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Probing the acoustic modes of a levitated nanoparticle

Understanding and controlling light-matter interactions is a cornerstone of physics and an essential resource for quantum technologies, communication and metrology. Levitated nano-objects offer a new paradigm to study the interaction between electromagnetic fields and matter at the very interface between quantum optics and macroscopic electrodynamics [1]. What is intriguing about levitated objects in high vacuum is that they can interact with the outside world only via their coupling to the electromagnetic field, this both grants an exceptional isolation from the environment while optical fields can be used to precisely interrogate and manipulate the system. So far, research on levitated nano-objects has mainly focused on controlling the center-of-mass motion and rotational degrees of freedom [2-4]. However, nanoparticles also possess highly discretised vibrational modes in the GHz band [5]: such internal degrees of freedom, remain scarcely explored.

Here, we describe the coupling mechanism of the nanoparticle acoustic vibrations to the electromagnetic field and implement a two-tone optical spectroscopy technique, namely stimulated Brillouin scattering, to probe these modes. We characterize the capabilities of our experimental setup and discuss some preliminary results. If successful these experiments will enrich the levitodynamics toolbox and allow to study fundamental excitations in solids in the extreme scenario of unclamped matter at the nanoscale, in high vacuum and out of equilibrium.

[1] C. Gonzalez-Ballestero et al. Science 374, 6564 (2021).
[2] L. Magrini et al. Nature 595, 373-377 (2021)
[3] F. Tebbenjohanns et al. Nature 595, 378–382 (2021).
[4] F. van der Laan et al. PRL 127, 123605 (2021).
[5] M.H. Kuok et al. PRL 90, 255502 (2003)

Abstract category

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