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Dynamical effects of optical feedback on InAs/ InGaAs Quantum dot semiconductor laser

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Abstract:

Quantum dot semiconductor InAs/ InGaAs laser subject to optical feedback is examined .The effect of control parameters viz. feedback strength , linewidth enhancement factor ,delay time and optical confinement factor are studied . Rich dynamics are observed ranging from steady state output ,oscillatory one in the shape of period one and period two to chaotic one

Keywords : Quantum dot laser, Optical feedback ,Periodic and chaotic output.

1.Introduction:

Since the early days of lasers ,the problem of feedback appeared to be inevitable facing the people working in the field of laser interaction with matter for example the experiments concerning frequency generation or injection locking [1].Part of the incident light is back reflected to laser cavity causing problems like instabilities in power level and frequency and at the same times leads to disappearance of the laser output ,a phenomena nowadays called death by delay[2].

Since the pioneer work of Lang and Kobayashi the problem of feedback in semiconductor lasers (SCLs)where it has been discussed and investigated thoroughly from the experimental part and theoretical one [3], enormous attention has been paid toward the study of feedback and many techniques have been explored and studied for different reasons . Kitching etal [4] have used weak ,dispersive optical feedback ,which led to the amplitude noise reduction in SCL ,Yousefi etal [5] have used filtered optical feedback to control the nonlinear dynamics of a SCL ,Lin and Liu [6] have used an optoelectronic feedback system applied to an optically injected SCL ,Zhong etal [7] have used phase –conjugated feedback in synchronization and communication based SCLs, Blin etal [8] have used a distributed feedback to study a spectral and time phenomena in optical injection SCL ,Guignard etal [9] have used a nonlinear optical feedback to study the phenomena harmonic in passive mode locked single-frequency SCL ,Li et al [10] has used a negative optoelectronic feedback system to control the nonlinear dynamics in external –cavity VCSELs ,etc . The study of feedback effect has not stopped in different directions [11-13]

A SCL on its own exhibits only simple dynamics :any perturbation of its steady state is damped out in an oscillatory behavior with a frequency corresponding to the so-called relaxation oscillation frequency. The dynamics of freedom linked to external perturbations may lead to highly complex nonlinear dynamics and bifurcations ,such as period doubling ,quasiperiodicity, or even chaotic regimes .A fundamental understanding of the nonlinear dynamics of externally driven SCLs is a major issue in any applications where instabilities needs to be avoided or controlled. On the other hand ,laser instabilities may also be considered as useful to develop new specific applications .For example ,synchronized optical chaos in coupled lasers can be implemented in data encryption and secure communication systems[14].SCLs with optical feedback are both of fundamental and practical importance and in general sense these belong to the class of delay systems. Optical feedback can increase emission noise, broaden or narrow the laser linewidth under specific conditions. The coherence length of the laser emission can be reduced to as little as a few centimeters at high feedback level. Such effect is referred to as coherence collapse[15], or feedback regime IV. Coherence collapse also causes a dramatic increase in laser linewidth and a substantial increase in optical intensity noise [16 ,17]. SCLs are commonly used for storage and retrieval of informations in optical recording systems .A measure of the importance of this emerging optoelectronic technology is provided by the compact –disc players that have already penetrated the consumer electronic market. The same technique is now being extended to the mass storage devices capable of storing gigabytes informations on a single optical disc. Although optical disc –based mass storage devices are already available commercially, several technological problems must be solved to further improve their performance. One such problem is related to the control of relative intensity noise of SCLs used inside the optical head for reading and writing data from/to the optical disc .A small fraction of the laser output is invariably fedback into the SCL because of the reflection occurring at the disc surface .Even at low levels of feedback (< 0.1%) in intensity an undamped relaxation oscillation followed by excitation of external cavity modes and finally catastrophic increase in laser linewidth and instabilities can occur[18].

Quantum –dot (QD) laser have attracted much attention in recent years due to their superior properties ,such as ultra –low and temperature –stable threshold current density, high –speed operation ,and low frequency chirping [19]. These properties together with the low linewidth enhancement factor and broad spectrum, make QD materials extremely attractive for applications as light emitters or amplifier, compact disc players and laser printer ,and play critical roles in optical communication schemes .In all these applications part of the output power of the QD laser can be feedback to the laser cavity where it can affect ,as it was mentioned earlier, all the dynamics of the QDLs . In this article we presents the results of an numerical experiments carried out to investigate the effect of optical feedback on the QDLs dynamics.

2.Rate equations model:

The model used in this work to study the dynamics of InAs/InGaAs quantum dot laser under the effect of feedback is based on the work of Ludge etal[20 ,21].The details dynamics and theoretical setup are shown in figures (1 and 2) .QD laser under optical feedback is considered to consist of a gain section of length L that contains the layers of self organized QDs as the active medium ,and a feedback section given by a mirror at a distance l with respect to the end facet of the QD laser, reflecting back the light into the gain region (see figure 2 [22]).The gain section of the QD laser is modeled by a microscopically based rate equations system [20].It allows for separate treatment of electron and hole dynamics in the QD as well as the surrounding wetting layer (WL) .

The energy scheme of the QD laser is shown in figure (1)[22].The present system of equations reads:

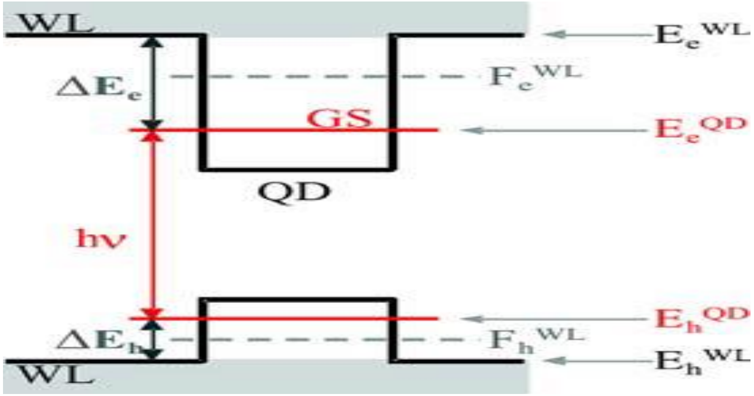

Figure 1: Energy diagram of the QD and WL system[23].

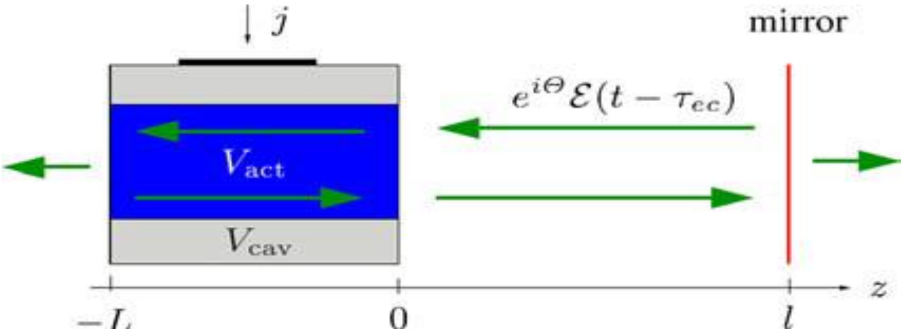

Figure 2: Schematic setup of the considered QD laser device with optical feedback from a short external cavity[22,23].

$$\dot{n}_e = -\frac{1}{\tau_e} n_e + S_e^{in} N^{QD} - \Gamma R_{ind}(n_e, n_h, n_{ph}) - R_{sp}(n_e, n_h) \qquad (1)$$

$$\dot{n}_h = -\frac{1}{\tau_h} n_h + S_h^{in} N^{QD} - \Gamma R_{ind}(n_e, n_h, n_{ph}) - R_{sp}(n_e, n_h) \qquad (2)$$

$$\dot{w}_e = \frac{j(t)}{e_o} + \frac{n_e}{\tau_e} \frac{N^{sum}}{N^{QD}} - S_e^{in} N^{sum} - \tilde{R}_{sp}(w_e, w_h) \qquad (3)$$

$$\dot{w}_h = \frac{j(t)}{e_o} + \frac{n_h}{\tau_h} \frac{N^{sum}}{N^{QD}} - S_h^{in} N^{sum} - \tilde{R}_{sp}(w_e, w_h) \qquad (4)$$

$$\dot{n}_{ph} = -2k n_{ph} + \Gamma R_{ind}(n_e, n_h, n_{ph}) + \beta R_{sp}(n_e, n_h) + 2\frac{K}{\tau_{in}} \sqrt{n_{ph,\tau_{ec}} n_{ph}} \cos(\phi - \phi_{\tau_{ec}} + \Theta) \qquad (5)$$

$$\dot{\phi} = \frac{\alpha}{2} \left\{ \Gamma W A (n_e + n_h - N^{QD}) - 2k \right\} - \frac{K}{\tau_{in}} \sqrt{\frac{n_{ph,\tau_{ec}}}{n_{ph}}} \sin(\phi - \phi_{\tau_{ec}} + \Theta) \qquad (6)$$

n_e, w_e, n_h and w_h are the densities of electrons and holes in the QD and WL respectively

n_{ph} is the density of photons . The induced processes of absorption and emission are modelled by a linear gain $R_{ind}(n_e, n_h, n_{ph}) = WA(n_e + n_h - N^{QD}) n_{ph}$. The spontaneous emission in the QDs is approximated by $R_{sp}(n_e, n_h) = (W / N^{QD})\, n_e\, n_h$ .The spontaneous recombination rate in the WL is given by $\tilde{R}_{sp}(w_e, w_h) = B^S w_e w_h$ where B^S is the band–band recombination coefficient in the WL. $\Gamma = \Gamma_g N^{QD} / N^{sum}$ is the optical confinement factor and Γ_g is the geometric confinement factor. N^{sum} is twice the density of the total QD and N^{QD} denotes twice the QD density of the lasing subgroup (the factor 2 account for the spin degeneracy) . W is the Einstein coefficient and A is the wetting layer normalized area . β is the spontaneous emission coefficient , $j(t)$ is the injection current density, e_o is the electronic charge .

