DYNAMICS OF QUANTUM DOT SEMICONDUCTOR LASERS ON MUTUAL LOOP SYSTEM WITH OPTOELECTRONIC FEEDBACK

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Dynamics of quantum dot semiconductor laser on mutual loop system with optoelectronic feedback is studied, analyzing its properties and determine the control parameters that lead to the behavior of the output laser like periodic, quasi-periodic to chaos. The chaotic dynamics are absolutely determined by the variation of all parameters without external perturbation. Correlation coefficient show that many Intersection points at different time delay. By knowing the intersection points the modulation areas are determined

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1. Introduction

Quantum Dot is generally used to describe a semiconductor Nanocrystals are classified by means of their dimension (2-10 nm) with new properties, and a described dimension less than nano size. QDs, also known as nanocrystals, are a nontraditional type of semiconductor crystals with limitless applications as an enabling material industry [1]. quantized strength as a subband approves growing QD structures with present degrees of freedom [2]. Quantum Dot semiconductor lasers a key function for many technological applications as for instance high bit charge communication [3] and delayed optoelectronic feedback are the techniques of era chaotic optoelectronic feedback[4]. By without feedback is present several dynamics behaviors including stable, pulsating, periodic and quasi-periodic [5]. Semiconductor lasers exhibit chaos under a variety of physical conditions such as optical feedback (OF) or optoelectronic feedback (OEFB)[6]. The disturbance to the injection current induces instabilities to semiconductor lasers and chaotic behaviors [7]. time-delayed feedback loops and coupling electricity might be intentionally implemented to control disturbances [8] .

Suppress undesired synchrony in chaos communication [9]. In 2009 K. A. Al Naimee et al. validated experimentally and theoretically the existence of slow chaotic spiking sequences in the dynamics of the quantum dot semiconductor laser with ac-coupled optoelectronic feedback. They reflect on consideration on a closed-loop optical system, consisting of a single-mode semiconductor laser with ac-coupled nonlinear optoelectronic feedback [10].

In optoelectronic feedback, chaotic pulses might also be generating by positive or negative feedback. Positive optoelectronic feedback is one of a kind from negative optoelectronic feedback in the mechanism that drives the nonlinear dynamics of a semiconductor laser [11-12].

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2. Theoretical model

The rich bifurcation graph as the negative large delay time and the feedback strength are varied. In small delay time, chaotic regions are interspersed with periodic and quasi-periodic ones and multistability of different sorts of attractors, which are a common feature. We find that the OEFB chaos through the quasiperiodic route [13].

$$\frac{dS_T}{dt}=S_T\left(-\frac{1}{2t_s}+\frac{g_o\upsilon}{2}(2\rho_T-1)\right)+R_{sp} \tag{1}$$

$$\frac{dS_R}{dt}=S_R\left(-\frac{1}{2t_s}+\frac{g_o\upsilon}{2}(2\rho_R-1)\right)+R_{sp} \tag{2}$$

$$\frac{d\rho_T}{dt}=-t_n\,\rho_T-g_o(2\rho_T-1)\left|S_T\right|^2+CN^2(1-\rho_T) \tag{3}$$

$$\frac{d\rho_R}{dt}=-t_n\,\rho_R-g_o(2\rho_R-1)\left|S_R\right|^2+CN^2(1-\rho_R) \tag{4}$$

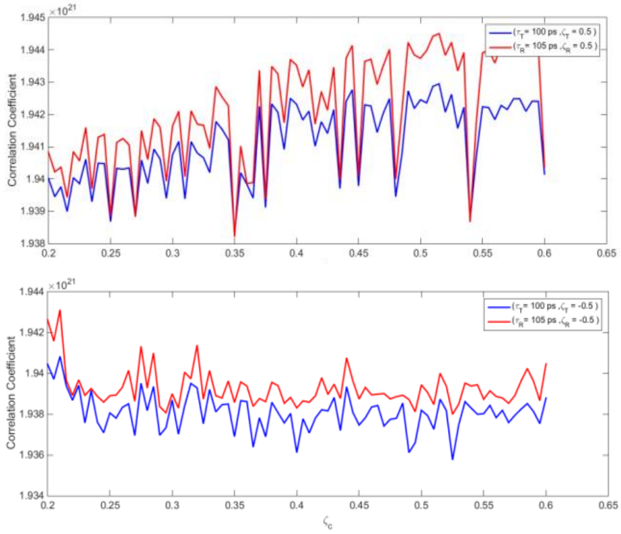
$$\frac{dN_T}{dt}=J_T+(1+\zeta_T\,S_T(t-\tau_T)+\zeta_c\,S_T(t-\tau_c))-\frac{N_T}{t_d}-2n_d\,CN_T^2(1-\rho_T) \tag{5}$$

