# Stationary phases and dynamic activation in parametrically driven stochastic resonators

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Many phenomena in physics, chemistry and biology share a common basis: thermally activated transition rates between metastable states. These phenomena are characterized by an underlying multi-modality, rooted in intricate nonlinear energy landscapes. The activation (transition) is in- duced by the stochastic kicks that the fluctuating environment enacts upon the system and, at long times, these dynamics lead to stationary probability distributions that sample the modes of the energy landscape or melt its order at high temperatures. Considering systems under parameteric drives (i.e., in a deep out-of-equilibrium setting), the focus of this theoretical project is the study of their activation dynamics and the corresponding stationary phases. In this context, the inter- play between the parametric drives and the system nonlinearities leads to a variety of oscillation responses to the drive. In a rotating picture with respect to the drive, this ultimately results in multi-modal quasienergy potential landscapes and the facilitated activation transitions appear to be similar to those relative to the static case.

Taking the better understood case of activation in static system as a reference, in the course of this project we aim at grasping a better understating and control over such out-of-equilibrium processes. Moreover, we aim at indentifying potential sources of out-of-equilibrium frequency noise, which may hinder quantum information processing applications. It will also be possible to explore how such system could potentially serve as analog stochastic annealers for solving optimization problems.

An interesting aspect of this project is that it introduces parametric driving to the CRC, open- ing up a to interesting experimental collaborations. We will develop methodologies for driven systems using different rotating *ansätze*, relying on the numerical and analytical methods for ac- tivation analysis in static systems as a basis. Our main interest lies in the interplay between the drives and the bath-induced stochastic activation, which may also lead to stochastic resonances. In static systems, it is possible to observe the physics of the so-called Kramers' turnover when the environment-induced dissipation is increased from underdamped to overdamped dynamics, lead- ing to a non-monotonous dependence of the activation rate on the system-bath coupling. However, since dissipation can destroy the drive-generated modalities, this phenomenon might not be visi- ble in the latter out-of-equilibrium domain. Studying such a crossover between underdamped and overdamped dynamics adds a novel bridge between the existing CRC projects that explore sys- tems that lie explicitly on one or the other side of the damping behavior. Finally, we would like to identify the conditions under which such activation rates appear and develop methods to suppress them.

Crucially, much of the conditions realized in the classical setting that we study carry over to the quantum driven domain. Recently, there is a growing interest in building quantum computers based on so-called cat qubits, which are commonly realized using similar parametric drives but with strongly nonlinear electric circuits. Our prospective results in this project can play an impor- tant role in understanding the semiclassical limit of such systems, and their response to fluctua- tions. As such, parallel (or future) activities in the CRC can benefit from our findings and explore their classical-to-quantum limit.