Quantum optomechanics

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Quantum mechanics has been formulated over hundred years ago and many experiments have supported this extraordinary theory. It remains however unclear how quantum mechanics can be combined with general relativity in a 4 dimensional space-time structure. Furthermore the emergence of the classical world from the underlying quantum mechanics, often discussed in connection with the collapse of the quantum wavefuntion, leaves open questions. Prof. R. Penrose has been one of the leading theorists in the past 50 years who addressed these fundamental issues. I will discuss some of his ideas leading to far reaching predictions that could be tested in future experiments. In particular I will discuss quantum optomechanical experiments that are designed to test the notion of quantum superpositions for macroscopic objects [1,2]. The ultimate goal is to bring a tiny optical mirror into a quantum superposition and to investigate it's decoherence.

The proposed experiments are technically very challanging and will require optomechanical systems at low mechanical resonator frequencies ($\sim$10-100 kHz) to be cooled to the quantum-mechanical ground state. The various cooling techniques, including optical cooling, will be discussed [3]. Furthermore the experimental challanges associated to the use of mirrors, as small as 10 micrometer in diameter, attached to mechanical resonators will be addressed [4].

[1] W. Marshall, C. Simon, R. Penrose, and D. Bouwmeester, Phys. Rev. Lett. 91, 130401 (2003).

[2] B. Pepper, R. Ghobadi,E. Jeffrey, C. Simon, D. Bouwmeester, Phys. Rev. Lett. 109, 023601 (2012).

[3] D. Kleckner and D. Bouwmeester, Nature, 444, 75 (2006).

[4] D. Kleckner, W. T. W. Irvine, S. S. R. Oemrawsingh, and D. Bouwmeester, Phys. Rev. A. 81, 043814 (2010).