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Noise in nonlinear nanomechanical resonators

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Noise limits the sensitivity of linear sensors, in a manner that is well understood, but also limits nonlinear systems in a less trivial way. Nonlinear nanomechanical resonators present interesting possibilities for the sensitive detection of forces and masses, but the noise limitations have not been explored much to date. Here we report on noise effects on nonlinear resonators operated in regimes where they have either one or two stable attractors. We have made quantitative measurements of the nonlinear response of a radiofrequency mechanical resonator with very high quality factor, measuring the noise-free transitions between the two attractors, and find good agreement with theory. We measure the transition rate response to controlled levels of white noise, and extract the basin activation energy. This allows us to obtain precise values for the relevant frequencies and the cubic nonlinearity in the Duffing oscillator, with applications to parametric sensing, in particular mass sensing. References: "Noise-enabled precision measurements of a Duffing nanomechanical resonator," J.S. Aldridge and A.N. Cleland, Phys. Rev. Lett. 94, 156403 (2005). "Thermomechanical noise limits on parametric sensing with nanomechanical resonators," A.N. Cleland, New J. Phys. 7, 235 (2005).