Coherence resonance of excitable localized structures in nonlinear optical cavities

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Dissipative solitons (DS), are spatially localized structures that appear in several nonlinear dissipative media, including nonlinear optical cavities where are also known as cavity solitons[1]. In recent work[2], it was shown that DS appearing in nonlinear Kerr cavities exhibit a excitability regime. This excitability is an intrinsic dynamical property of the system, as excitability appears in an extended system that is not locally excitable. In other words, excitability is an emergent feature that appears due to spatial coupling.

The excitable nature of the DS exhibited by this type of systems makes them natural candidates to exhibit coherence resonance[3], that is the resonant behavior exhibited by excitable systems in the presence of noise. This effect is present in a more clear cut way in Class II excitable systems, characterized by a frequency response curve with a narrow band of frequencies, and that is the case studied in Ref.[3]. In Ref.[4] it has been shown that one can also find coherence resonance (or stochastic resonance without external periodic force, as is called in these references) in Class I excitable systems, characterized instead by an unbounded distribution of response times (i.e., a frequency response curve that starts from zero). In particular, the excitability of the DS reported in this work is Class I.

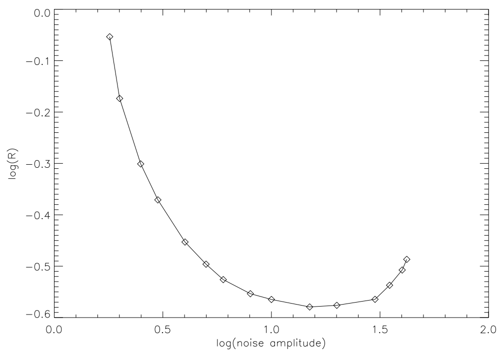

Figura 1. Noise-to-signal ratio R as function of noise intensity

Coherence resonance behavior is quantitatively measured through Pikovsky's[3] noise-to-signal ratio, defined as the normalized fluctuations of pulse durations, $R_p = \sqrt{Var(t_p)}/\langle t_p \rangle$, that can be shown to exhibit a relative minimum as a function of the noise intensity (cf. Fig. 1. In our case, external noise is applied on top of a localized Gaussian pump, as defined in Ref.[5], for parameters in the excitable region close to the SNIC (Saddle Node on the Invariant Circle) bifurcation. The effect of noise for three intensities of noise, respectively before the resonant value, close to it, and larger than the resonant value, are shown in Fig. 2.

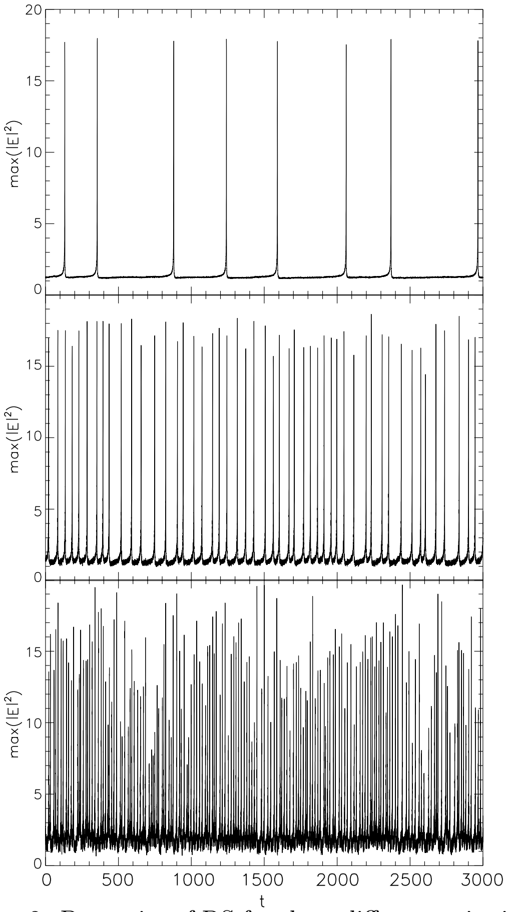

Figura 2. Dynamics of DS for three different noise intensities, where a more regular distribution of pulses can be observed for an intermediate value of the noise intensity.

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