$$\frac{dN_R}{dt}=J_R+(1+\zeta_R\,S_T(t-\tau_R)+\zeta_c\,S_R(t-\tau_c))-\frac{N_R}{t_d}-2n_d\,CN_R^2(1-\rho_R) \tag{6}$$

where (S_T, S_R) is the photon density, (ζ_T, ζ_R) is the feedback strength of transmitter and receiver Laser. $(\rho_{T,R})$ is the occupation probability for two lasers. $(N_{T,R})$ Is the carrier density in the well of dots; and $(J_{T,R})$ is the pump. C is Auger carrier capture rate. g_0 gain factor, v_g Group velocity. R_{sp} is a spontaneous emission factor. (ζ_c) feedback strength coupling for transmitter and receiver Laser. (τ_T, τ_R, τ_c) are time delay for transmitter, receiver Laser and coupling time delay between transmitter and receiver Laser.

3. Results and discussion

Nonlinear dynamics of semiconductor lasers have been widely studied due to the fact a semiconductor laser with an optoelectronic feedback (OEFB) is an excellent model for generating chaos in its output power that described by nonlinear delays differential equations. The results are depending on time delay when feedback strength equal (0.5and -0.5). by solving equations (1-6), the chaos synchronization in quantum dot semiconductor lasers with positive and negative optoelectronic feedback are studied at delay time $(\tau_{T,R}=100-500\ ps)$.

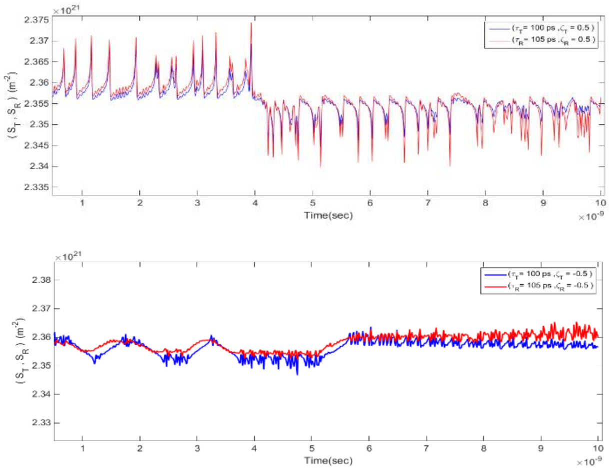


(a)

(b)

Fig. 1. Correlation Coefficient as a function of (ζ_c) of (QDSL) when $(\tau_T = 100\,ps, \tau_R = 105\,ps\ )$ *with (a): positive and (b): negative optoelectronics feedback.*

Fig. (1-a,b) show the correlation coefficient as a function of feedback strength for positive and negative optoelectronics feedback, two Intersection points when $(\tau = 100\ ps,\ \zeta_c = 0.5)$ and no Intersection points when $(\tau = 100\ ps,\ \zeta_c = -0.5)$ with chaotic behavior respectively. Photon density reach to ($2.373*10^{21}$ m^{-2}) oscillates by chaotic behavior with variable values of photon density until to time (4ns) a same behavior with Lower values of photon density when $(\tau = 100\ ps,\ \zeta_c = 0.5)$ as in Fig. (2-a). A chaotic behavior of photon density evident from Fig. (2-b) for $(\tau = 100\ ps,\ \zeta_c = -0.5)$.



(a)

(b)

Fig. 2. Photon density with time for Transmitter and Receiver laser of (QDSL) when $(\tau_T = 100\,ps, \tau_R = 105\,ps\ )$ *for (a) : positive and (b) :negative optoelectronics feedback.*

Fig. (3-a,b) show the correlation coefficient as a function of feedback strength for positive and negative optoelectronics feedback, many Intersection points when $(\tau = 150\ ps,\ \zeta_c = 0.5)$ and many Intersection points when $(\tau = 150\ ps,\ \zeta_c = -0.5)$ with chaotic behavior respectively.

Photon density reach to (2.372*10^{21} m^{-2}) oscillates by periodic chaotic behavior with variable values of photon density when $(\tau = 150\ ps,\ \zeta_c = 0.5)$ as in Fig. (4-a). A periodic chaotic behavior of photon density evident from Fig. (4-b) for $(\tau = 150\ ps,\ \zeta_c = -0.5)$.

