Squeezing of quantum noise of motion in a micromechanical resonator

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According to quantum mechanics, particles cannot simulateneously have both the position and momentum well defined. These quantities have fundamental fluctuations which are bound by the Heisenberg uncertainty relation setting a lower limit for their product. The same holds for any pair of conjugate observables, such as quadrature amplitudes of motion of an oscillating body. However, long time ago in optics it has been demonstrated the possibility to create squeezed quantum states of light, where fluctuations of an observable can be reduced below the Heisenberg limit, at the cost of increased fluctuations of the conjugate. Here we prepare a nearly macroscopic moving body, realized as a micromechanical resonator, in a squeezed quantum state which approximates a squeezed vacuum. In a microwave cavity optomechanical experiment, we utilize the novel idea of dissipative squeezing [1], where a transformed system is allowed to cool towards a squeezed low-energy state. This method is suitable for creation of unconditional squeezing in the steady-state. This contrasts to many other plausible methods of squeezing generation, such as those relying on parametric modulation. We obtain squeezing of one quadrature amplitude about 1.1 dB below the quantum limit. This work achieves a longstanding goal of preparing macroscopic objects in such states, having implications for sensitive measurements e.g. in gravitational astronomy.

[1] A. Kronwald, F. Marquardt and A. A. Clerk, Arbitrarily large steady-state bosonic squeezing via dissipation. Phys. Rev. A **88**, 063833 (2013).

[2] J.-M. Pirkkalainen, E. Damskägg, M. Brandt, F. Massel ja M. A. Sillanpää, Squeezing of quantum noise of motion in a micromechanical resonator. Phys. Rev. Lett. **115**, 243601 (2015)