2κ is the optical intensity loss, α is the linewidth enhancement factor and K is the strength of the optical feedback . Nonradiative carrier–carrier scattering rates (nonlinear scattering rates) S_e^{in} and S_h^{in} for electron and hole capture into the QD levels, S_e^{out} and S_h^{out} for carrier escape from the QD levels, and scattering times $\tau_e = (S_e^{in} + S_e^{out})^{-1}$ and $\tau_h = (S_h^{in} + S_h^{out})^{-1}$. τ_{in} is the time given by the single –pass time of gain region, $\tau_{in} = L / c_m$ where c_m is the speed of light inside the gain region. The phase shift of light during one round trip in the external cavity ($\tau_{ec} = 2l / c$) is given by $\Theta = \omega_{th} \tau_{ec}$ with ω_{th} denoting the frequency of the solitary laser at lasing .The number of photon labeled by the subscript τ_{ec} i.e $n_{ph,\tau_{ec}}$ and the optical phase ϕ_{ec} are taken at the delayed time $(t - \tau_{ec})$. ϕ is the electric field phase.

3.Results and discussions:

The set of equations (1-6) describes the overall dynamics of an QDL under the effect of feedback .Many distinct control parameters that can play the roles of these control parameters viz feedback strength, *K*and the round- trip time in the external cavity , τ_{ec} , which appeared in equation (5),the phase , Θ , and the confinement factor, Γ .The set of equations (1-6) was solved using the Runge –Kutta numerical method of the fourth order and the Mat-lab system making use of certain initial conditions .Table 1 shows the parameters values used in the calculations and obtaining the results[22] .

Table 1 :Parameters values used in the simulations

symbol	value	symbol	value
W	$0.7\ \mathrm{ns}^{-1}$	A	$4\times10^{-5}\ \mathrm{cm}^2$
α	0.9	N^{QD}	$0.6\times10^{10}\ \mathrm{cm}^{-2}$
2κ	$0.1\ \mathrm{ps}^{-1}$	N^{sum}	$20\times10^{10}\ \mathrm{cm}^{-2}$
Γ_g	0.075	β	5×10^{-6}
Γ	2.25×10^{-3}	B^S	$540\ \mathrm{ns}^{-1}\ \mathrm{nm}^2$
Θ	π	$\tau_{\mathrm{in}}(L)$	$24\ \mathrm{ps}$
T	$300\ \mathrm{K}$	$\tau_{\mathrm{ec}}(l)$	$160\ \mathrm{ps}$
ΔE_e	$190\ meV$	ΔE_h	$69\ \mathrm{meV}$
m_{e}	$0.043\ m_0$	m_{h}	$0.45\ m_0$
λ	$1.3\ \mu\mathrm{m}$	$\omega_{\mathrm{th}}/2\pi$	$230\ \mathrm{THz}$

3.1: The effect of feedback strength , *K*:

Varying K in the range 0.12-0.228 and keeping τ_{ec} =160 *ps* and $\alpha = 0.9$, the followings were noticed :bifurcation scenario is noticed which followed by chaotic output then multi chaotic state appears which ends up with pulsating output or self-pulsating output which can be regarded as multi-chaotic state(see figure 3 for more details) .When varying K through 0.11-0.2 and taking $\alpha = 0.9$ while τ_{ec} =180 *ps* the system follows the same previous trend .The same trend happen again for low K values and higher delay time , τ_{ec} (see figure 4).

Varying K in the range 0.08-0.225 and keeping (τ_{ec} =150 *ps* , $\alpha = 2$) we have noticed the followings: The system follows the same trend noticed in the previous case , see fig(5) . Keeping the parameters values constant (τ_{ec} =160 *ps* , $\alpha = 2$) and varying K from 0.08 to 0.7 we have noticed the followings : period 1(P.1) appeared first at *K*=0.08 which switch to the ordinary output signal that usually obtained from an ordinary SCLs. Chaotic signal overcome the output when $K \geq 0.15$ then at *K*=0.5 p.1 reappeared that followed with multistable output at *K*=0.6, see figure 6

By varying K through 0.1-0.18 and keeping (τ_{ec} =180 *ps* , $\alpha = 2$) p.1 reappeared followed by p.3 then the system settled at p. 2 after some –kind of instability .When *K*=0.08 and $\alpha = 2$ while τ_{ec} =200 *ps* the system started with p.1 at *K*=0.08 then chaotic state appeared at *K*=0.15 . The system ends up with steady state output after passing through chaotic one ,as shown in figure (7). For the same variation of K with $\tau_{ec} = 160\ ps$ and higher values of the linewidth enhancement factor ,α , the results reveals the richness of the dynamics that can be obtained from the InAs/InGaAs QD laser as can be seen in figures (8-11).

3.2: The effect of confinement factor , Γ :

Keeping K=0.08 , τ_{ec} =160 ps ,$\Theta=\pi$, $\alpha=0.9$, varying Γ through 0.0011-0.0025 ,the output signal have the usual QD laser shape which increased in level for increasing Γ which is in the shape of rising edge representing the transient regime followed by constant output . As Γ increased through the same range the oscillating behavior in the transient region enhanced followed by the constant output. Keeping τ_{ec} =160 ps ,$\Theta=\pi$, $\alpha=0.9$ while K=0.12 the system start with ordinary output signal that breaks to P.1 output, as can be seen in figure12. As K increased to 0.18 while τ_{ec} =160 ps ,$\Theta=\pi$, $\alpha=0.9$ the system breaks into oscillator p.1 output for small Γ values then it switch to period 3 state as can be seen in fig.(13). The self –pulsating output appeared once more for K = 0.225 keeping the rest parameters at the same values as can be seen in fig.14. For α = 2, τ_{ec} =160 ps and Γ=0.001-0.0025 we have noticed the following: The usual output is followed by p.1 then chaos followed by p.1 once more and chaos appears again ,see figure 15. Keeping all parameters invariant while K=0.18 the same behavior appears again. For K= 0.2 the period 3 state appears .For even higher values of K special behavior appears in the output of the QDLs as can be seen in fig 16. For even higher values of α, K and the same parameters values the system generated an oscillatory output almost p.1 after the transient region ,as can be seen in figure 17.

The gain in the presence of optical feedback depends on the round trip time τ_{ec} and it changes periodically for the variation of the external cavity length. The mode for the maximum gain is attained at $\omega\tau = 2m\pi$ (m being an integer). As the gain varies depending on the optical feedback level one can control or suppress the adjacent modes from the main oscillation mode by using the gain difference when the external mirror is positioned close to the laser facet. The linewidth with optical feedback at the maximum gain condition is always less than the value of the solitary oscillation .These results holds for stable laser operations even when the laser is subjected to optical feedback. However, for optical feedback above a certain level, the laser does not oscillate at one of the modes but many modes are simultaneously excited or even drifting or wandering among the modes (external modes and antimodes) occur .Such oscillations give rise to much noise (actually chaotic fluctuations) and even result in the collapse of coherent [15,16] . At this state ,the linewidth of the laser is much broadened. However, the coherence of the laser recovers and the linewidth becomes narrow for a sufficiently strong optical feedback.

The optical feedback affects the noise and dynamics of the laser in different ways[24], depending on the length of the external cavity and the strength of the feedback .It is common to divide these different effects into five regimes of feedback [17] .For the level of optical feedback common in optical recording systems ,one is interested primarily in regime II through IV .Briefly ,regime II is characterized by mode hopping between external cavity modes ,regime III by the possibility of frequency locking to one mode of the external cavity ,and regime IV by a drastic reduction of the laser coherence length ("coherence collapse ") caused by the severe broadening of the laser line .The optical feedback in the write-once optical data recording systems is in the range 1-2%,falling into regimes II through IV.

