Hybrid ion-nanoparticle system

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Coupling a mechanical oscillator to a qubit provides a means to control the oscillator's motion at the quantum level. Our goal is to couple a levitated nanoparticle oscillator to an atomic ion qubit. Levitated oscillators are highly isolated from the environment and fundamentally unrestricted in the spatial extension of the wave function, allowing tests of quantum mechanics in new mass and size regimes [1]. Trapped ions are long-lived levitated qubits with exquisite state control capabilities [2], which makes them suitable for use in combination with levitated oscillators.

I will present our steps towards realizing such a system. First, we trapped a nanoparticle in a Paul trap in ultra-high vacuum and achieved a quality factor above 10^{10} — the highest quality factor for a nanomechanical oscillator at room temperature [3]. Second, we adapted methods originally developed to detect and control the motion of atomic ions, including self-homodyne detection [4] and sympathetic cooling [5]. Finally, we co-trapped the nanoparticles and an atomic ion using a dual-frequency drive of the Paul trap [6].

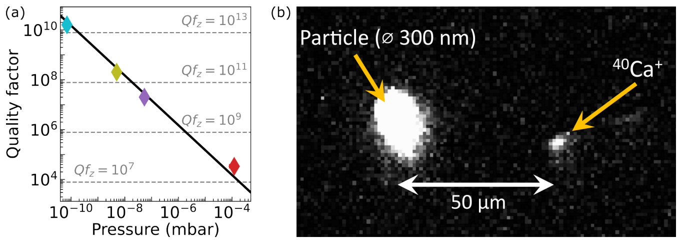

Fig. 1: Hybrid system consisting of a high-Q levitated oscillator and an atomic ion (a) Quality factor of the levitated nanomechanical oscillator for different pressures. (b) Image of a nanoparticle co-levitated with a single Ca ion. Both the particle and the ion are illuminated with a 397 nm laser light. The particle scatters the light elastically, while the light coming from the ion is a fluorescent light produced in the Doppler cooling cycle.

References

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