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Moderate averaged deviations with jumps and memory

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Abstract

Heterogeneous phenomena in Nature are often modeled in Physical Sciences by stochastically perturbed multiscaled equations. This technique of understanding diversity tries to exploit the relation between two or more sets of diverse variables that relate under the tuning of a parameter measuring this degree of heterogeneity/homogeneity. Typical examples are in Climatology, where climatic transitions are understood within the use of slow/fast variables that encode different factors used to build statistical parametrizations. In the description of those climatic models short/large timescales must be taken into consideration (daily weather forecast vs clima prediction) and often it is necessary to consider non Markovian features in order to capture more richness such as as memory effects on the dynamics under study.
The averaging principle is a mathematical statement that says that the degree of complexity of those models falls drastically under certain assumptions that can be done for the heterogeneous part of the phenomena (the fast variable). If we take the interaction between the variables as the average of the mixing factors against the invariant measure of the last dynamics we can perform a decoupling property for the other component (the slow variable) that is a legitimate (strong/weak) approximation. A much sharper statement is a large/moderate deviations principle, that quantify the deviations of the dynamics of the slow variable from the averaged dynamics in the vanishing noise limit within the use of a deterministic object, commonly known in Probability theory as the rate function.
We present a stochastic system of differential equations driven by Lévy noise with memory effects and we design a moderate deviations principle for the slow variable of the dynamics. We construct a sufficient criteriion for a random dynamical system driven by jump noises to obey a uniform moderate deviations principle, based on the weak convergence approach of Budhiraja, Dupuis and collaborators. The verification of this criteria reduces to the proof of tightness and of the existence of weak limits for controlled versions of the dynamics under consideration. The novelty here is within the methodology that we implement in order to achieve the result. As an illustration we solve the first exit time problem for such perturbed dynamics in the small noise limit.