New frontiers in quantum optomechanics: From levitation to gravitation

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Quantum optics provides a high-precision toolbox to enter and to control the quantum regime of the motion of massive mechanical objects [1]. Levitation of solid-state objects is a unique approach to realise (nano- or micro-) mechanical devices with minimal mechanical losses [2]. Besides improved sensing capabilities such systems have the potential for significantly increased coherence time when operated in the quantum regime. This opens the door to a hitherto untested parameter regime of macroscopic quantum physics [3,4]. The availability of quantum superposition states involving increasingly massive objects could enable a completely new class of experiments, in which the source mass character of the quantum system starts to play a role. This addresses directly one of the outstanding questions at the interface between quantum physics and gravity, namely “how does a quantum system gravitate?”. This is reminiscent of Feynman’s proposal at the 1957 Chapel Hill Conference on the generation of entanglement through gravitational interaction [5]. I will discuss the feasibility of such experiments and the relevance of quantum controlling levitated mechanical systems [6-8].

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