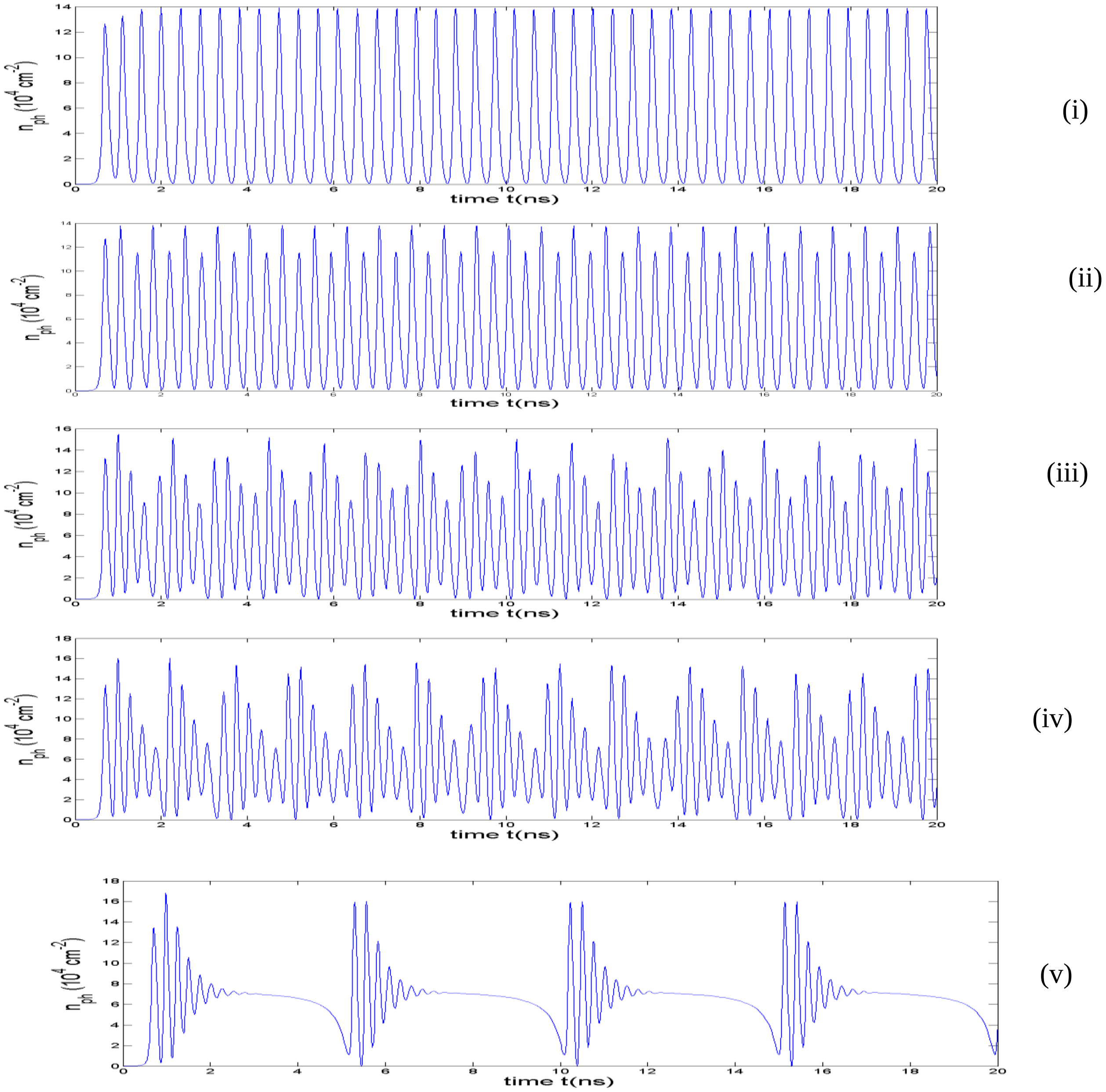

Figure (3):Time series of photon density (n_{ph}) for selected τ_{ec} , α and K : (i) 160, 0.9, 0.12 ; (ii) 160, 0.9, 0.15;(iii) 160, 0.9, 0.2; (iv) 160, 0.9, 0.21; (v) 160, 0.9, 0.228.

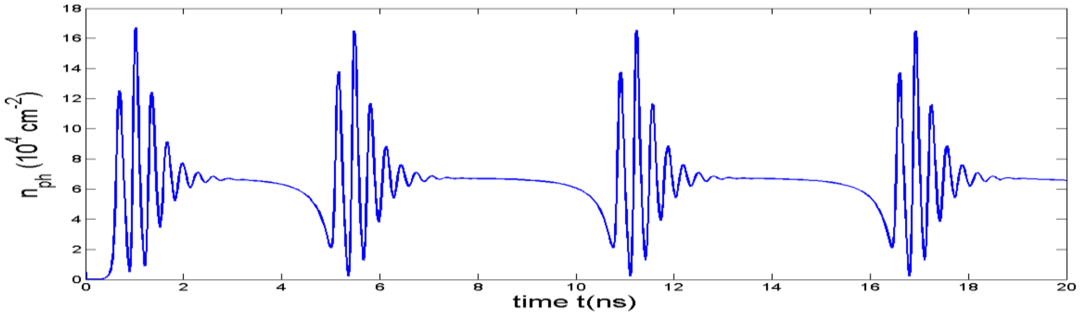

Figure (4): Time series of photon density (n_{ph}) for selected τ_{ec} , α and K : 200, 0.9, 0.185.

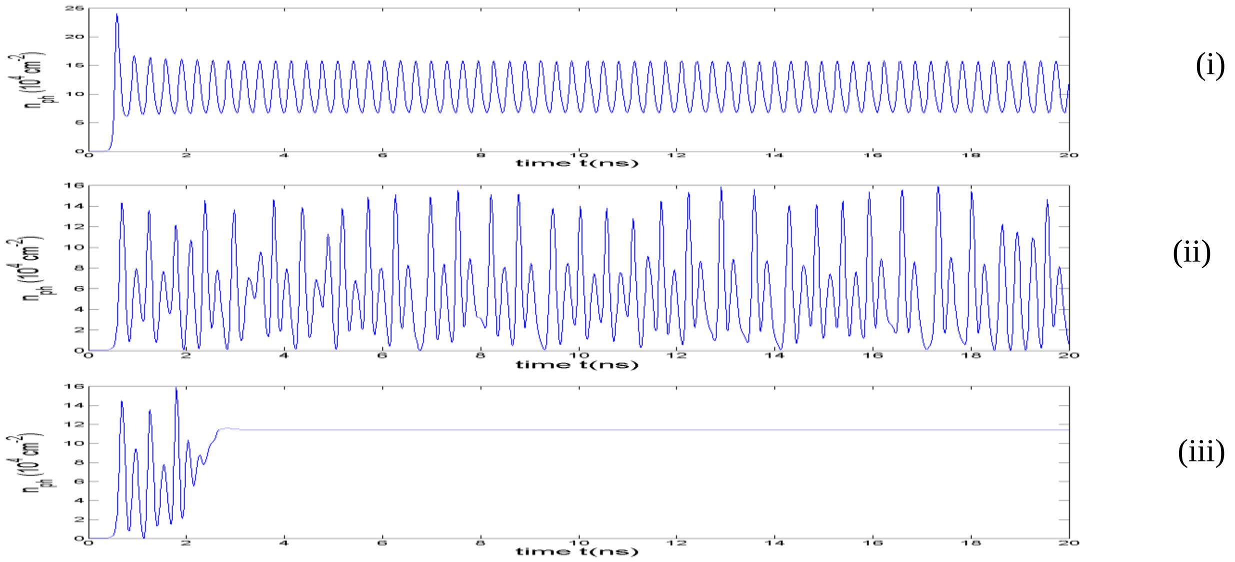

Figure (5): Time series of photon density (n_{ph}) for selected τ_{ec} , α and K : (i) 150, 2, 0.08 ; (ii) 150, 2, 0.21;(iii) 150, 2, 0.225.

