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Resonance frequency shifts due to quantized electronic states in atomically thin NEMS CHANGYAO CHEN, Argonne National Lab, VIKRAM DESHPANDE, Department of Physics and Astronomy, University of Utah, MIKITO KOSHINO, Department of Physics, Tohoku University, SUNWOO LEE, Department of Electrical Engineering, Columbia University, ALEXANDER GONDARENKO, Department of Mechanical Engineering, Columbia University, ALLAN MACDONALD, Department of Physics, University of Texas, Austin, PHILIP KIM, Department of Physics, Harvard University, JAMES HONE, Department of Mechanical Engineering, Columbia University — The classic picture of the force exerted on a parallel plate capacitor assumes infinite density of states (DOS), which implies identical electrochemical and electrostatic potential. However, such assumption can breakdown in low-dimensional devices where the DOS is finite or quantized. Here we consider the mechanical resonance shift of a nanoelectromechanical (NEMS) resonator with small DOS, actuated and detected capacitively at fixed electrochemical potential. We found three leading correction terms to the classical picture: the first term leads to the modulation of static force due to the variation in chemical potential, and the second and third terms are related to the static and dynamic changes in spring constants, caused by quantum capacitance. The theory agrees well with recent experimental findings from graphene resonator in quantum Hall regimes, where the chemical potential and quantum capacitance are tuned by magnetic field, while the gate voltage is kept constant.

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