Cavity Optomechanics with Levitated Nanospheres

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The field of cavity optomechanics features an impressively large variety of devices, all offering different sets of properties and potential applications. With the goal to operate these devices in the quantum regime, they all share the requirement to minimize coupling to the environment. While clamped mechanical devices face limitations in this respect, levitating mechanical resonators may allow orders of magnitude improvement in mechanical quality. In fact, mechanical quality factors of $Q \approx 10^7$ and higher have been demonstrated [1, 2]. Combining levitated harmonic oscillators with optical cavities will enable the full level of (quantum) control offered by cavity optomechanics. This will add a new member to the family of optomechanical devices with new features, like (in principle) full control over the spring constant up to the point where the nanoparticle wavefunction can evolve freely.

I will shortly review the principles underlying levitating optomechanics and proceed to present our recent experiments on optomechanical cooling of a levitating nanoparticle in a high-finesse Fabry-Perot cavity [3]. I will discuss current limitations and strategies to overcome them in order to access the ultra-high Q regime, followed by a brief outlook into the future of this novel system.

[1] Ashkin, A., & Dziedzic, J. M., Optical levitation in high vacuum. *APL*, **28**, 333 (1976).

[2] Gieseler, J et al., Subkelvin Parametric Feedback Cooling of a Laser-Trapped Nanoparticle. PRL, **109**, 103603 (2012).

[3] Kiesel, N et al., Cavity cooling of an optically levitated nanoparticle**,** arXiv:1304.6679