University of Thi-Qar Journal Of Science (UTsci)
Website: jsci.utq.edu.iq Email: jsci@utq.edu.iq
Volume 7, Number 1, June 2019

# Theoretical Study of Parameters Affecting for a chaiotic system by Bifurcation Scenarios

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## Abstract:-

We modeled the appearance of scenario in quantum dot chaotic system with different of parameters. The system show chaotic manner .In addition, there is capability to introduce mixture of oscillation sad stability. The most calculation of the chaotic dynamics by the variation of the all parameters without external perturbation, as evidenced by bifurcation diagram. The diagram of capture rate explain increase the percentage of control to the system dynamics.

**Key words:** chaotic system, nonlinear dynamic, bifurcation scenarios**.**

## Introduction:-

Quantum dots (QDs) a wetting layer (WL) are grown as results of using the self-assembling process. QD chaotic system LEDs are utdized in more reliable in the state of incoherent light sources in many applications for instent lighting and short-distance optical fiber communications [AL-Husseini and Khursan, 2009]. An important performance characteristics of a QD- chaotic system is the output efficiency. In addition, high modulation speed is important for short-distance communication applications, since higher modulation speed implies a larger information capacity [Chuang, 1996]. Optical chaos in QD has attracted an intensive research due to its applications in secure optical communications [Steiner, 2004] – [Plenge *et.al.*, 2001], and the generation of random numbers [Bertram, 2003]. However, stochastic disturbances and spikes are produce sharp fluctuations suddenly, which commonly observed among natural and laboratory-scale systems, they can perturb the multi stable dynamics significantly results in a serious impediment when the device is designed for a certain dynamical behavior [Bertram and Mikhailov, 2001]. LEDs display the same laser dynamics, experimentally, and are much more easily controllable [Marino et.al, 2011] - [Al-Naimee *et.al.*, 2009]. It does not exist a model that simulates the chaotic behavior in QD, yet. We modeled a QD-chaotic system by using a rate equations analysis which incorporates the essential aspects of electronic transitions in the two dimensional wetting layer and ground state of QD taking into account both the photon reabsorption and non-radiative recombination processes. Our results agree largely with the practical results in Ref. [Al-Naimee, 2010]. It exhibits extremely complicated behaviors of QD- chaotic systems.

## QD Model:-

In theoretical model, the spontaneous emission coefficient and absorption coefficient possess identical lineshapes. For realistic QD material system both the QD and WL states can be inhomogenously broadened. Population distributions in the lower and upper levels have to be taken into account explicitly in order to determine the correct relation between absorption and spontaneous emission spectra [Kummer, 2000]. The energy scheme of the QD-LED is shown in Fig. 1.

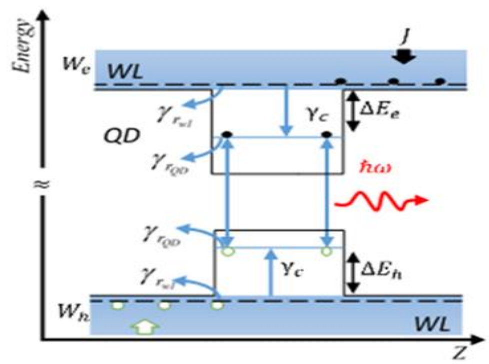


Figure 1: Energy diagram illustrating the recombination mechanisms active layer QD

First of all, the electrons are injected inside WL before recombine bythe QDs. The equations explaned the behaver of the system of carriers in the QD ground state, and the amount of photons in the optical mode:

$$\dot{S} = A n_{QD} - \alpha S - \gamma_s S$$

$$\dot{n}_{QD} = \gamma_c n_{wl}\left(1-\frac{n_{QD}}{2N_d}\right) - \gamma_{r_{QD}} n_{QD} - \left(A n_{QD} - \alpha S\right)$$

$$\dot{n}_{wl} = \frac{I}{e} - \gamma_{r_{wl}} n_{wl} - \gamma_c n_{wl}\left(1-\frac{n_{QD}}{2N_d}\right) \qquad (1)$$

Here, $A$ is the spontaneous emission rate into the optical mode, $\gamma_{r_{QD}}$ and $\gamma_{r_{wl}}$ are the non-radiative decay rates of the number of carriers in the QD and WL respectively; $N_d$ is the is the total number of QDs; and $I$ is the injection current, $e$ is elementary charge, $\gamma_c$ is the capture rate from WL into the dot, $\alpha$ and $\gamma_s$ are the absorption and output coupling rate of photons in the optical mode, respectively.

For a three-level atomic system where the transition is homogeneously broadened, it can be shown from the Einstein relation that [Bertram and Mikhailov, 2001].

$$\alpha = A\Gamma n_o \qquad (2)$$

Where $n_o$ is the initial occupation number of the QDs, $\Gamma$ is the optical confinement factor and $A$ is constant value.

The main goal of this work is to provide a physical model reproducing qualitatively the experimental results and showing that chaotic spiking of the QD-LED. To do so, we rescale the system (1) to a set of dimensionless equations as is done more often in the literature [Mikikian et.al.,2008]-[Alonso and Llin, 1989]. Defining new variables and dimensionless parameters by

$$x = S, \quad y = \frac{A}{\gamma_s}(n_{QD} - \Gamma n_o S), \quad w = \frac{n_{wl}\gamma_c}{A}, \quad \gamma_{r_{wl}} = \frac{t'}{t},$$

$$\gamma = \frac{\gamma_s}{\gamma_{r_{wl}}}, \quad \gamma_1 = \frac{A}{\gamma_{r_{wl}}}, \quad \gamma_2 = \frac{A}{\gamma_s}, \quad \gamma_3 = \frac{\gamma_{r_{QD}}}{\gamma_{r_{wl}}}, \quad \gamma_4 = \frac{\gamma_c}{\gamma_{r_{wl}}},$$

