Thermomechanical Squeezed Graphene Optomechanics for Weak Signal Amplification

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Graphene based nano-mechanical resonators[1] have emerged as excellent candidates for precision measurements. Here we show such 2D resonators can transduce small motion with giant gain and high sensitivity. Specifically, we use a large area, high quality factor (Q) Silicon Nitride (SiN) membrane as a target resonator. Suspended graphene resonators couple strongly to SiN with distinct signature of avoided-level crossing in the spectrum of mechanical resonances. When SiN is driven externally, we observe induced motion on graphene with an average gain in excess of 38 dB. Nevertheless, we find that the large thermal or Brownian motion of graphene resonators limit the measurement sensitivity. To improve further, we capacitively modulate the tension of graphene at twice its resonance frequency which leads to phase dependent parametric amplification along with thermo-mechanical suppression (squeezing) of the Brownian noise[2]. We achieve a maximum squeezing of 4.7dB, leading to enhancement in detection sensitivity by factor of ~2. Accordingly, we conclude that low mass, broad bandwidth, tension induced tunability and strong coupling to substrate resonator via electrostatic forces make graphene 2D resonators powerful motion transducers for SiN based opto- and electromechanical systems.

References

[1] Bunch,J.S, et. al. ,Science ,315, [2007]490-493.
[2] Rugar,D. and Grutter,P., Phys. Rev. Lett. 67, [1991]699-702.

Figures

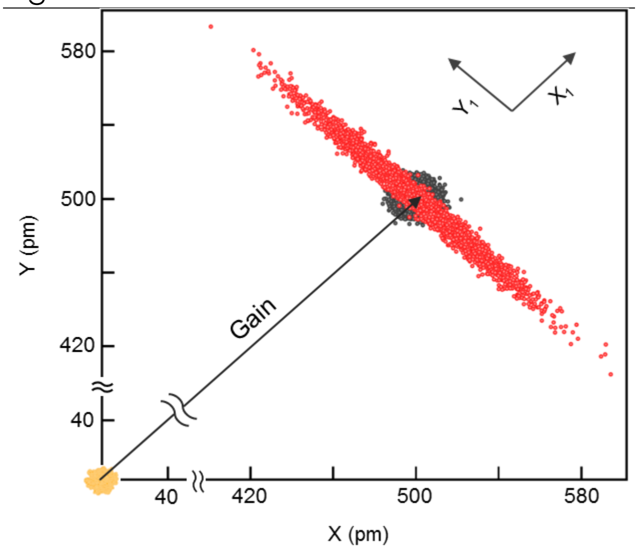

Figure 1: Quadrature plot of SiN mode (orange dots) which when coupled to graphene mode leads to amplification with the gain of 38dB (grey dots). To improve the detection sensitivity of graphene, it is parametrically pumped to squeeze the Brownian noise by 4.7dB (red dots).