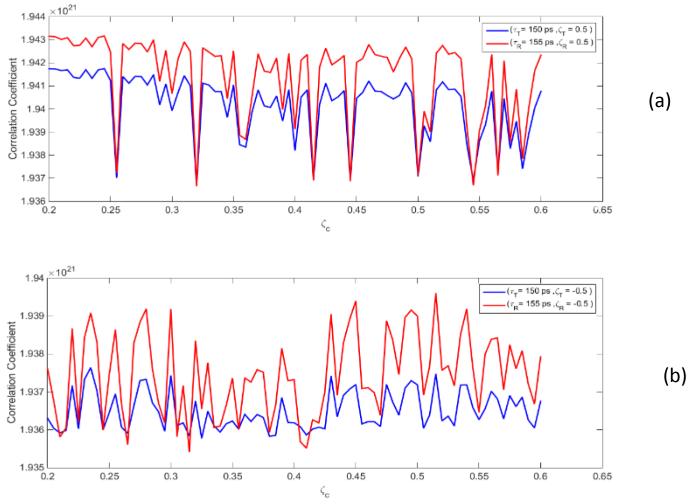


Fig. 3. Correlation Coefficient as a function of (ζ_c) of (QDSL) when $(\tau_T = 150\,ps, \tau_R = 155\,ps)$

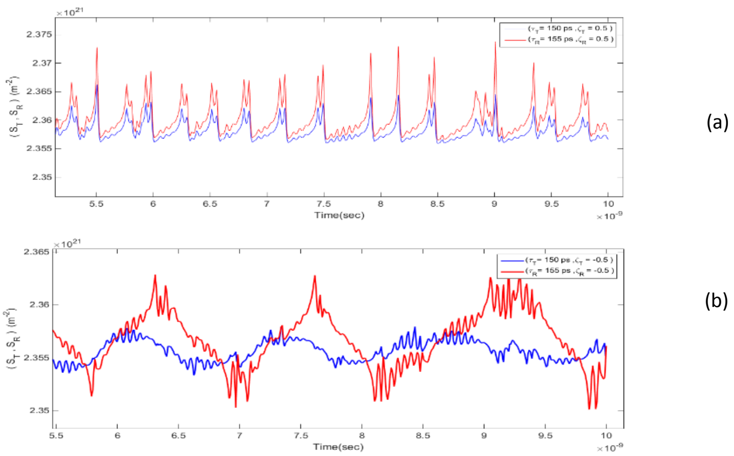


Fig. 4. Photon density with time for Transmitter and Receiver laser of (QDSL) when $(\tau_T = 150\,ps, \tau_R = 155\,ps)$ *for (a): positive and (b): negative optoelectronics feedback.*

Many Intersection points when $(\tau = 200\ ps,\ \zeta_c = 0.5)$ and many Intersection points when $(\tau = 200\ ps,\ \zeta_c = -0.5)$ with chaotic behavior respectively as in Fig. (5-a,b) for correlation coefficient as a function of feedback strength for positive and negative optoelectronics feedback,. Photon density reach to (2.356*10^{21} m^{-2}) oscillates by a chaotic behavior with variable values of photon density until to time (5ns) a same behavior with Lower values of photon density when $(\tau = 200\ ps,\ \zeta_c = 0.5)$ as in Fig. (6-a). A chaotic behavior of photon density evident from Fig. (6-b) for $(\tau = 200\ ps,\ \zeta_c = -0.5)$.

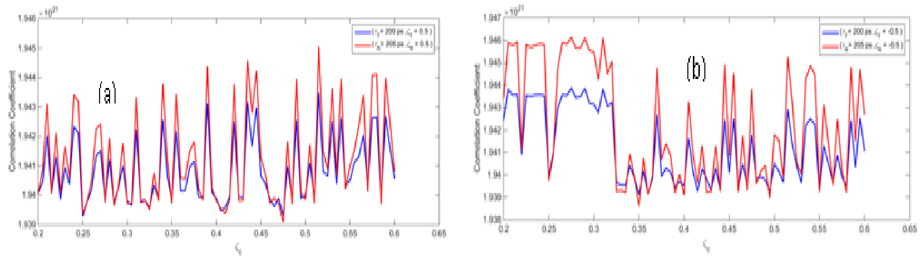
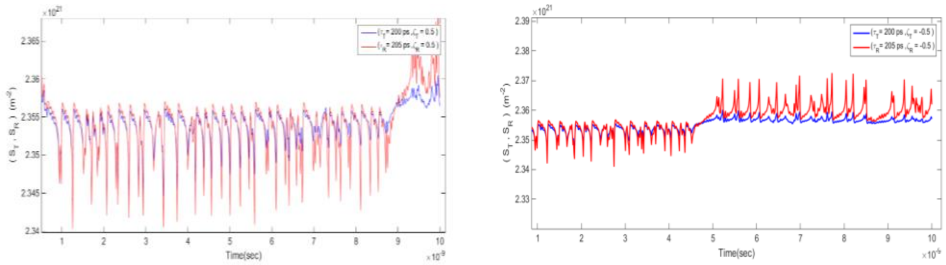