$N_d \equiv a,\ \Gamma n_o \equiv b \text{ and } \delta_o = \dfrac{I}{Ae}$ Eqs. (1) can be rewritten in the following form

$$x' = \gamma(y - x)$$

$$y' = \gamma_1\gamma_2 w\left(1-\frac{b}{a}x\right) - \gamma_1 y\left(1+\frac{1}{a}w\right) - b\gamma_1(x-y) - \gamma_3(y+b \ldots) \qquad (3)$$

$$w' = \gamma_4\delta_o - w\left(1-\frac{\gamma_4}{a\gamma_2}y\right) - \gamma_4 w\left(1-\frac{b}{a}x\right)$$

Here, prime means differentiation with respect to $t$ and the bias current is represented by $\delta_o$.

## Results and discussion:-

we discuss the dynamics of chaos in QD without external effect and show various routes to chaos under parameter variations.The variables are normalized. The system rate equations (2) are solved numerically using the fourth-order Runge-Kutta method by Matlab system. The parameters used in simulation are: δo=0.0015, $\gamma$ =0.158, $\gamma 1$ = 0.049, $\gamma 2$ = 0.026, $\gamma 3$ = 0.03, $\gamma 4$ =0.078, and a = 0.891. The initial values are: $xo$ = 0.066, $yo$ = 0.99, $wo$ = 0.0049. They are obtained by solving the system (2) at steady state.

Fig. 2 shows bifurcation diagrams as a function of the parameters affecting on our model. The injection current and another parameters have been chosen carefully. Except Fig. 2 (c) and (e), bifurcation diagrams of the parameters studied began from limit cycle (or steady state), goes to double period which evolves to chaos. A behavior of mixed mode was shown in Fig. 2 (b). Note that these parameter values are critical, above and below them the system is at steady state. Fig. 2 (c) and (e) exhibits an inverse behavior, they begins chose, relaxes to double period and then attains limit cycle. Behavior of mixed mode was also shown in Fig. 2 (e). More controllability was shown with capture (γc) where the system returns to double period after mixed mode behavior, returns to chaos, and returns to mixed mode behavior.

The lowest rate at which the system attains supercritical Hopf bifurcation is obtained for the Einstein coefficient in QD as shown in Fig. 2 (c) whereas the largest critical parameter value for the Hopf bifurcation occurs was obtained for the output coupling rate of photons in the optical mode, Fig. 2 (a). Note that only this cases, (a) increases the power linearly.

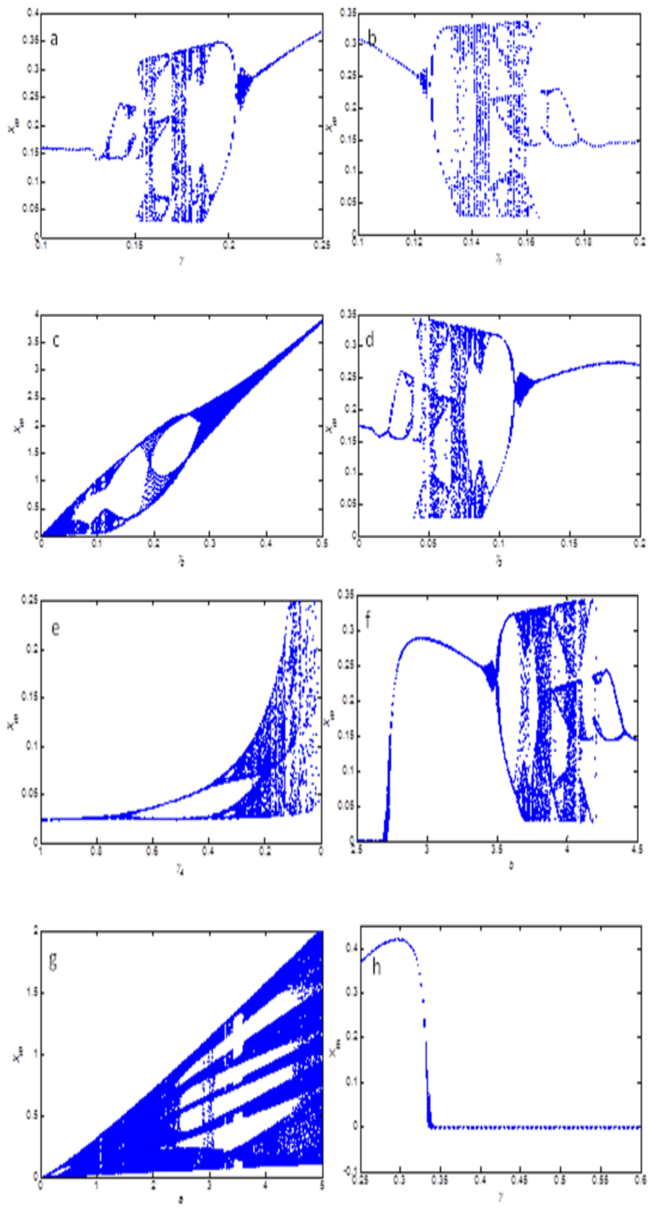


Figure 2. Bifurcation diagrams for the parameters affecting of QD: (a) Output coupling rate of photons in the optical mode. Einstein coefficient with coupling rate (b) and non-radiative decay rate in the WL orelation (c), (d) non-radiative decay rate in the QD, (e) QD capture rate, and (f) total number of QDs.

## Conclusions:-

In conclusion, a model for QD- chaotic system dynamics was proposed in this report. An evidence of the complex periodic and chaotic mixed-mode oscillations in a QD without feedback. The capture rate takes the system to different dynamics, i.e., more control.

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