Sideband effects and frequency comb in nonlinear mechanical membrane resonators

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Recently, "quasi modes" induced by the nonlinearity of resonators in Duffing model have attracted broad interest in mechanical and hybrid systems due to their potential on the characterization of noise squeezing [1], sideband cooling [2], etc. Here, we demonstrate an antiresonance effect between the quasi modes in the sideband spectra throuhg low-frequency two-tone probing measurements based on a suspended silicon nitride (Si-N) membrane (~ 500 nm thickness). We also establish a direct connection between the antiresonance frequency and the noise squeezing factor in the system, and develop a novel method of squeezing factor characterization [3].

In addition, we extend the study on the quasi modes into the flexural-mode-coupling regime [4]. A novel tunable frequency comb is observed around the frequency of the quasi modes under one-tone excitation. The frequency spacing between neighboring sidebands of the frequency comb strongly depends on the damping factor, nonlinearity, vibration amplitude and the detuning frequency of the two coupled flexural modes and therefore is tunable. By injecting external noise and varying the drive frequency, we monitor the generation of frequency comb. We show that more than one pair of quasi modes exist under flexural-model-coupling regime. The observed frequency comb is generated when the quasi modes produced by the nonlinearity of the coupled flexural modes are crossing each other. A model accounting for this observation is also discussed.

References:

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