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Large deviations and stochastic resonance

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We consider potential type dynamical systems in finite dimensions with two meta-stable states. They are subject to two sources of perturbation: a slow external periodic perturbation of period T and a small Gaussian random perturbation of intensity ϵ, and therefore mathematically described as weakly time inhomogeneous diffusion processes. A system is in stochastic resonance provided the small noisy perturbation is tuned in such a way that its random trajectories follow the exterior periodic motion in an optimal fashion, i.e. for some optimal intensity $\epsilon(T)$. The favorite measures of quality of periodic tuning – and thus stochastic resonance – such as spectral power amplification or signal-to-noise ratio have proven to be defective. They are not robust w.r.t. effective model reduction, i.e. for the passage to a simplified finite state Markov chain model reducing the dynamics to a pure jumping between the meta-stable states of the original system. An entirely probabilistic notion of stochastic resonance based on the transition dynamics between the domains of attraction of the meta-stable states – and thus failing to suffer from this robustness defect – is proposed before in the context of diffusions. It is investigated by using extensions and refinements of the Freidlin-Wentzell theory of large deviations for time homogeneous diffusions. Large deviation principles developed for weakly time inhomogeneous diffusions prove to be key tools for a treatment of the problem of diffusion exit from a domain and thus for the approach of stochastic resonance via transition probabilities between meta-stable sets.