Ph. D. Thesis   (TALLA Mbé Jimmi Hervé)

Title: CHARACTERIZATION THROUGH BIFURCATIONS ANALYSIS OF CURRENT MODULATED VCSELS, ELECTRONIC VCSELS AND OPTICAL MICROTOROID.

Abstract

This thesis deals with the dynamics of Vertical-Cavity Surface-Emitting Lasers (VCSELs) and High-Q optical toroid microcavity. The dynamics are studied by the analysis of bifurcation schemes.

The dynamics of VCSELs is based on the phenomenological current-dependent gain and the combined models of Danckaert *et al*. The second model is shown to be more complete since it displays both switching of the photon density modes as well as bistability.

- We demonstrate that subjected to current modulation (CM), VCSELs exhibit interesting behaviors: for few hundred MHz frequencies of current, the threshold current is reduced and the polarization switching is accompanied by an anti-phase dynamics of polarization modes. When the injected modulated current fluctuates between values greater or lower than the threshold, VCSELs emit single pulses or pulse packages. In the specific case of combined model, the suppression of bistability hysteresis loop in VCSELs usually obtained with optical feedback is shown possible with modulated current. Bifurcation diagrams plotted in terms of the modulation parameters have presented the appearance of period-n ($n > 1$) as well as the period-doubling transition route to chaos.

- Based on the current-dependent gain model, a scale model of VCSELs has been constructed. It consists of an electronic circuit that copies the behavior of

real VCSELs. In addition to switching that it exhibits, the circuit has also proved its capabilities in terms of the voluntary reduction of the threshold current by the use of an external voltage supplier.

The bifurcations analysis of toroidal microcavity reveals that the device can present diverse phenomena concerning the mechanical displacement and the intracavity energy as the input varies: at few input power, the system presents clockwise (CW), counter clockwise (CCW) hysteresis cycles and hysteresis switching which are limited by mechanical displacement of the cavity; at high input, chaotic dynamics are present.

   Applications of most phenomena found in this thesis are also proposed.

Keywords: Vertical-Cavity Surface-Emitting Lasers, High-Q Optical toroid Microtoroid, Hysteresis, Switching, Pulse Packages, Chaos, Bifurcation.