Extreme intensity pulses in a semiconductor laser with a short external cavity

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ABSTRACT

We present a numerical study of the pulses displayed by a semiconductor laser with optical feedback in the short cavity regime, such that the external cavity round trip time is smaller than the laser relaxation oscillation period. For certain parameters there are occasional pulses, which are high enough to be considered extreme events. We characterize the bifurcation scenario that gives rise to such extreme pulses and study the influence of noise.

1- Model

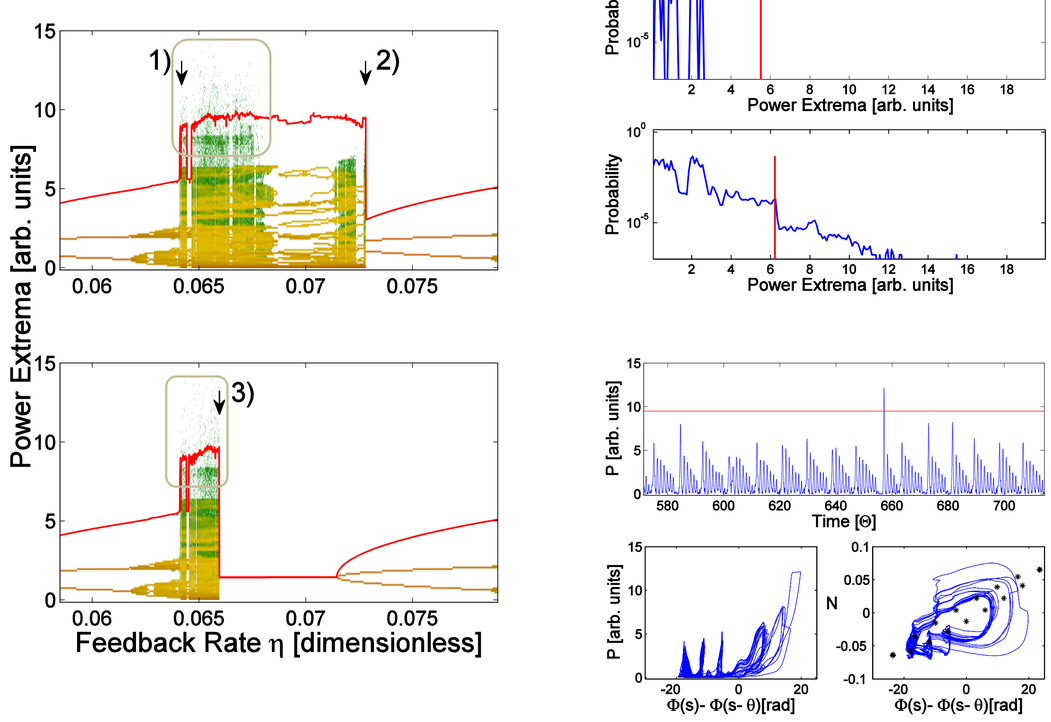
We use the well-known Lang-Kobayashi model as a framework for a SCL with optical feedback in the short cavity regime [1].

$$\frac{dE}{ds} = (1+i\alpha)NE(s) + \eta e^{-i\omega\theta}E(s-\theta) + \beta\xi$$
$$T\frac{dN}{ds} = J - N - (1+2N)\left|E(s)\right|^2$$

The variables correspond to the complex optical field, E, and the excess carrier number, N. Parameters are: T = 1710, J = 1.155, α = 5, θ = 70 and ωθ=−atan(α).

