CMP Seminar

Ho Bun Chan

University of Science and Technology – Hong Kong

Correlated anomalous phase diffusion and negative nonlinear friction in coupled electromechanical resonators

The dynamical backaction from periodically driven optical, microwave or phonon cavities can alter the damping of mechanical resonators. When the overall damping is reduced below zero, parametric instability develops and self-sustained oscillations are excited. We investigate new aspects of self-sustained oscillations using a micromechanical resonator designed to have two vibrational modes with strongly differing frequencies and decay rates. The high-frequency mode acts as a phonon cavity, playing a similar role as photon modes in optomechanical systems. Strong pumping is applied at the blue-detuned sideband of the phonon cavity. We find that self-sustained oscillations are induced not only in the mechanical mode as measured in previous experiments, but also in the high frequency cavity mode. In the presence of weak noise, the phase of each mode diffuses. Interestingly, the phase fluctuations of the two modes are nearly perfectly anti-correlated. At the same time, in each mode the phase undergoes anomalous diffusion, where the mean square phase change in time follows a superlinear rather than the standard linear power law. The exponent of this power law is determined by the 1/f-type intrinsic frequency noise of the resonator. In another experiment, the sideband pumping frequency is moved from the primary to the secondary blue-detuned sideband. The pumping opens a relaxation channel where two quanta of the lower mode and one quantum of upper mode are simultaneously excited. The resulting negative nonlinear friction of the lower mode can be controlled and made strong enough to overcome the intrinsic positive linear friction. We find that the modes can then settle into a state of stable self-sustained vibrations. However, these vibrations need to be activated, i.e., require a sufficiently strong initial excitation. Our findings show that self-sustained oscillations induced by dynamical backaction offer new opportunities of phase manipulation and investigation of fundamental properties of resonating cavities.

Monday, January 13th, 2020 at 4:10 p.m.
Room: 1400 BPS Bldg.
Host: Mark Dykman