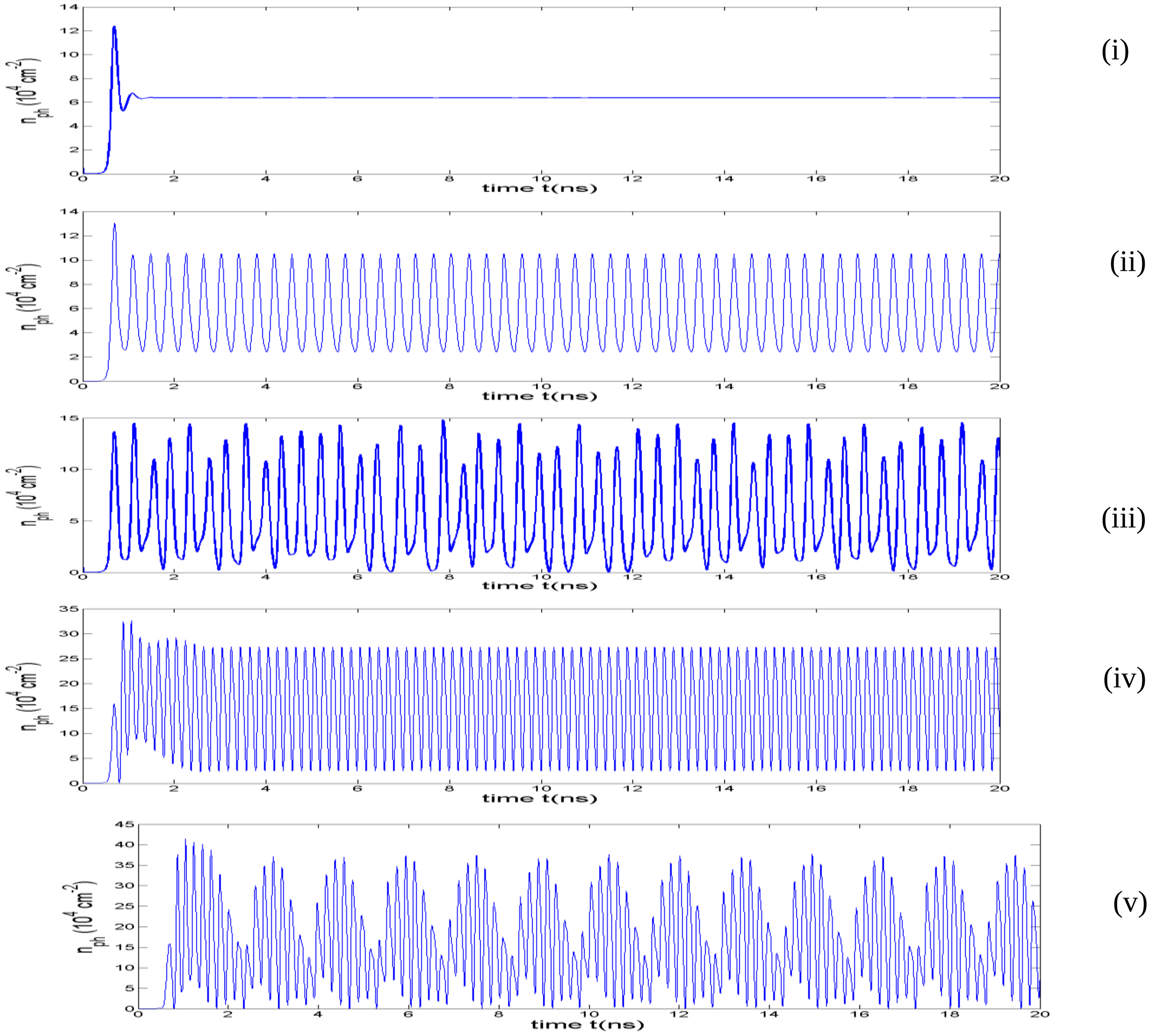

Figure (6): Time series of photon density (n_{ph}) for selected τ_{ec} , α and K : (i) 160, 2, 0.01 ; (ii) 160, 2, 0.08;(iii) 160, 2, 18; (iv) 160, 2, 0.5; (v) 160, 2, 0.6.

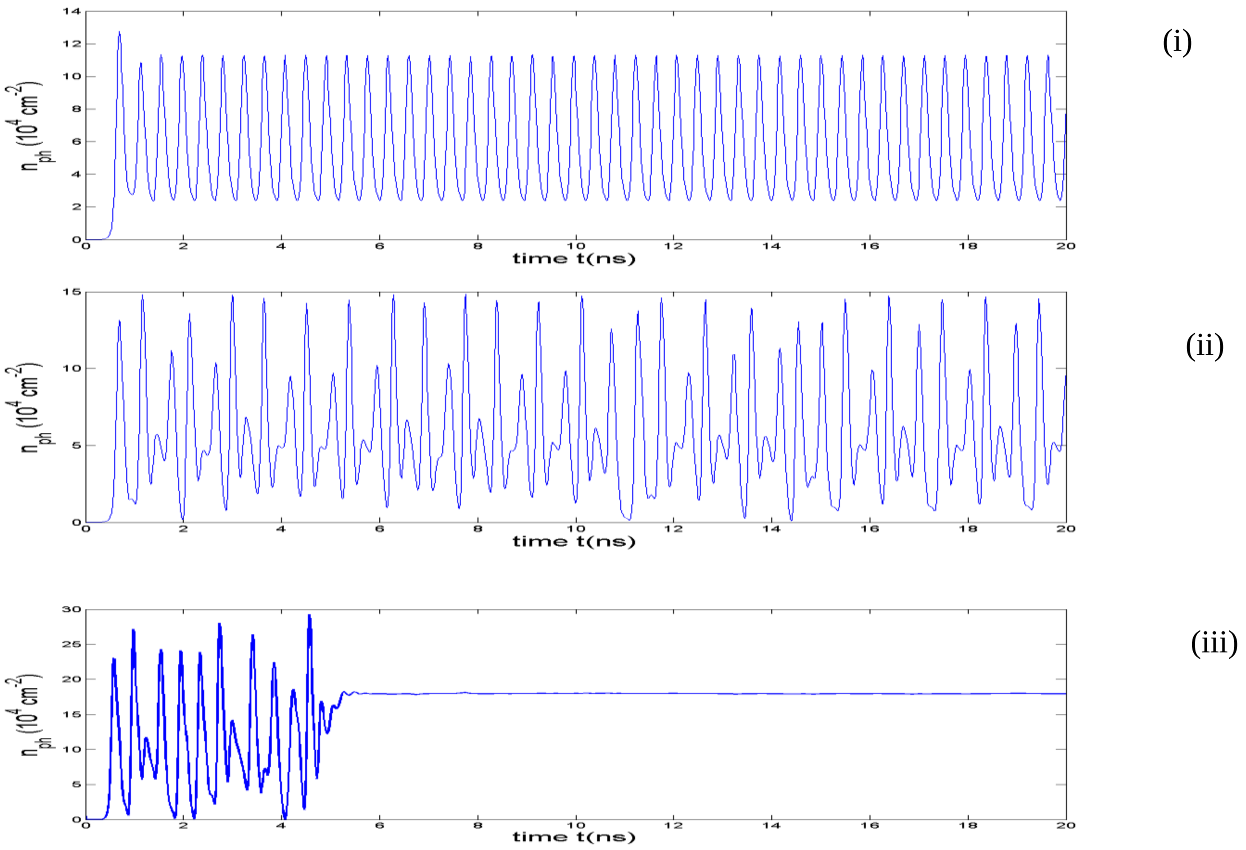

Figure (7): Time series of photon density (n_{ph}) for selected τ_{ec} , α *and* K : (i) 200, 2, 0.08 ; (ii) 200, 2, 0.15;(iii) 200, 2, 0.18.

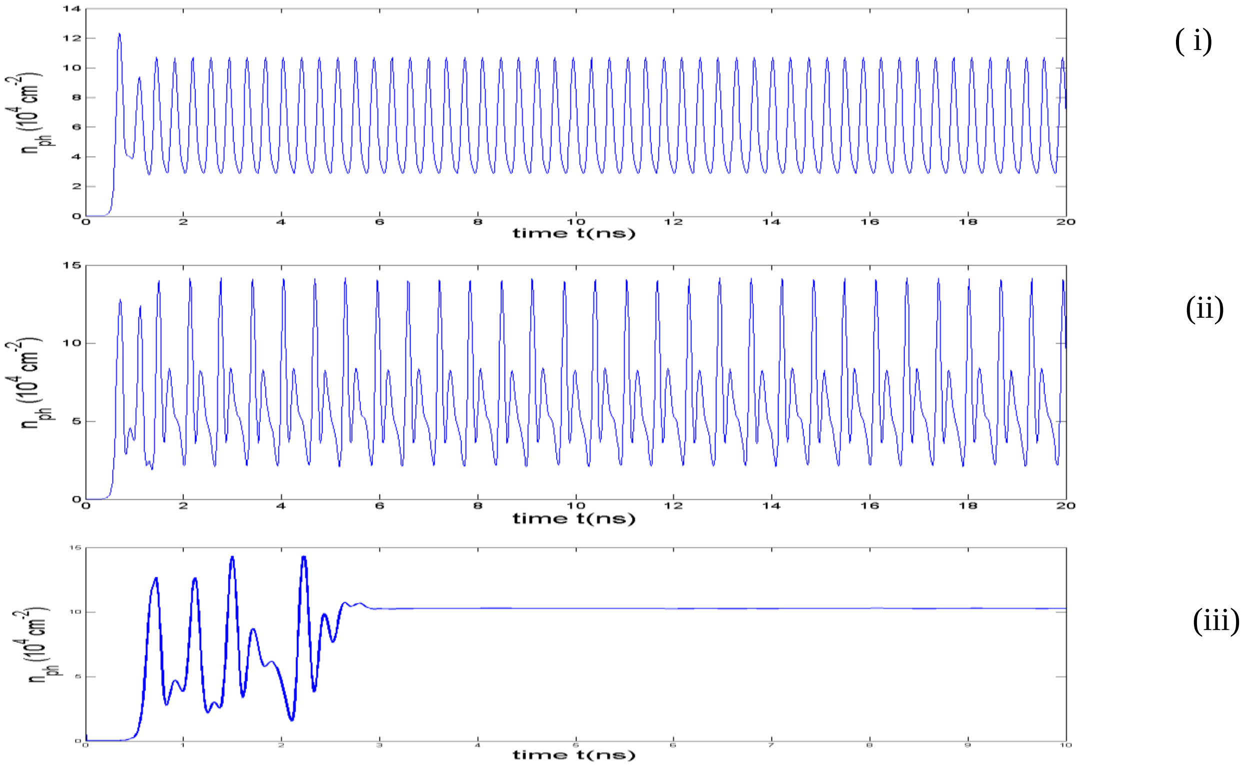

Figure (8): Time series of photon density (n_{ph}) for selected τ_{ec} , α *and* K : (i) 150, 3.2, 0.08 ; (ii) 150, 3.2, 0.17;(iii) 150, 3.2, 0.18.