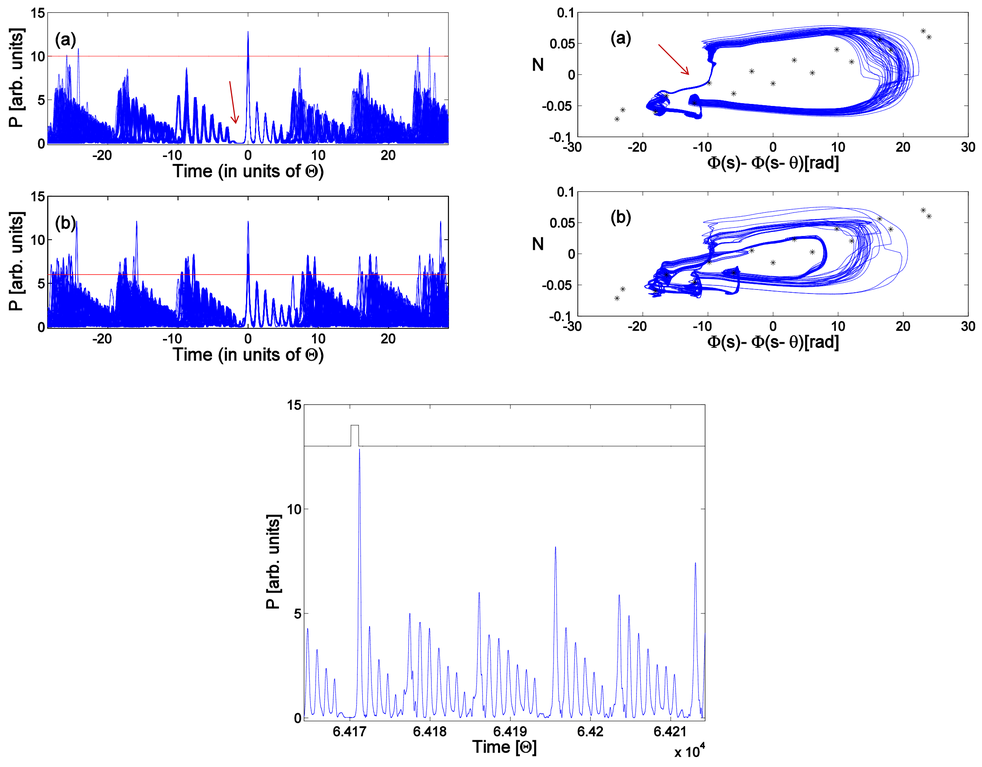
2- Identifying extreme intensity pulses

We find extreme intensity pulses in a region where regular pulse packages take place [2], as we see from the bifurcation diagram, the probability density function and the time series. Above the red line, pulses are considered extremes.



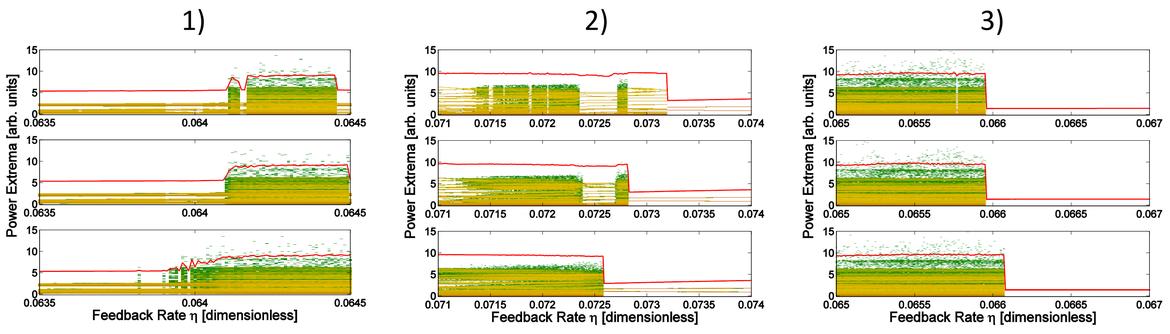
3- Features of extreme pulses

A narrow curve previous to the extreme pulse characterizes the trajectory. It helps us to detect extreme pulses before occurs.



4- Influence of spontaneous emission noise

Noise does not modify this scenario but only anticipates the different transitions. In the following figures, noise increases from top to bottom.



CONCLUSIONS

a) We demostrate that in a SCL with a short external cavity exists parameters where the laser intensity displays extreme pulses.

b) We identified 3 relevant transitions involved in the appearance of the extreme intensity pulses.

c) The trajectories converge to a narrow region of the phase space before an extreme pulse is triggered.

d) Extreme events are observed also under the influence of spontaneous emission noise. Noise anticipates the appearance of extreme pulses.

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