Title: Contribution to the study of the dynamical behavior of edge-emitting semiconductor laser: analytical, numerical and analog simulations

Abstract:

This thesis, we study the dynamics of edge-emitting semiconductor lasers (EELs) subject to sinusoidal and non-sinusoidal modulated current from self-sustained oscillators. After the description of the system constituted by a Van der Pol oscillator that powers an edge-emitting semiconductor laser (diode laser), the rate-equations and the less bulky electronic circuit of the models are established.

Lindstedt-Poincarre, harmonic balance and appropriate computational tools are used on the system to characterize their dynamical states. For small value of the parameter controlling the dissipation in Van der Pol oscillator, the Lindstedt–Poincaré method is used to find analytically high accurate solutions of the van der Pol equation with a bias term. Then by using the harmonic balance method, we obtain the amplitude of the oscillatory states of the laser output. The analytical results are compared with those from numerical simulation and a good agreement is obtained. By varying the parameter controlling the dissipation in the Van der Pol oscillator and the normalized reverse bias saturation of the injection current in the laser, we numerically show that the laser output exhibits a period-doubling route to chaos.

The coexistence between periodic and chaotic behaviors is found in edge emitting semiconductor laser driven by a van der Pol oscillator for specific parameters values. We also demonstrate that the edge-emitting semiconductor laser driven by a Van der Pol oscillator generates

dynamical behaviors found in edge-emitting semiconductor laser subject to a sine modulated current demonstrating the advantage of using a simple and less bulky electronic device to modulate the semiconductor laser pump current. The edge-emitting semiconductor laser (EEL) powered by three dimensional autonomous oscillator (Sifeu et *al*. oscillator) is studied numerically. An electronic/analog model of the system is constructed in order to imitate the behavior of the material model. Period-doubling to chaos, is obtained when varying the amplitude of the reverse bias saturation current.

The experimental results show agreement with those obtained numerically. An electronic analog circuit of the edge-emitting semiconductor laser is proposed. It is powered with a sine wave, triangular wave and square wave. The numerical results are compared to the experimental one and an agreement is found. By using one parameter controlling the normalized reverse bias of the injection current, the bifurcation diagram obtained when the electronic system is powered with the triangular wave shows that the system exhibits a period-doubling to chaos and this bifurcation diagram appears to be a shift compare to the one obtained with the sinusoidal wave.

Keywords: Edge-emitting semiconductor laser, self-sustained oscillators, Lindstedt–Poincaré, Harmonic balance, period-doubling, chaos, bi-stability, bursting oscillations, spiking oscillations, electronic analog circuit, analog model of semiconductor laser.