Entangling mechanical resonators

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Hybrid quantum systems have been developed with various mechanical, optical and microwave harmonic oscillators. The coupling produces a rich library of interactions including two mode squeezing, swapping interactions, back-action evasion and thermal control. In a multimode mechanical system, coupling resonators of different scales (both in frequency and mass) leverages the advantages of each resonance. For example: a high frequency, easily manipulated resonator could be entangled with a low frequency massive object for tests of gravitational decoherence. We demonstrate coherent optomechanical state swapping between two spatially and frequency separated resonators with a mass ratio of 4. We find that, by using two laser beams far detuned from an optical cavity resonance, efficient state transfer is possible through a process very similar to STIRAP (Stimulated Raman Adiabatic Passage) in atomic physics. Although the demonstration is classical, the same technique can be used to generate entanglement between oscillators in the quantum regime.