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(G*) Towards 2D materials as Quantum Nano-Electromechanical Systems

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Two dimensional (2D) materials are tempting for nano-electromechanical systems (NEMS), as they are atomically thin, have low mass and high flexibility. 2D materials have tunable optical and electronic properties, and can display other exotic properties, such as superconductivity. Over the last decade, scientists have begun stacking 2D materials into heterostructures that have desirable properties. One heterostructure is twisted bilayer graphene (TBG), which is comprised of two monolayers of graphene stacked at a rotated angle. If the angle of rotation is 1.1 degree, this material can display superconductivity at cryogenic temperatures.

The goal of this work is to model 2D drums, and to prepare sample fabrication techniques for NEMS devices. We developed analytic and numerical approximations for the motion of a 2D drum resonator. We use thin plate solutions due to a non-zero bending rigidity, and assumed low strain . We contrasted these solutions to linear and nonlinear membranes, where tension forces dominate. We consider nonlinearities inherent in the deflection driven by electrostatic forces and where strain dominates over rigidity. We also describe how finite element models can be constructed in Comsol, where the vanishing thinness makes conventional models impractical. These agree with the analytic plate approximations.

We use flake exfoliation, pick up and placement methods to fabricate heterostructures. We produce graphene flakes via mechanical exfoliation from low residue tape. We detail techniques for optimized cleanliness and monolayer production. The flake pick up is verified via optical and atomic force microscopy (AFM). Our eventual aim is to study a 2D material when it forms the top plate of a capacitor in an LC circuit –allowing a light mass resonator for quantum nanomechanics.

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