Approaching the quantum limit of thermal motion on a graphene mechanical resonator

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Graphene is a perfect two dimensional crystal with high Young's modulus and extremely low mass (7.6×10^{-19} kg/μm^2), which makes it ideal for high frequency mechanical resonators. With a mechanical resonance frequency approaching 1 GHz, the crossover from thermal motion to zero-point vibrations becomes detectable at $\sim$ 50 mK. Comparing with other mechanical resonators like metallic beams, graphene provides a much higher vibration amplitude. As for carbon nanotubes, graphene offers a much bigger area, which makes capacitive determination of vibration amplitudes feasible down to the quantum limit. We have developed a new method to integrate graphene mechanical resonators with superconducting high-Q RF cavities. High quality exfoliated graphene is transferred with a micron sized PMMA stamp and assembled onto a premade Al superconducting circuit with 1 μm precision using a micromanipulator. A fully electric readout scheme was used where the graphene vibration is observed from the sideband of the RF carrier. Using realistic parameters for our graphene resonators and for the phase-modulated sideband detection scheme, we obtain a displacement sensitivity of $\sim 10^{-15} m/\sqrt{Hz}$ for one-micron-wide resonators. This sensitivity is sufficient for observing zero-point vibrations up to a frequency of 1GHz. So far our highest resonant frequency has been $f = 200$ MHz where we are bound to be limited to a few quanta, unless additional sideband cooling is employed.