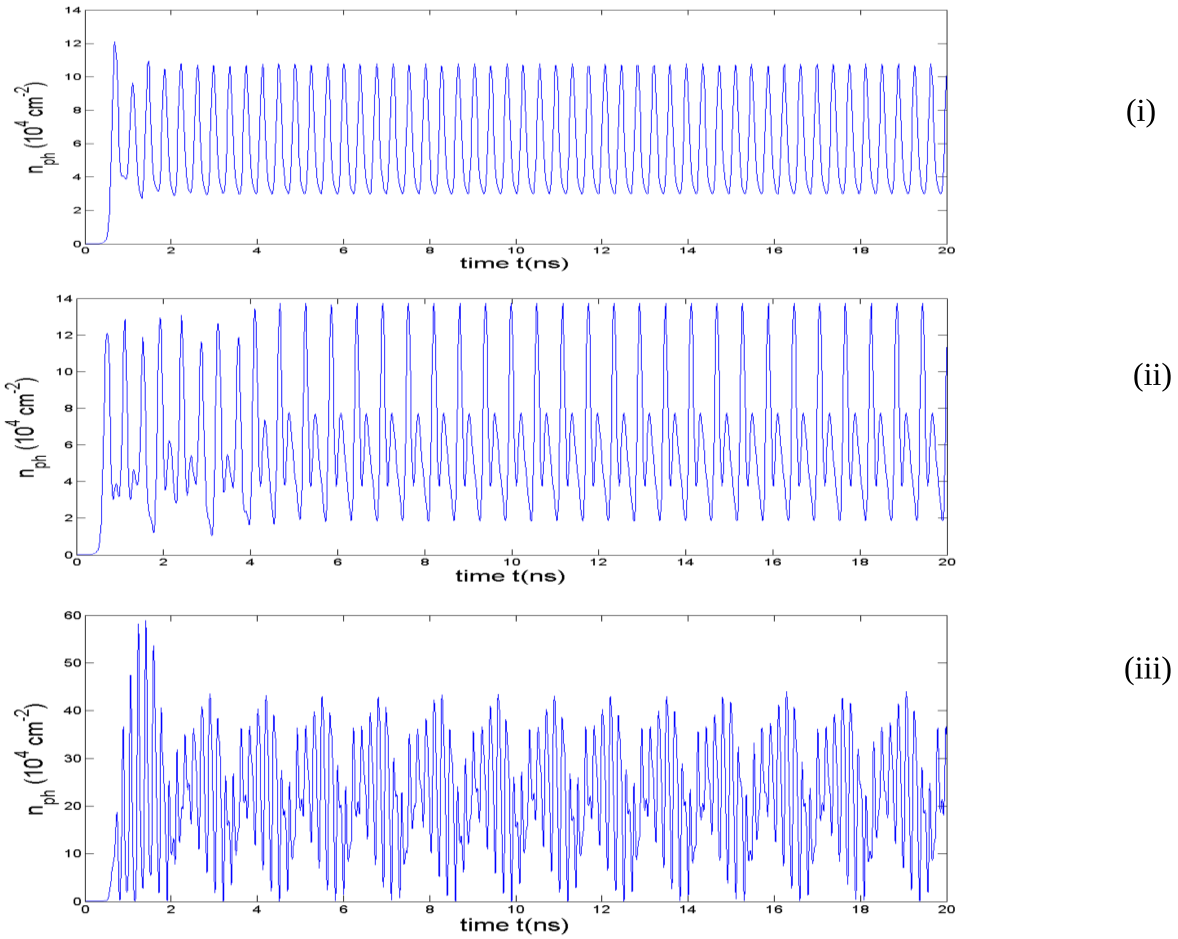

Figure (9): Time series of photon density (n_{ph}) for selected τ_{ec} , α and K : (i) 160, 3.2, 0.08 ; (ii) 160, 3.2, 0.15;(iii) 160, 3.2, 0. 7.

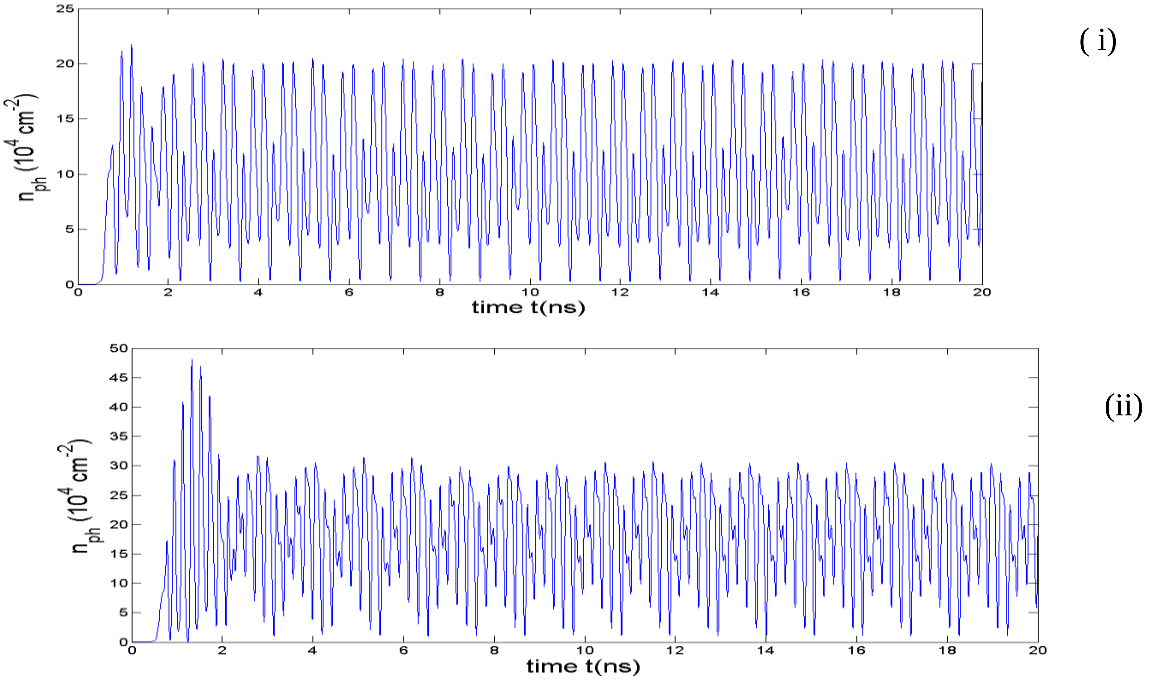

Figure (10): Time series of photon density (n_{ph}) for selected τ_{ec} , α and K : (i) 180, 3.2, 0.35 ; (ii) 180, 3.2, 0.4.

