Visualization of spatial modulation and persistent response states of strongly-driven membrane resonators

Micro- and nano-scale mechanical resonators operated in the strongly nonlinear regime exhibit unusual dynamic behavior, including the phenomenon of persistent response, which denotes the development of a vibrating state with nearly constant and high amplitude over a wide frequency range. The origin of this persistent response state can be revealed for membrane resonators by optical profilometry. By applying a combination of temporally and spatially resolved methods we show that the rectangular membrane adopts a peculiar ring-shaped pattern I which different parts of the membrane oscillate at different frequencies, a phenomenon that we denote as spatial modulation [1]. At even larger driving strength, the persistent response arises as a signature of mode coupling between different flexural modes and their localized overtones.

Finally, we propose a phase diagram for the manifold vibrational states that the membrane can adopt and a model based on the coupling of nonlinear oscillators that qualitatively describes the experimental observations.