

Cavity solitons in driven VCSELs above threshold

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From a theoretical viewpoint, in the case of a laser above threshold the simple adiabatic elimination of the material polarisation variable is not always correct, possibly leading to spatial oscillatory instabilities with a spuriously high critical wave-number. This problem is well-known for a free-running two-level laser [1].

We therefore decided to study the complete system of equations, describing a broad-area driven Vertical Cavity Surface Emitting Laser (VCSEL). We started from a model recently proposed by Agrawal [2], and adapted it to the case with injected field. By performing the linear stability analysis we found a Hopf instability, typical of lasers above threshold, affecting the lower intensity branch of the homogeneous steady state, while the higher intensity branch is affected by a

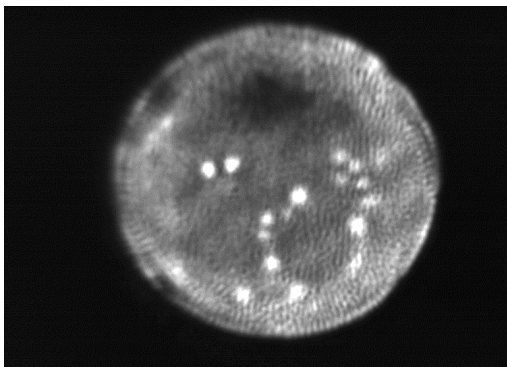


Fig. 1 Two CSs are clearly distinguishable on the left of the device (Experiment).

Turing instability. Depending on the injected frequency, two different situations can be realized: in one case, for injected frequencies larger than the material gain frequency peak, only a small portion of the lower homogeneous branch turns out to be Hopf unstable. In the other case, for injected frequencies lower than the material gain frequency peak, a spatio-temporal Hopf instability affects a larger portion of the lower branch. Numerical results obtained by direct integration of the dynamical equations show that writable/erasable CSs can exist in both regimes, possibly sitting on unstable background. Therefore CSs result to be robust structures and realistic candidates for optical information treatment also in VCSELs somewhat above threshold.

Some recent experimental results obtained at INLN in Nice confirm this theoretical predictions, showing the existence of several CSs in VCSELs driven above threshold. The possibility of writing and erasing them by external control is also analysed.

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[1] P. Jakobsen, J. Lega, Q. Feng, J. Moloney, and A. Newell, *Phys. Rev. A* **49**, pp. 4189–4200, (1994).

[2] G.H.M. van Tartwijk, G.P. Agrawal, *Progress in Quantum Electronics* **22**, 43 (1998).