

Trieste Quantum Seminar Series

Tuesday October 21st 2025, at 16:00

Aula A, Edificio F (Dip. di Fisica)

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Optimal control of mechanical systems in the quantum regime

Abstract: Continuous-variable quantum systems enable encoding complex states in fewer modes through large-scale non-Gaussian states. Motion, as a continuous degree of freedom, underlies phenomena from Cooper pair dynamics to levitated macroscopic objects. Hence, realizing high-energy, spatially extended motional states remains key for advancing quantum sensing, simulation, and foundational tests.

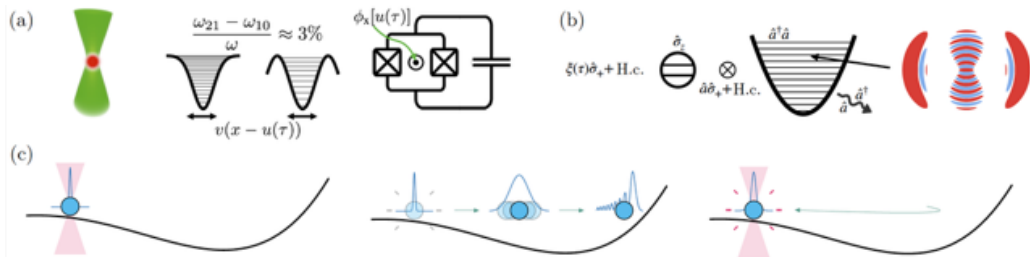
In the talk, I will present the following control tasks for various nonlinear mechanical systems, including trapped atoms, levitated particles, and clamped oscillators with spin-motion coupling.

(i) **Nonharmonic potential modulation:** Optimal control of a particle in a nonharmonic potential enables generation of non-Gaussian states and arbitrary unitaries within a chosen two-level subspace [1, Fig. (a)].

(ii) **Macroscopic quantum states of levitated particles:** Rapid preparation of a particle's center of mass in a macroscopic superposition is achieved by releasing it from a harmonic trap into a static double-well potential after ground-state cooling [2, (c)].

(iii) **Phase-insensitive force sensing:** For randomized phase-space displacements, quantum optimal control identifies number-squeezed cat states as optimal for force sensitivity under lossy dynamics [3, (b)].

These approaches exploit either intrinsic nonharmonicity or coherent nonlinear coupling, providing a unified framework for motion control in continuous-variable quantum systems—from levitated nanoparticles to optical and microwave resonators—paving the way toward universal quantum control of mechanical motion.



[1] Quantum 9, 1824 (2025); [2] Phys. Rev. Lett. 132, 023601 (2024); [3] arXiv: 2505.20832 (2025)

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