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Quantum optomechanics: exploring the interface between quantum physics and gravity

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Massive mechanical objects are now becoming available as new systems for quantum science. Quantum optics provides a powerful toolbox to generate, manipulate and detect quantum states of motion of such mechanical systems – from nanomechanical waveguides of some picogram to macroscopic, kilogram-weight mirrors of gravitational wave detectors. Recent experiments, including laser-cooling of massive mechanical devices into their quantum ground state of motion, and demonstrations of the strong coupling regime provide the primary building blocks for full quantum optical control of mechanics, i.e. quantum optomechanics. This has fascinating perspectives for both applications and for quantum foundations: For example, the on-chip integrability of nano- and micromechanics, together with their flexibility to couple to different physical systems, offers a novel perspective for solid-state quantum information processing architectures. At the same time, the mass and size of mechanical resonators provides access to a hitherto untested parameter regime of macroscopic quantum physics via the generation of superposition states of massive systems and of optomechanical quantum entanglement, which is at the heart of Schrödinger's cat paradox. Finally, and somewhat surprisingly, due to the large available masses it becomes even possible to explore the fascinating interface between quantum physics and (quantum) gravity in table-top quantum optics experiments. I will discuss a few examples.