Colloquium

Levitated nanoparticles: a route to the quantum regime

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Can we prepare quantum-mechanical states of motion of macroscopic objects — for example, superposition states of massive objects where the distance scale of the superposition is as large as the object itself? Such states would allow us both to investigate fundamental questions about quantum mechanics and to build novel sensors and transducers. A levitated nanoparticle in ultra-high vacuum is a promising experimental system with which to investigate these questions.I will present experimental work with silica nanoparticles in ion traps in which we aim to bring these particles into the quantum regime. Here, we adapt techniques originally developed for trapped atomic ions, including detection via self-interference and sympathetic cooling, for the domain of nanoparticles [1,2]. Quality factors above 1010 provide evidence of the particles' extreme isolation from their environment [3]. Recently, we have trapped a calcium ion and a nanoparticle together in a linear Paul trap [4], which provides a potential route to prepare the nanoparticle's motion in nonclassical states.In these experiments, light is both an enabling tool and a source of decoherence. On one hand, optical interference allows us to detect a nanoparticle's position precisely. On the other hand, photon recoil and heating of the particle's internal temperature present challenges to reaching the quantum regime.[1] L. Dania, K. Heidegger, D. S. Bykov, G. Cerchiari, G. Arenada, T. E. Northup, Phys. Rev. Lett. 129, 013601 (2022)[2] D. S. Bykov, L. Dania, F. Goschin, T. E. Northup, Optica 10, 438 (2023)[3] L. Dania, D. S. Bykov, F. Goschin, M. Teller, A. Kassid, T. E. Northup, Phys. Rev. Lett. 132, 133602 (2024)[4] D. S. Bykov, L. Dania, F. Goschin, T. E. Northup, arXiv:2403.02034 (2024)

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Moonstone Building / Ground Floor / Seminar Room G

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