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Noise-activated switching and signal amplification in nonlinear resonators, from nanomechanical beams to superconducting striplines

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A driven nonlinear system operating close to bifurcation, namely, close to transition between different stability zones, is extremely sensitive to external perturbations. This behavior can be exploited for amplifying small signals, and also for noise reduction (squeezing). We experimentally demonstrate these effects using two classes of systems, namely, nanomechanical resonators in the form of doubly clamped beams, and electromagnetic resonators made of superconducting striplines. While a bifurcation between monostable and bistable zones is employed for the first class of resonators, a bifurcation between monostable and astable zones is employed for the second one. In both cases we observe extremely high gain and very strong noise squeezing as we approach bifurcation. While the Duffing-like nonlinearity of the mechanical beams is well understood, the piecewise-linear behavior exhibited by the superconducting stripline resonators is yet not fully accountable. We provide theoretical evidence to support our hypothesis that the underlying mechanism responsible for the observed piecewise-linear behavior is thermal instability in a narrow stripline section (a microbridge), which is integrated into the resonator. A simple theoretical model predicts a rich variety of dynamical effects, including self-sustained oscillations, stochastic resonance, and intermittency between different steadystate and limit-cycle solutions. These effects are experimentally observed by tuning the system close to the zone of astability, where no steadystate response exists. A comparison with theory yields partial agreement. Moreover, in more recent experiments we study a new configuration in which the microbridge is replaced by a superconducting interference device (SQUID) in the form of a loop containing two microbridges. Our preliminary experimental results show that self-sustained oscillations occur also in this configuration. Moreover, the frequency and lineshape of these oscillations exhibit periodicity as a function of externally applied magnetic flux. Further work is needed to theoretically account for the observed behavior.