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Towards On-Demand Loading of Nanoparticles in Ultra-High Vacuum for Quantum Levitodynamics

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Levitated optomechanics offers a promising pathway to explore the boundary between quantum and classical physics, as well as for quantum-enhanced sensing with mesoscopic objects. In particular, levitated silica nanoparticles cooled to their quantum ground state could enable fundamental tests of quantum mechanics. Achieving this goal requires efficient particle loading into ultra-high vacuum (UHV) hybrid traps that combine optical and electrodynamic confinement, allowing for optimal quantum control.

We present progress towards implementing laser-induced acoustic desorption (LIAD) as a robust and clean method for loading on-chip hybrid traps with silica nanoparticles at UHV conditions. LIAD involves ejecting particles from the surface of a thin metal foil, initiated via a high-intensity laser pulse. Thin targets were fabricated and characterised using scanning electron microscopy, while tests were conducted in atmosphere to extract loading statistics. LIAD particle emission was monitored with high-speed imaging and analysed to determine the feasibility for UHV integration.

Integrating LIAD with on-chip hybrid traps in ultra-high vacuum allows experiments to reach pressures where decoherence from background gas collisions no longer constrains the observation of quantum effects. This advancement supports both high-precision sensing and rigorous experimental tests of quantum mechanics in the mesoscopic regime.

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