Friction-induced Resonance of a Noisy Fractional Oscillator

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Mathematical models with fractional-order derivatives provide an excellent instrument for describing the memory and hereditary properties of various viscoelastic materials and processes. Thus motivated, the influence of the friction coefficient on the long-time behavior of the spectral amplification and the signal-to-noise ratio (SNR) for the output signal of a fractional oscillator with fluctuating eigenfrequency subjected to a periodic force is considered. The influence of the fluctuating environment is modeled by a multiplicative white noise and by an additive noise with a zero mean. The viscoelastic type friction kernel with memory is assumed as a power-law function of time. On the basis of exact formulas it is demonstrated that interplay of multiplicative noise and memory can generate a multiresonance of SNR versus the friction coefficient. The necessary and sufficient conditions for such a resonance effect are also discussed. Particularly, it is shown, that resonance-like behavior of SNR versus friction coefficient is qualitatively different in the cases of external and internal additive noise. The advantage of the effect of friction-induced resonance is that the control parameter is the damping coefficient, which can easily be varied in possible experiments as well as potential technological applications, e.g., in electric oscillator devices with circuit elements of a fractional type (i.e., tree or chain fractances).

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