Ground state cooling of a nanomechanical resonator by electron transport

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Nano-electro-mechanics pave the way to the formidable task of observing quantum effects in large mechanical systems formed by millions of atoms. To achieve such a goal, a crucial requirement is cooling the mechanical resonator to very low temperature. So far ground-state cooling has not been reported for NEMS using purely electron transport. I discuss two proposals to achieve the ground-state cooling for the mechanical vibration of a nanotube suspended between: (i) spin-polarised contacts [1,2] or (ii) a normal metal and a superconducting contact [3]. Assuming a suitable coupling between the vibrational modes and the charge or spin of the quantum dot formed on the nanotube itself, I show that ground-state cooling of the mechanical oscillator can be achieved for many of the oscillator's modes simultaneously as well as selectively for single modes. The range of parameters for ground-state cooling is within the reach of the state of the art for the suspended carbon nanotube devices. Finally, I will discuss how to detect the resonator's non-equilibrium state by analysing the current-voltage characteristic.

[1] P. Stadler, W. Belzig and G. Rastelli, Phys. Rev. Lett. 113 (2014), 047201.

[2] P. Stadler, W. Belzig and G. Rastelli, Phys. Rev. B 91 (2015), 085432.

[3] P. Stadler, W. Belzig and G. Rastelli, Phys. Rev. Lett. 117 (2016), 197202.