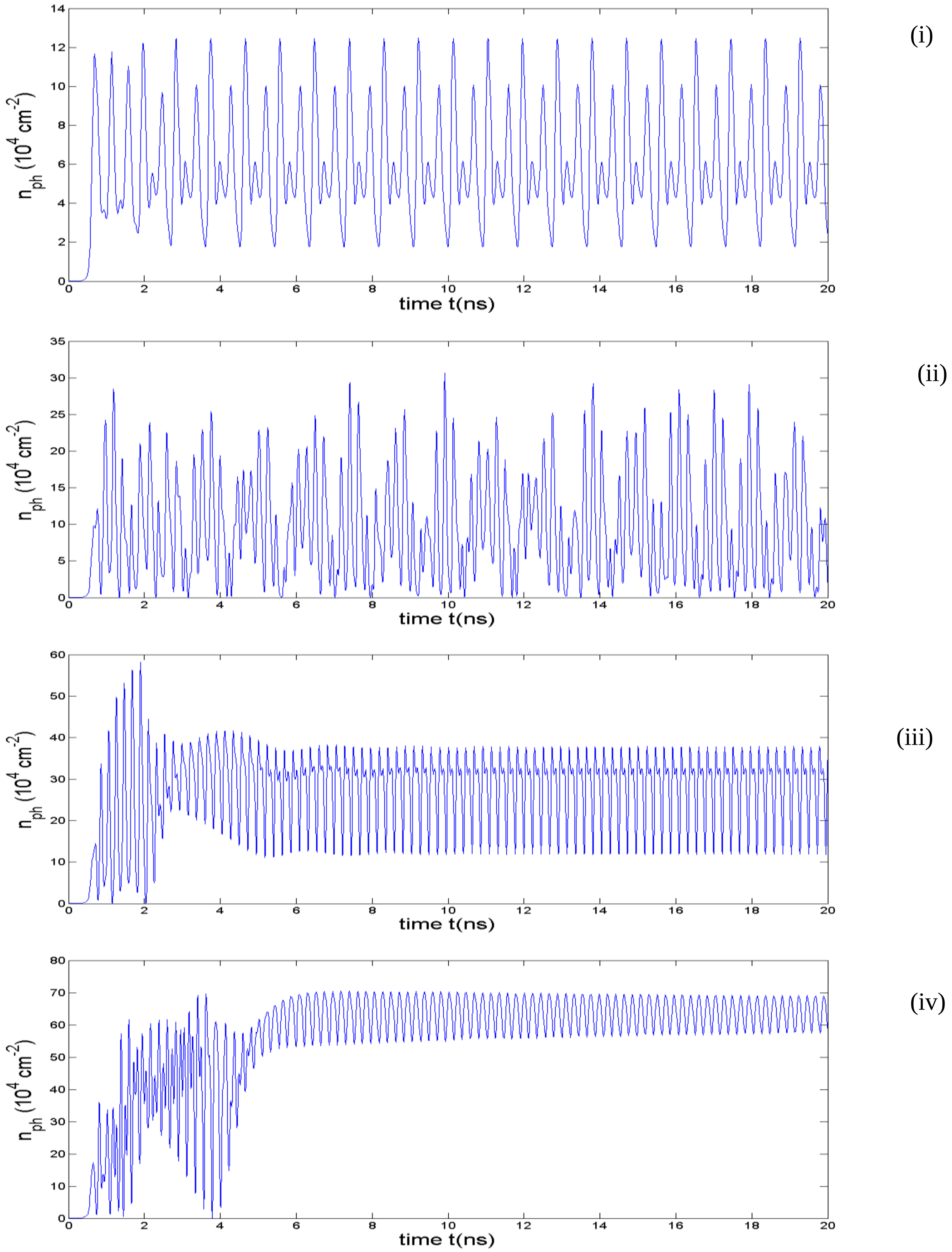

Figure (11): Time series of photon density (n_{ph}) for selected τ_{ec} , α and K : (i) 200, 3.2, 0.1 ; (ii) 200, 3.2, 0.4;(iii) 200, 3.2, 0.7; (iv) 200, 3.2, 0.9.

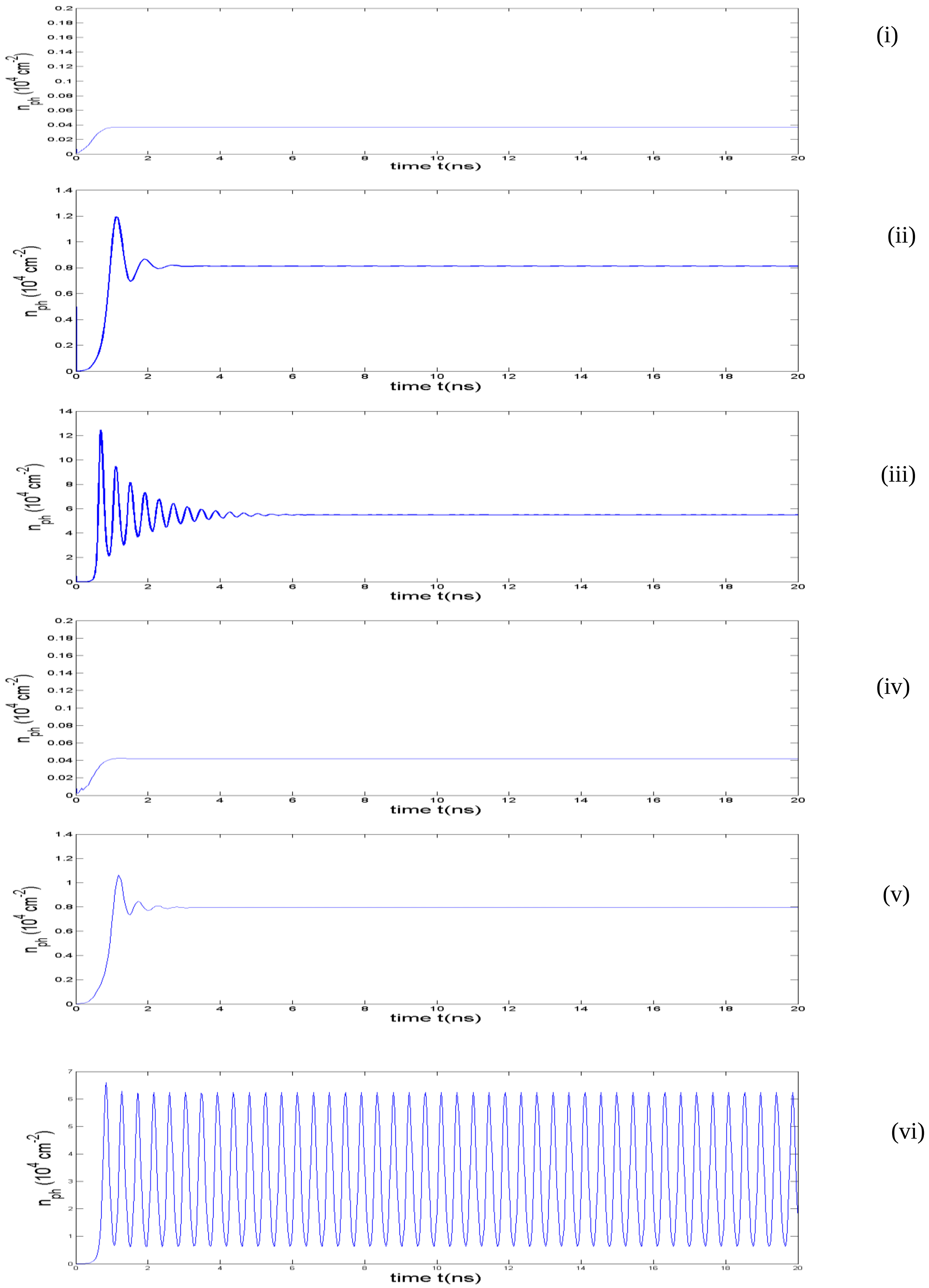

Figure (12): Time series of photon density (n_{ph}) for selected Γ , α and K : (i) 0.0011, 0.9, 0.08 ; (ii) 0.00175, 0.9, 0.08;(iii) 0.00225, 0.9, 0.08; (iv) 0.0011, 0.9, 0.12; (v) 0.0015, 0.9, 0.12; (vi) 0.00225, 0.9, 0.12.

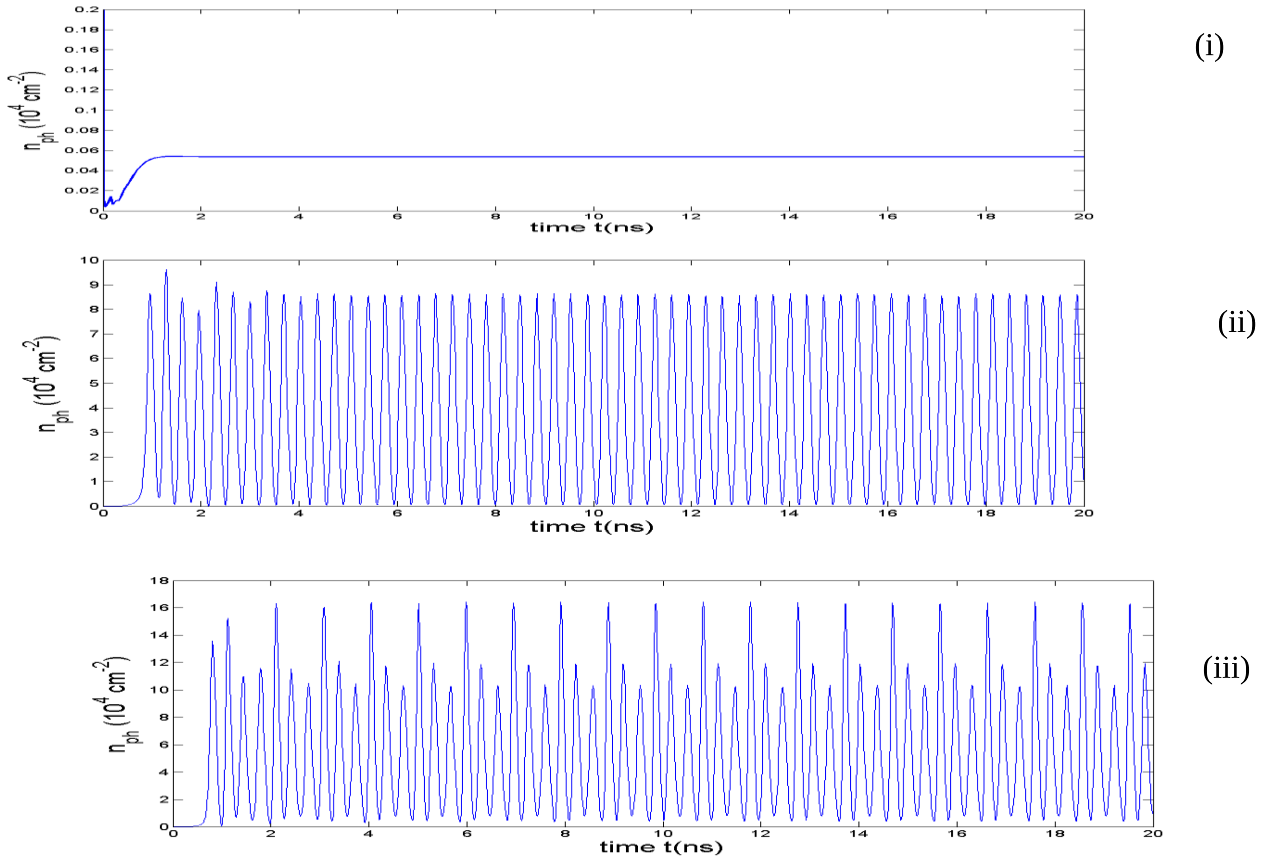

Figure (13): Time series of photon density (n_{ph}) for selected Γ , α and K : (i) 0.0011, 0.9, 0.18 ; (ii) 0.00175, 0.9, 0.15;(iii) 0.002, 0.9, 0.18.

