OPTOMECHANICAL MICRO-MACRO ENTANGLEMENT

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Vigorous efforts are currently being undertaken to bring quantum effects such as superposition and entanglement to the macroscopic level. One prominent goal in this context is the creation of entanglement between a microscopic system and a macroscopic system, following Schrödinger's famous thought experiment that involved a decaying nucleus and a cat. A natural setting for testing these predictions would be quantum optomechanics, where we study the interaction of light with mechanical devices at the quantum level. In our work (R. Ghobadi, S. Kumar, B. Pepper, D. Bouwmeester, A.I. Lvovsky, and C. Simon, "Optomechanical Micro-Macro Entanglement", Phys. Rev. Lett. 112, 080503 (2014)), we propose to create and detect optomechanical entanglement by storing one component of an entangled state of light in a mechanical resonator, and then retrieving it. Successful demonstration of entanglement for the retrieved light then demonstrates the existence of optomechanical entanglement in the intermediate state. We propose to first create purely optical micro-macro entanglement by amplification (displacement in the phase space) of one mode of an initial microscopic entangled state, as was recently demonstrated. For optomechanical micro-macro entanglement, we convert the photons in the amplified mode into phonons. The phonons are then reconverted into photons. Next, we de-amplify (again by displacement in the phase space) these photons and verify entanglement using homodyne detection. We show that this method also makes it possible to create an optomechanical cat state, which is a superposition of macroscopic states. Based on an analysis of the relevant experimental imperfections, the scheme appears feasible with current technology.

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