Abstract

Nanosystems are very sensitive to small mechanical deformations or vibrations, especially in the quantum regime. Can we measure the “mechanics” of quantum transport (charge and energy flow) by pulling materials with extreme precision? First, we will discuss some introductory concepts of quantum transport, how we can experimentally create nanometer-sized 2-dimensional (2D) or one-dimensional (1D) transistors, and how to explore their Hamiltonian (energy) with both mechanical and electromagnetic fields. We outline some theoretical predictions and measurements which motivated us to build a unique experimental platform for quantum transport “strain”-tronics.

In the second part, we present some of our recent research. We measured ballistic charge conductivity in strained suspended graphene and observed previously predicted [1] strain-induced scalar and vector potentials. The strain-induced scalar potential shifts (work function changes) ranged up to 25 meV. We mechanically controlled gauge vector potentials which significantly suppresses the quantum transmission of graphene’s charge carriers. We find quantitative agreement between calculations and experiments in our quantum strain transistors. We discuss ongoing experiments on quantum strain engineering in carbon nanotubes. We conclude with a project where we transferred suspended 2D materials above planar optical cavities [2] towards achieving tunable nano-opto-electro-mechanical (NOEMS) systems.

[1] A. C. McRae, G. Wei, and A. R. Champagne, Phys. Rev. Applied 11, 054019 (2019).

[2] I. G. Rebollo, F. C. Rodrigues-Machado, W. Wright, G. J. Melin, A. R. Champagne, 2D Mater. 8, 35028 (2021).