Effect of Noise Correlation on Multiplicative Noise induced Intermittency

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Random fluctuations, popularly called *'noise'*, are known to significantly affect nonlinear systems in multiple ways like shift in a transition or bifurcation point, noise induced intermittency and stochastic resonance. This study deals with investigation of the effect of the noise correlation on parametric noise induced intermittency. Parametric noise induced intermittency has been observed in many physical scenarios like- solar sunspot cycles, earthquake occurrence, and thalamo-cortical oscillations. Such behaviour could be observed in systems which undergo transition between two parameter regimes, for example rest and oscillatory, when a system parameter fluctuates about its critical value [1]. This parametric noise is otherwise called 'multiplicative' noise or 'state-dependent noise' since the effect of noise depends upon the state variables. Depending on the context and character of such intermittent system responses, multiplicative noise induced intermittency (mNII) has been called by diverse names- *'on-off intermittency'*, *'snapshot attractors'* and *'modulational intermittency'*. Despite progress in characterising mNII, the necessary conditions for fluctuations to cause mNII are still not completely understood. Some progress in this regard has been made with respect to the relation of the noise spectrum and appearance of NII in [2]. They observed that amplitude of the noise did not govern intermittency as usually argued in literature [3]. Instead, they concluded that the noise should necessarily have a low frequency component for mNII to appear and whenever such components were filtered out in experiments, intermittency disappeared. On the other hand, several researchers have reported NII in the presence of templorally uncorrelated fluctuations [3, 4] which do not have a dominant low frequency. The spectrum for such noise are almost flat and hence the spectral value at zero frequency, though non-zero, is not much different from others. This indicates that intermittency can appear even when the fluctuations lack a prominent low frequency. To explain this contradiction, this study investigates the role of correlation in the fluctuations on the appearance of mNII. This is examined by considering a simple nonlinear dynamical system- the noisy logistic map, given by,

$$\begin{aligned} x_{n+1} &= a_n x_n (1 - x_n). \\ a_n &= a_m + a_i \xi_n \end{aligned} \tag{1}$$

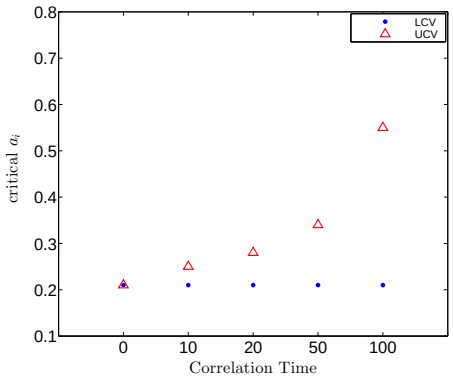

Figure 1: Variation of regime of intermittency with change in correlation. LCV and UCV are the lower and upper bounds of noise amplitude a_i within which intermittency appears.

where a_n is the noisy parameter, a_m and a_i are quantities defining the range of the a_n and ξ_n is the fluctuation modelled as a uniformly distributed random variable. This map has been studied in NII literature and 'on-off' intermittency has been observed when $a_m = 0$ and $a_i > 2.718$ [3, 4] for temporally uncorrelated noise. In this study, the effects of variation of the correlation time τ_c of the noise ξ_n is explored and the role played by the noise correlation on the qualitative and quantitative features of mNII is investigated. It is shown that mNII can occur for both correlated ($\tau_c > 0$) and δ-correlated ($\tau_c = 0$) noise , and the parameter regime, over which mNII occurs, widens with a corresponding increase in the correlation time associated with the fluctuations, see Fig.1.

References

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