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Cavity cooling by coherent scattering of a levitated nanosphere in vacuum

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Abstract:

Optically levitated nanoparticles in ultra-high vacuum promise access to quantum behavior of massive objects at room temperature. Coupling the nanoparticle center-of-mass motion to an optical cavity provides a route to control its motion at the quantum level and gives rise to a new type of light-matter interface.

Here we demonstrate a new method of cavity cooling a silica nanosphere based on coherent scattering. An optical tweezer allows for precise positioning of the nanosphere inside an empty optical cavity. In contrast to standard optomechanics, cooling of its motion is performed by cavity-enhanced coherent scattering of the red-detuned optical tweezer. We demonstrate genuine three-dimensional cavity cooling, which also allows for stable levitation in high vacuum. Our observed cooling performance and absence of laser phase noise heating indicates that this new method enables ground state cooling of levitated nanoparticles in our current experiment.