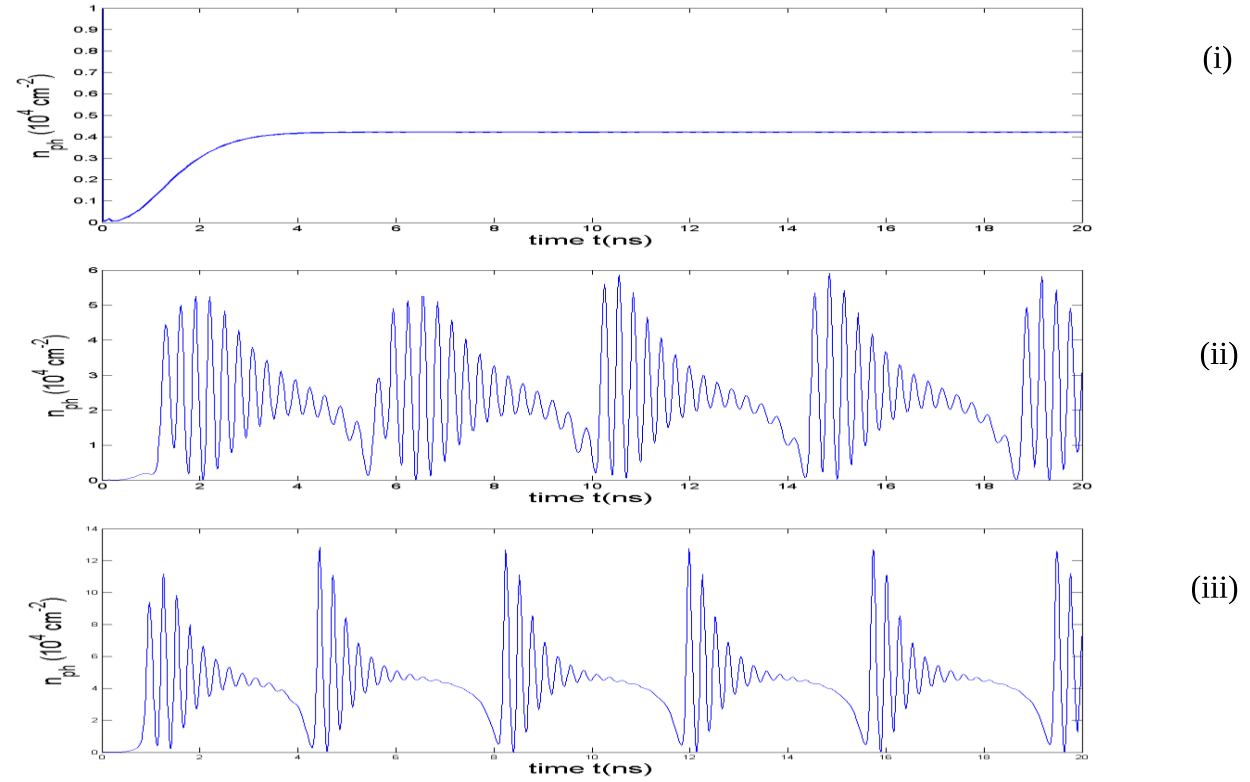

Figure (14): Time series of photon density (n_{ph}) for selected Γ , α and K : (i) 0.0011, 0.9, 0.225 ; (ii) 0.0015, 0.9, 0.225;(iii) 0.00175, 0.9, 0.225.

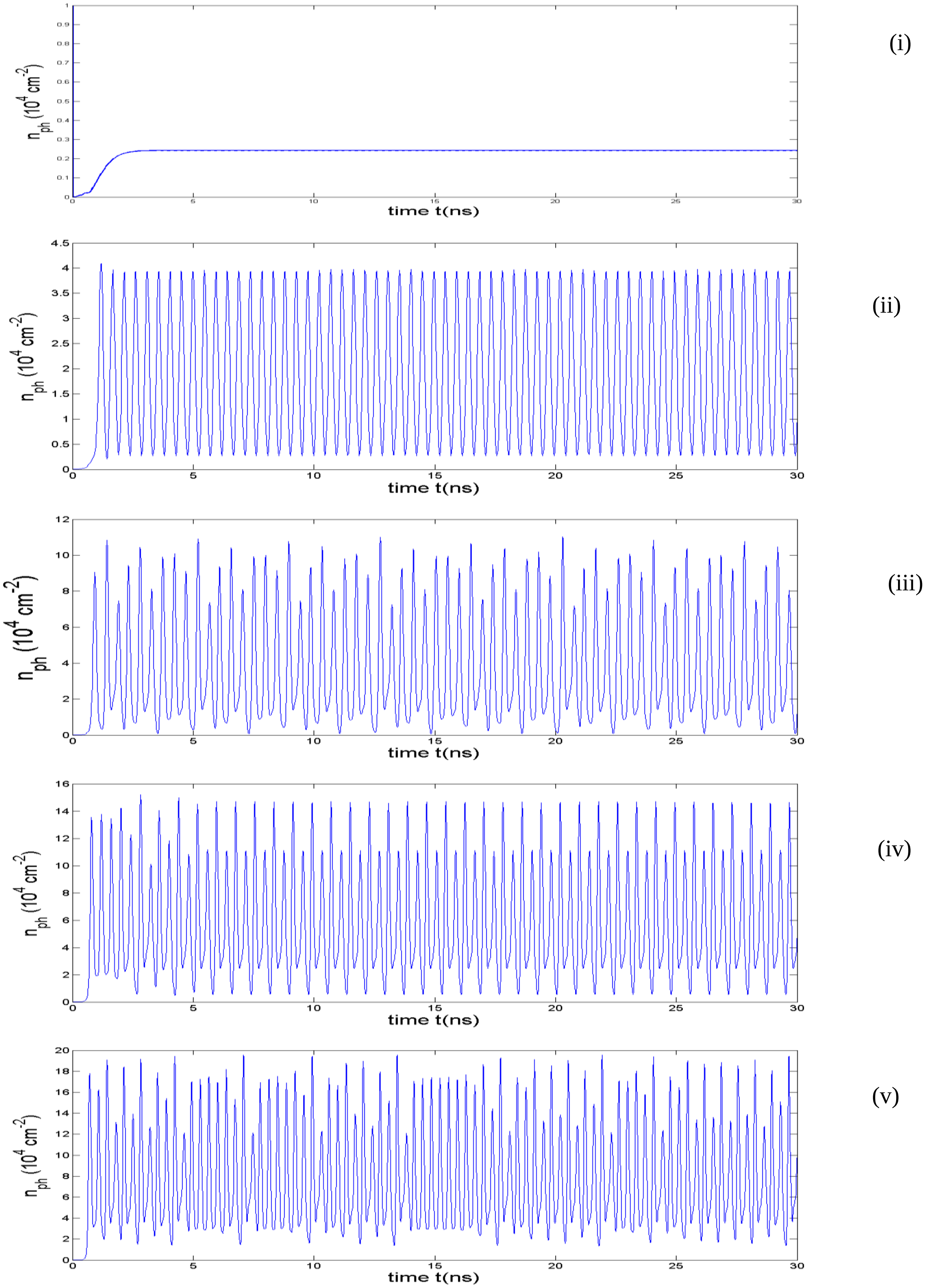

Figure (15): Time series of photon density (n_{ph}) for selected Γ , α and K : (i) 0.0011, 2, 0.12 ; (ii) 0.0015, 2, 0.15;(iii) 0.00175, 2, 0.12; (iv) 0.002, 2, 0.12; (v) 0.00225, 2, 0.12.

