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Dynamic instabilities in the output of InAs/InGaAs quantum dot semiconductor laser as a result of noise

M.O. Oleiwi C.A. Emshary

Physics Department , Education College for Pure Sciences, Basrah University, Basrah ,Iraq

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Abstract:

Quantum dot semiconductor InAs/InGiaAs laser under the effect of noise are found to exhibit chaotic oscillation in the steady state regime of the light intensity together with decay to zero intensity proportional to the gain of the laser medium, injection current density and spontaneous emission factor. Such effect appears in the temporal variation of electrons occupation probability in the quantum dots too.

Keywords: Quantum dot semiconductor laser, noise, chaos.

Introduction:

The subject of semiconductor laser SCL noise has received considerable attention during the last thirty years[1,2]. Noise in SCLs has two major contributions[3]: field noise originating mainly from spontaneous emission and carrier noise which has its origin in the carrier recombination and is, in addition, affected by the noise of the pump source. In theoretical models, they are usually accounted for by the inclusion of Langevin noise terms in the field and in the carrier equations [4,5].

Classification of noise in semiconductor lasers is based on either the application of laser light as carrier of information transmission or the generating mechanism of physical disturbance. So, noises related to semiconductor are divided as follows [6,7]:
(i)those which are based on the application of the optical wave such as intensity noise or intensity modulation noise.
(ii) frequency modulation noise where frequency of phase of the optical wave is used as the signal and is caused due to the fluctuation in frequency of light.
Other type based on the generating mechanism of physical disturbance such intrinsic noise known as quantum noise or shot noise and external noise such as feedback noise (optical phase distortion and mode hopping noise, the former also known as coherent collapse or noise due to external mode competition and the later are due to the competition among internal lasing mode) and noise due to fluctuations in temperature ,driving current and voltage [8-13].

The field noise is often considered to affect the dynamics more strongly[5]. The influence of noise has two aspects. First, it can affect the dynamical state and their stability [14].Second, noise might even play a potentially constructive role ,giving rise to ordering effects [15]. Therefore, with a perspective on applications, noise will be an important factor to consider.