Controlling the unstable emission of a semiconductor laser subject to conventional optical feedback with a filtered feedback branch

I. V. Ermakov[1,2], V. Z. Tronciu[3,2], Pere Colet[2] and Claudio R. Mirasso[2]
1. Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium
2. Instituto de Física Interdisciplinar y Sistemas Complejos, Campus Universitat de les Illes Balears, E-07122 Palma de Mallorca, Spain
3. Weierstrass Institute for Applied Analysis and Stochastics, Mohrenstr. 39, 10117 Berlin, Germany

The control of semiconductor exhibiting dynamical instabilities has received considerable attention during recent years. Our purpose in this work is to prevent periodic or chaotic oscillations in a semiconductor laser subject to conventional optical feedback (COF) by stabilizing it in a CW regime. We propose the use of a filtered optical feedback (FOF) from an external mirror in one of the external branches. Using FOF rather than COF the control of the system is easier and more effective. The proposed device (Fig. 1, left) consists of a semiconductor laser coupled to the two external reflectors. One branch is the conventional feedback branch (CFB) and the other is the filtered feedback branch (FFB). The frequency dependent reflectivity in the FFB is described by a Lorenzian function [1]. The laser dynamics is analyzed in the framework of the extended Lang-Kobayashi rate equations [2] for the complex field amplitudes $E(t)$, $F(t)$ and excess carrier density $N(t)$.

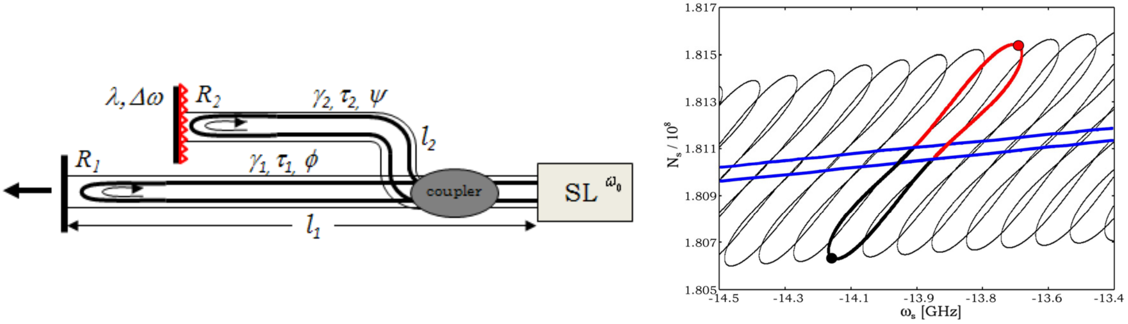

Fig. 1. Left : Investigated setup. A laser with fiber-based external cavities. The cavities lengths are l_1 = 0.05 m and l_2 = 0.03 m. Right: ECMs distribution. Big black and red points are the modes and the 'anti-modes', respectively, when both phases are fixed to zero. The blue line shows saddle-node bifurcations where modes and anti-modes collide.

We present the analytical solutions of the system, i.e. stationary states that are given by rotating wave solutions (external cavity modes, ECMs). When only the CFB is present a finite number of solutions which are located on top of an ellipse in the frequency vs. carrier density projection exists [3]. The feedback phase determines the precise location of those points on the ellipse. When the FFB is added the locations of the modes and the general picture become more complicated (Fig. 1, right).

The filter width and the detuning between the central frequency of the filter and the solitary laser frequency strongly influence the dynamics of the laser and the system exhibits different opportunities of control. We observed that the size of the regions in parameter space, where control can be achieved, increases with increasing feedback strength of the second branch γ_2. Fig. 2(a) shows how delay time of the second branch τ_2 influences the dynamics in case of narrow filters. For comparison the case of control using the two CFB scheme is shown in the Fig. 2(b). The parameter regions in which CW operation is stabilized are much broader when using the FFB.

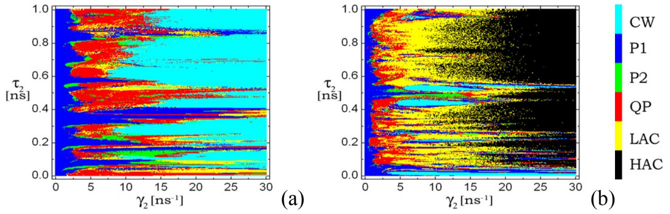

Fig. 2. Effect of control of CFB exhibiting periodic oscillations. The notations: CW - continuous wave; P1, P2 - period one and two oscillations respectively; QP - quasi-periodicity; LAC, HAC - low and high amplitude chaos respectively.

We show that with help of FFB scheme the chaotic oscillations can be also suppressed.

References

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