in

Multifractal Conductance Fluctuations in Single-layer Graphene Field Effect Transistor Devices

Multifractality, characterized by an infinite number of scaling exponents, is ubiquitous in classical systems. Since the pioneering work of Mandelbrot [1, 2], the detection and analysis of multifractal scaling in such systems have enhanced our understanding of several complex phenomena such as turbulent flows. In quantum condensed-matter systems, signatures of multifractality are rare and have only been found in the scaling of eigenfunctions or in the structure of the wave functions at critical point [3]. We report the first observation of multifractality in the transport coefficients in a quantum condensed matter system. We show that, in high-mobility SLG-FETs, the universal conductance fluctuations (UCF), as a function of the magnetic field, are multifractal. Figure 1 shows illustrative magnetoconductance plots measured at a particular gate voltage, at different temperatures. The periodic but reproducible oscillations confirm UCF in the device. We obtain the multifractal singularity spectra of the magnetoconductance plots using standard Multifractal Detrended Fluctuation Analysis (MFDFA) [4] method. Figure 2 shows plots of multifractal exponents; (a) shows the generalized Hurst exponent $h(q)$, and (b) shows plot of multifractal singularity spectrum $f(\alpha)$ versus α, obtained from Legendre transformation of $h(q)$ versus q. The wide range of $h(q)$, or correspondingly, wide multifractal spectra (width $\delta\alpha$=1.05) quantifies multifractality of the UCF of graphene.

We have studied multifractality in UCF in a wide range of temperature and doping, and show that the multifractality decreases as the temperature increases or as the doping moves the system away from the Dirac point. Our measurements and analysis conclusively indicate an incipient Anderson-localization in graphene near the Dirac point and resolves the long-standing problem of the nature of electronic wave-functions near the Dirac point in single-layer graphene.

References

[1] Benoit B. Mandelberot. *The Fractal Geometry of Nature*. Freeman: San Francisco, 1982.
[2] G Parisi and Uriel Frisch. *Turbulance and Predictibility of Geophysical Fluid Dynamics*, North-Holland, Amsterdam, 1985.
[3] S. Faez, A. Strybulevych, J. H. Page, A. Lagendijk, and B. A. van Tiggelen, Phys. Rev. Lett. 103 (2009), 155703.
[4] J. W. Kantelhardt, *Mathematics of complexity and dynamical systems* (Springer, 2012) pp.463–487.