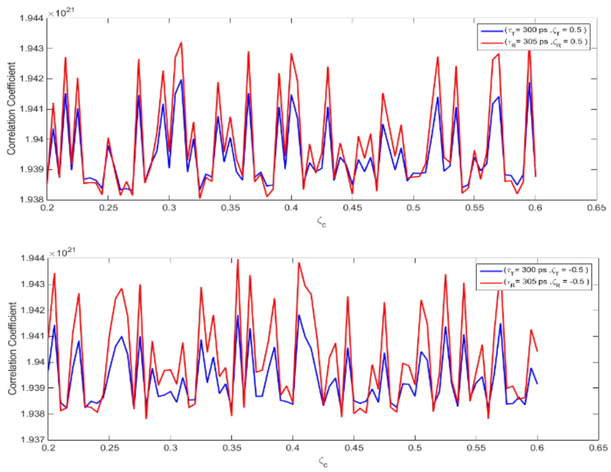
Fig. 5. Correlation Coefficient and Photon density as a function of (ζ_c), time of (QDSL)when $(\tau_T = 200\,ps, \tau_R = 205\,ps)$ *with (a) : positive and (b) :negative optoelectronics feedback.*



a) b)

Fig. 6. For photon density with time of transmitter and receiver laser of (QDSL) when $(\tau_T = 200\,ps, \tau_R = 205\,ps)$ *for (a) : positive and (b) :negative optoelectronics feedback.*

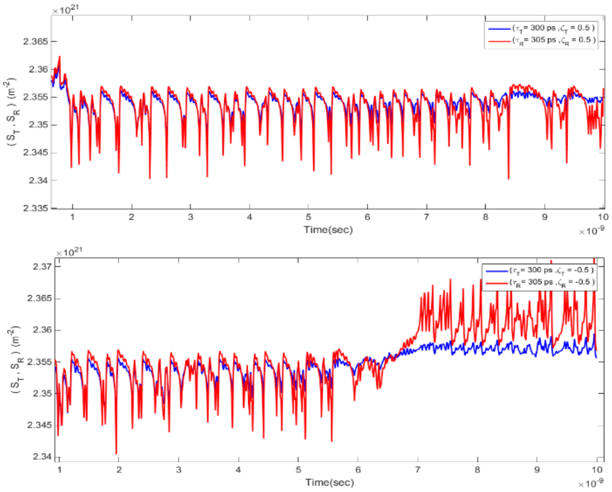
Same behavior for correlation coefficient and photon density for both positive and negative optoelectronic feedback for transmitter and receiver QDSLs between two statuses when $(\tau_T = 200\ ps, \tau_R = 205\ ps)$ *and* $(\tau_T = 300\ ps, \tau_R = 305\ ps)$ respectively as in Figs. (7,8-a,b).



(a)

(b)

Fig. 7. Correlation Coefficient and Photon density as a function of (ζ_c, time) of (QDSL)when $(\tau_T = 300\,ps, \tau_R = 305\,ps)$ *with (a) : positive and (b) :negative optoelectronics feedback.*



(a)

(b)

Fig. 8. Photon density with time of transmitter and receiver laser of (QDSL) when $(\tau_T = 300\,ps, \tau_R = 305\,ps)$ *for (a): positive and (b): negative optoelectronics feedback.*

4. Conclusions

The Dynamics of Quantum Dot Semiconductor Lasers on mutual loop system with negative and positive Optoelectronic Feedback are studied in this search with one value of optoelectronic feedback strength. Critical behaviour of chaotic synchronization for many values of time delay like $(\tau_{T,R} = 100 - 300\ ps)$. Large Intersection points when $(\tau_{T,R} = 300 - 350\ ps)$, that's a good results for application communication.

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