Nonlinear dynamics and fluctuations in micronscale membrane resonators

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Micronscale membrane resonators are ideal model systems to investigate nonlinear dynamics, since information detected in the time domain as well as spatial information can be directly obtained optically [1,2] or using an inductive method [3]. From these measurements we have access to the dispersion relations of bending waves [1] and to the spatially resolved material properties (Young's modulus, stress) of the membrane under study [4].
Prestressed siliconnitride membane resonators operated in the nonlinear regime, far beyond the Duffng regime, exhibit unusual dynamic behavior, including localized overtones of spatial modulation [5], parametric flexural mode coupling and persistent response [6]. We discuss the experimental observations and possible mechanisms for the strong nonlinearity of these resonators underlying the observations. In this talk we will also report about a novel method based on low-frequency modulation in the Duffing regime to characterize the noise squeezing arising from the nonlinearity. We demonstrate an antiresonance effect between the "quasi modes" of the nonlinear mechanical system in the sideband spectra and show that the antiresonance frequency is directly connected to the noise squeezing factor of the system, establishing hence a simple and robust method for its determination [3].

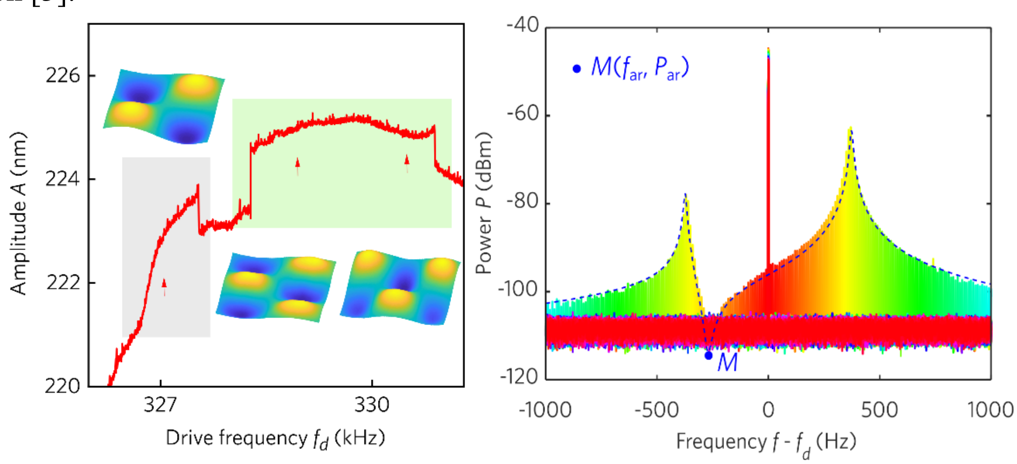

Fig. 1: *Left: Averaged amplitude of a rectangular membrane (thickness ~ 340 nm) obtained from imaging optical profilometry in the persistent response regime, where several flexural modes are superimposed to the ground mode (here: linear eigenfrequency f_0 = 322 kHz). The insets show examples of mode patterns captured at the frequencies indicated by arrows (adapted from [6]). Right: Power spectrum of sidebands when using very-low frequency modulation as a function of the detuning, showing an antiresonance at detuning M and which is related to noise squeezing. From [3].*

References:

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