Cavity cooling a single charged levitated nanosphere

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The cooling of the centre-of-mass motion of a levitated macroscopic particle is seen as an important step towards the creation of long-lived macroscopic quantum states and the study of quantum mechanics and nonclassicality at large mass scales [1]. Levitation in vacuum minimizes coupling to the environment, while the lack of clamping leads to extremely high mechanical quality factors of the oscillating particle [2]. The ability to rapidly turn off the levitation coupled with cooling, offers the prospect of interferometry in the absence of any perturbations other than gravity [3]. However, like cold atoms trapped in vacuum, levitated nanoparticles are sensitive to parametric noise and internal heating via even a small absorption of the levitating light field [4]. To date this has limited the lower pressure at which particles can be stably trapped and cavity cooled. We overcome this problem by levitating a naturally charged silica nanosphere in a hybrid electro-optical trap by combining a Paul trap with an optical dipole trap formed from a single mode optical cavity (figure 1). We show that the hybrid nature of the trap introduces an unexpected synergy where the Paul trap plays an important role in the cavity cooling dynamics by introducing a cyclic displacement of the equilibrium point of the mechanical oscillations in the optical field [5]. This eliminates the need for a second, dedicated cooling optical mode of the cavity [6] and importantly allows us to cool the trapped particle in vacuum to mK temperatures.

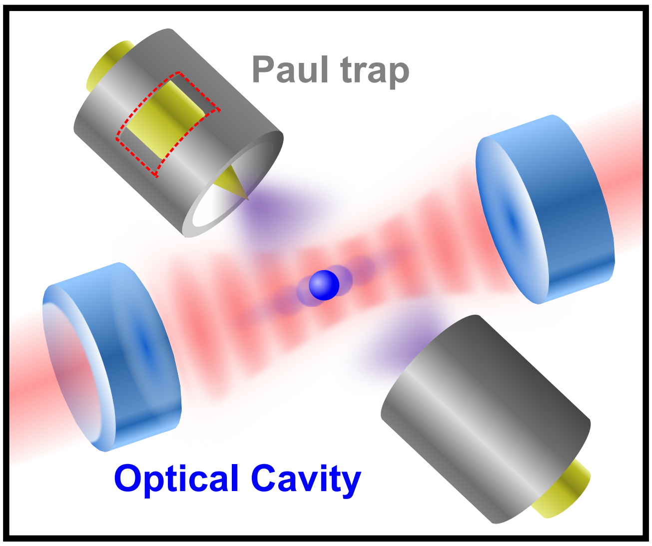

Figure 1: *A schematic diagram of the hybrid trap consisting of a Paul trap and standing wave optical cavity potential.*

References

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