PHOTONICS - EUROPHOTONICS MASTER COURSE

MASTER THESIS PROPOSAL

Course 2014 –2015

Laboratory: Research group on Nonlinear Dynamics, Nonlinear Optics and Lasers

City, Country: Terrassa, Barcelona, Spain

Title of the master thesis: Numerical study of extreme intensity pulses in semiconductor lasers

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Summary of the subject (maximum 1 page) :

Extreme events are of great importance because they can result in natural catastrophes such earthquakes, severe rain falls and economic crisis. Rogue waves are rare and giant (freak) waves that occur in ocean waters and scientific interest on such extreme waves increased substantially during the past decade because they display similar statistical features as extreme events in other fields including optics. In particular, in laser systems extreme intensity pulses have been identified as optical rogue waves. Their study by using simple laser models offers great potential for understanding the mechanisms that trigger extreme pulses, and also, the mechanism that are capable of controlling them or even suppressing them.

We have recently studied such optical rogue waves in a simple and controllable laser system [1, 2]: a modulated semiconductor laser that is injected light from another laser. We found that appropriated modulation parameters (amplitude and frequency) are capable of fully suppressing the extreme pulses. The numerical study proposed for this thesis will continue this work and is aimed at understanding the role of modulation, when the parameters such that the rogues are not suppressed. In this case, we aim to determine if the modulation is capable of inducing some periodicity/regularity in the occurrence of rogue waves, in other words, if we can generate regular extreme pulses.

The work will be divided in three main tasks:
- Simulate the laser model in the absence of modulation and analyze the distribution of waiting times between consecutive extreme pulses. Consider the influence of model

parameters that have not been previously investigated, such as the line-width enhancement factor.
- Include current modulation in the simulation with parameters such that the extreme pulses are not suppressed, and analyze the influence of modulation in the distribution of waiting times.
- Design of the optimal modulation scheme (find optimal modulation parameters) that produce regular extreme pulses, i.e., determine the amplitude and frequency of modulation that produce most regular sequences of extreme intensity pulses.

References

[1] J. Ahuja et al, "Rogue waves in injected semiconductor lasers with current modulation: role of the modulation phase," Optics Express 22, 28377 (2014).
[2] S. Perrone et al, "Controlling the likelihood of rogue waves in an optically injected semiconductor laser via direct current modulation," Phys. Rev. A 89, 033804 (2014).

Keywords: Semiconductor lasers, optical rogue waves, extreme intensity pulses, ordinary differential equations, statistical analysis.

Additional information :

* Required skills: as the work will involve numerical simulations of a laser model (consisting of two ordinary differential equations) and the use of statistical tools (such as probability distributions of waiting times between consecutive extreme pulses), basic programming skills are required (Matlab or Fortran or C).

* Miscellaneous: the simulations can be performed by using the student's own computer or the computers available at the DONLL group. The student will meet once a week with the supervisors in Terrassa, to discuss the progress of the work.