Computing escape paths in periodically driven nonlinear coupled oscillators with small noise

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The dynamics of mechanical systems such as turbomachinery with multiple blades are often modeled by arrays of periodically driven coupled nonlinear oscillators. A periodically driven nonlinear monostable oscillator at a certain range of excitation frequency has a low-amplitude stable vibrational mode and a high-amplitude stable vibrational mode. Arrays of N such oscillators may have, respectively, up to 2^N stable vibrational modes if the coupling is not too large, and the excitation frequency is within a certain range. Adding small noise to such systems enables escape from undesirable modes where the system might get as a result of unfortunate external influence. A methodology for finding the Most Probable Escape Paths and estimating the escape rates in the small noise limit is developed and applied to a collection of arrays of coupled monostable oscillators with cubic nonlinearity, small damping, and harmonic external forcing. The methodology is built upon the action plot method (Beri et al. 2005) and relies on the large deviation theory, optimal control theory, and the Floquet theory. The action plot method is promoted to non-autonomous high-dimensional systems, and a method for solving the arising optimization problem with discontinuous objective function restricted to a certain manifold is proposed. The maximum likelihood transition paths between stable vibrational modes in arrays of up to five oscillators and the corresponding quasipotential barriers are computed and visualized. The dependence of the quasipotential barrier of the parameters on the system is discussed.

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