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# Quantum control of a levitated nanoparticle's motion to explore novel physics at large scales

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A nanosphere levitated in electromagnetic fields is a promising testbed for physics at the interface between the classical and the quantum realm. Recently, levitated particles have attracted attention as potential gravity *quantum* sources due to their large mass, ranging from $10^9$ to $10^{12}$ amu. A prerequisite to test the quantization of the gravitation field is, however, to prepare the nanoparticle into a Schroedinger's cat, that is to place it in a superposition state of two different locations. To prepare this state, it is important first to reach a full quantum control on the levitated particle's motion.

When trapped in an optical tweezer, we manage to continuously measure its center of mass motion in a quantum-limited fashion. Building from this measurement, we exert feedback cooling to cool the nanoparticle motion along one direction close to the ground state of the trapping potential. The obtained state is closely described by a Gaussian wavefunction with a spatial extension of only 10 pm. To go beyond Gaussian states, one can exploit for instance the non-linear dynamics generated by the optical potential. Such a nonlinearity, however, becomes relevant at a length-scale dictated by the optical wavelength (˜1 µm), five orders of magnitude larger than the initial wavefunction. To bridge this gap, we plan to expand the initial state by parametrically modulating the trapping stiffness. A combination of hybrid electro-optical trapping scheme, our optical measurement capability and a cryogenic environment should be capable of increasing the coherence time enough to expand the mechanical wavefunction by several orders of magnitude. I will show you our recent progresses towards this goal.

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