Mechanical Control of Quantum Transport in Graphene and Single-wall Carbon Nanotubes

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Low dimensional materials are fundamentally electro-mechanical systems. Their environment unavoidably strains them and modifies their quantum transport properties. We report measurements of quantum transport in strained graphene transistors which agree quantitatively with models based on mechanically-induced gauge potentials [1]. The data are measured with a custom experimental platform able to precisely tune both the mechanics and electrostatics of suspended transistors at low-temperature over a broad range of strain. Mechanically generated vector potentials $|A_y|$ suppress the ballistic conductance G of graphene by up to 30% (Fig. 1) and control its quantum interferences. In addition, a scalar potential is mechanically induced in situ to modify graphene's work function by up to 25 meV. We also report an applied theory of quantum transport in strained single-wall carbon nanotube (SWCNT) transistors. In single conduction mode SWCNTs, mechanical strain can precisely control the quantum phase of charge carriers, this is shown in Fig. 2, where clear quantum transport interferences are visible. Lastly, we present our latest experimental data on three SWCNT transistors ($d \sim 1.5$ nm, and $L \sim 30$ nm). The data are in agreement with the theoretical model and show that conductance and quantum interferences are mechanically tunable.

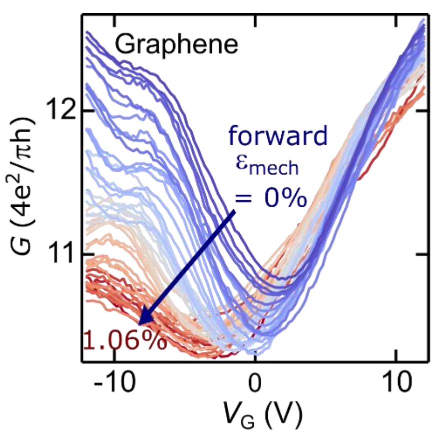

Fig. 1. Conductance G - V_G experimental data in a graphene transistor for the forward ε_{mech} sweep from 0% (dark blue trance) to 1.06% (dark red trace)

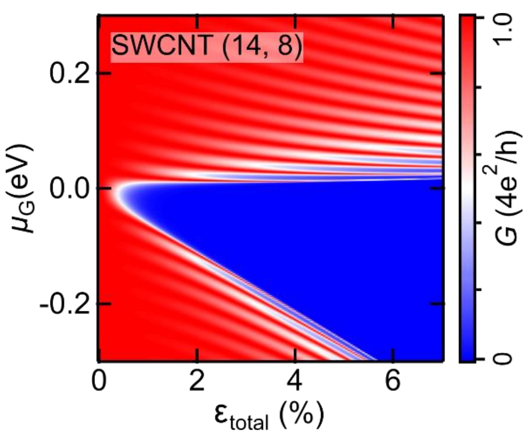

Fig. 2. Conductance G - ε_{total} - μ_G theoretical data in a quasi-metallic SWCNT transistor.

References

[1] A. C. McRae, et al., Advanced Materials, 2313629 (2024).