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Generation and Detection of Quantum Entanglement in Optomechanical Systems

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ABSTRACT:

Quantum entanglement between a mechanical system and laser light may be used to prepare massive mechanical systems in quantum states, thereby opening the door to quantum experiments on new mass scales. I discuss the conditions under which optomechanical entanglement arises and present an experimental protocol that allows to detect this entanglement. The proposed protocol works for a continuously driven optomechanical cavity and even in the presence of multiple mechanical modes. Because the resulting optomechanical entanglement is continuously available, it could enable time-continuous quantum control of massive mechanical systems.

I also present the first implementation of optimal state estimation in cavity optomechanics, allowing us to extract the maximum amount of information about the mechanical system. Our estimation method, Kalman filtering, can be applied in real-time and therefore enables optimal feedback control of mechanical systems. Kalman filtering is widely used in science and engineering. We show that it can also be applied in optomechanics, even to imperfect experiments plagued by colored laser noise, multiple mechanical modes or inefficient detection.