Figures

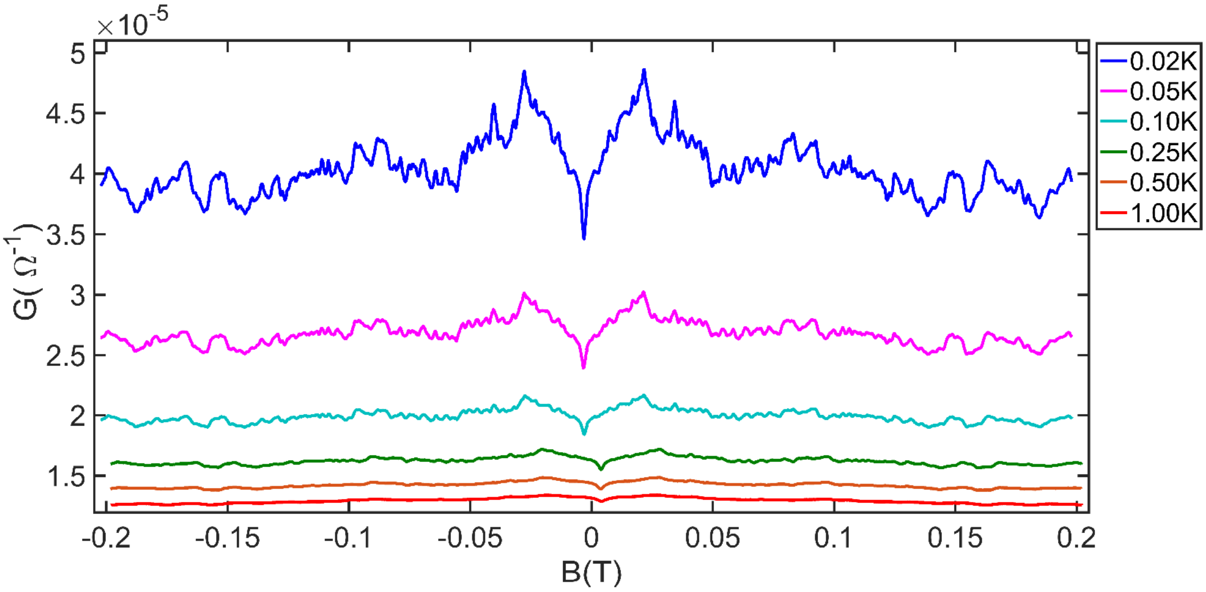

Figure 1: Illustrative plots of the magnetoconductance G versus the magnetic field B measured at different temperatures -the curves have been shifted vertically for clarity; the aperiodic but reproducible oscillations confirms UCF.

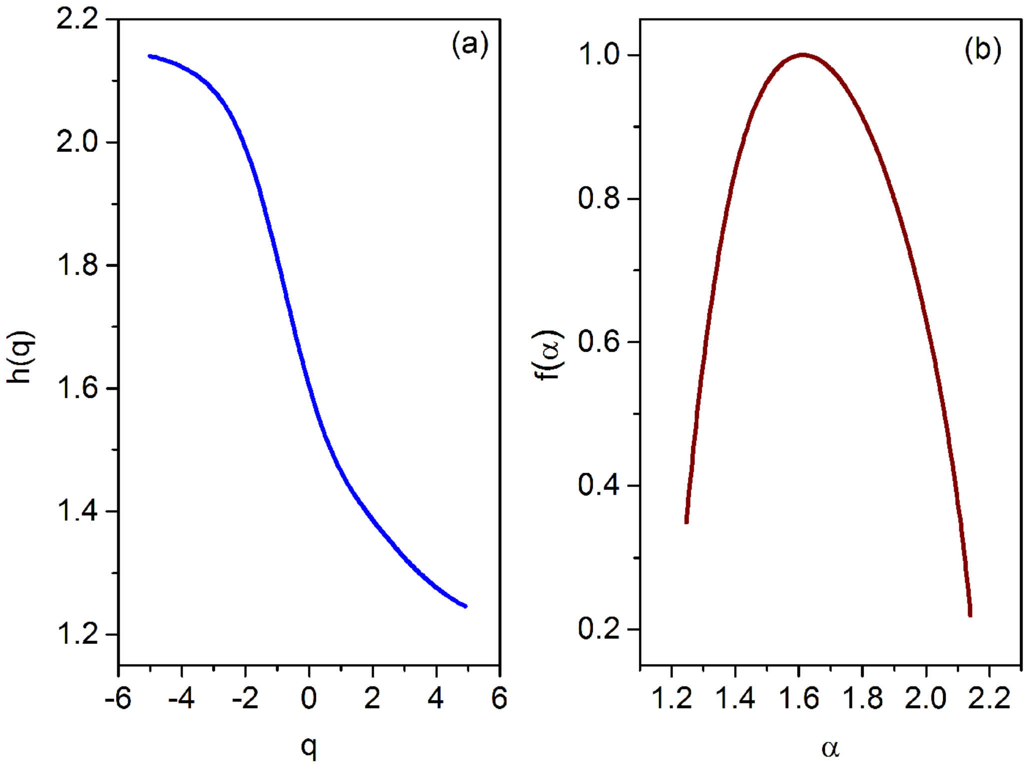

Figure 2: Plot of Multifractal spectrum. (a) Shows plot of generalized Hurst dimension *h(q)* versus (q). The corresponding multifractal singularity spectrum *f(*α*)* versus α is shown in (b).