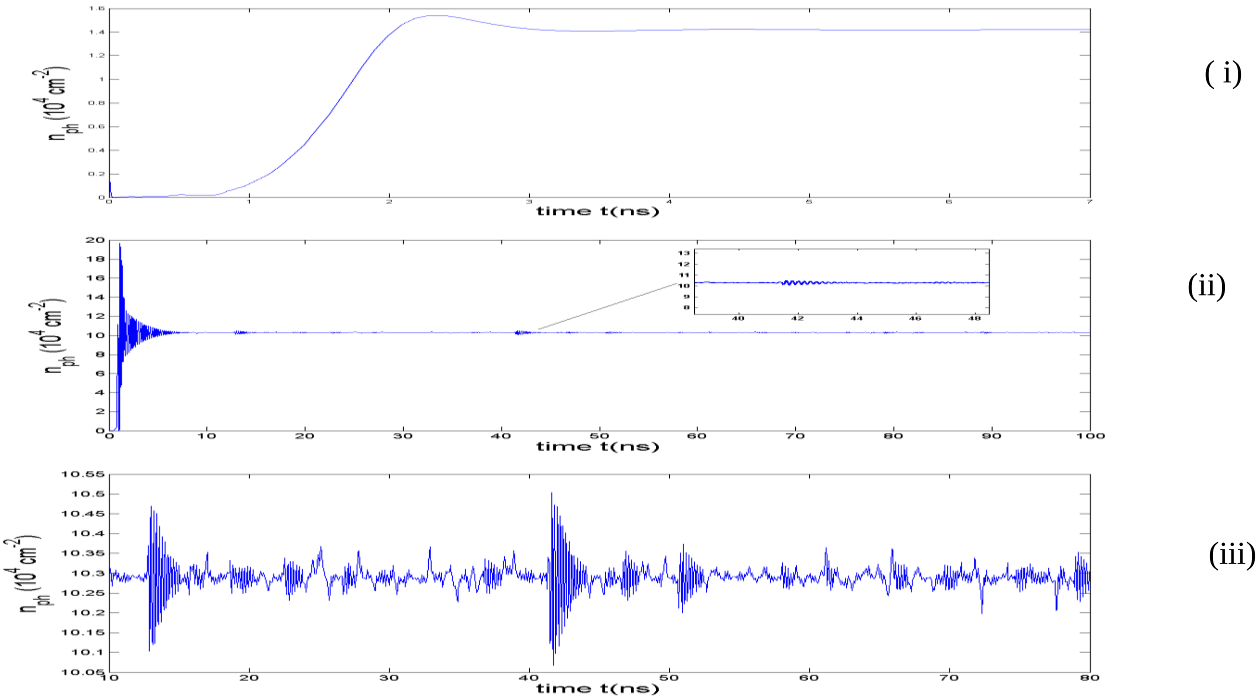

Figure (16): Time series of photon density (n_{ph}) for selected Γ , α and K : (i) 0.0011, 2, 0.24 ; (ii) 0.00175, 2, 0.4;(iii) 0.00175, 2, 0.4.

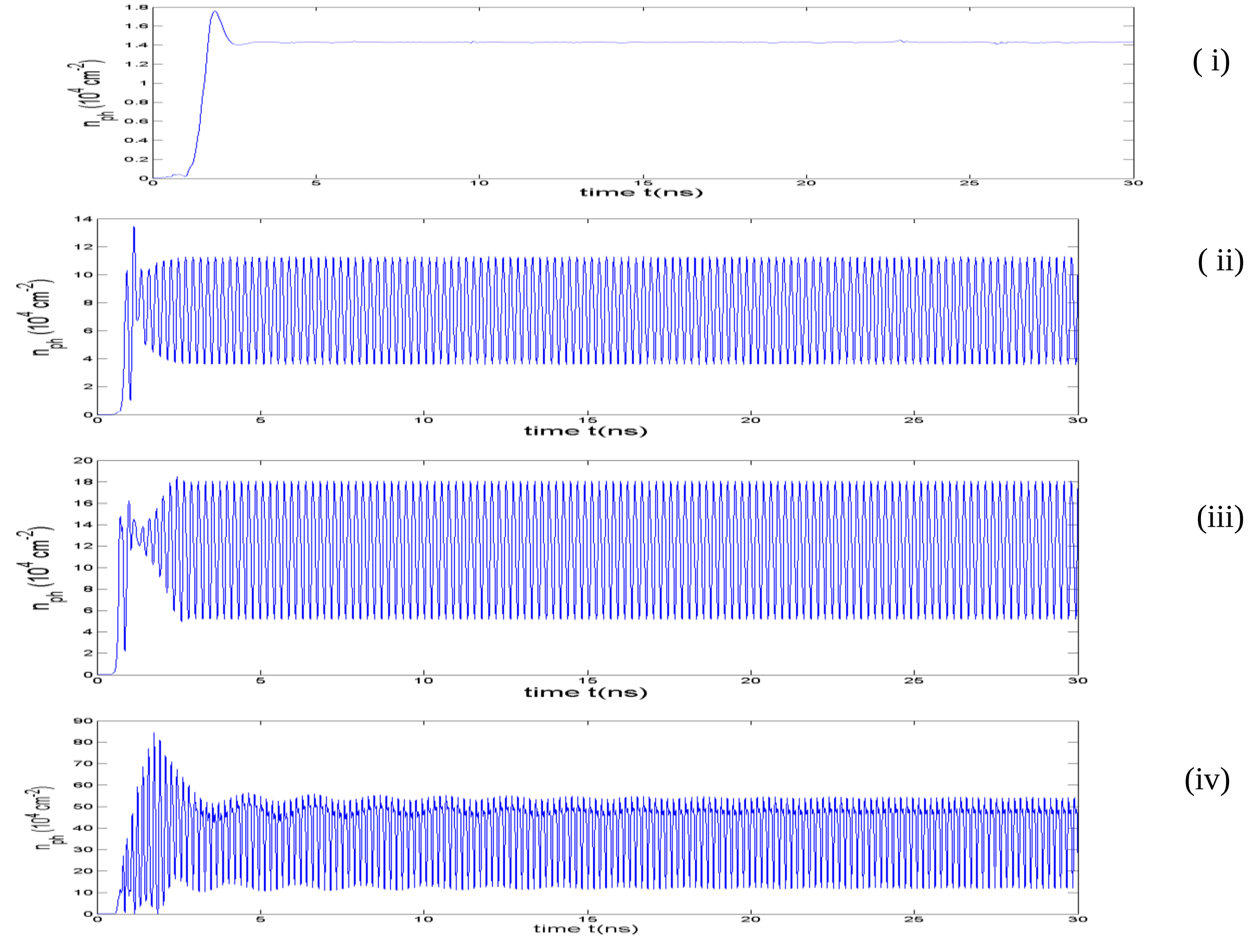

Figure (17): Time series of photon density (n_{ph}) for selected Γ , α and K : (i) 0.0011, 3.2, 0.3 ; (ii) 0.00175, 3.2, 0.3;(iii) 0.00225, 3.2, 0.3; (iv) 0.00225, 3.2, 0.9.

Conclusion:

The present work demonstrate that quantum dot semiconductor InAs/InGaAs laser under the effect of optical feedback is able to show various dynamical behaviors. These behaviors are in the shape of steady state output ,period two state up to chaotic one .Chaotic output is important in the chaotic communications .The effects of control parameters are studied viz , the feedback strength ,linewidth enhancement factor, delay time and optical confinement factor.

References:

1-C.A.Emshary ,Mode control of TEA CO_2 lasers :Application to nonlinear optics,
PhD thesis ,Heriot-Watt University, Scotland ,UK (1984).

2-S.H.Strogatz ,Death by delay ,Nature ,394,316-317(1998).

3-R.Lang and K.Kobayashi ,External optical feedback effects on semiconductor injection laser properties ,IEEE J.Quant.Electron., 16,347-355(1980).

4-J.Kitching ,R.Boyd ,A.Yariv ,and Y.Shevy ,Amplitude noise reduction in semiconductor lasers with weak,dispersive optical feedback,Opt.Lett,19,1331-1333(1994) .

5-M.Yousefi ,D.Lenstra ,G.Vemuri and A.Fischer ,Control of nonlinear dynamics of a semiconductor with filtered optical feedback ,IEEE Semi.Opto-Elect.,148,233-237(2001).

6-F.Y.Lin and I.M.Liu ,Nonlinear dynamical characteristics of an optically injected semiconductor laser subject to optoelectronic feedback ,Opt. Commun ., 221,173-180(2003).

7-D.Zhong ,G.Xin ,Z.Wu, Synchronization and communication based on semiconductor lasers with phase-conjugated feedback, J.Opt.Elect.Adv.Mat.,6, 1233-1241(2004).

8-S.Blin ,O.Vaudel, T.T.Tam , P.Besnard ,S.Larochelle,R.Gabet, and G.M.Stephan ,Int .workshop on photonics and applications,Hanoi, Vietnam, April 5-8(2004) .

9-C.Guignard ,P.Besnard A.Mihaescu ,and N. Zheludev, Harmonic passive mode –locking of a single –frequency semiconductor laser submitted to nonlinear optical feedback ,IEEE J.Quant.Elect.,42,1185-1195(2006) .

10-X.Li,W.Pan,B.Luo,D.Ma,Control of nonlinear dynamics in external –cavity VCSELs with delayed negative optoelectronic feedback ,Chaos ,Solitons and Fractals,30,1004-1011(2006).

11- K.-H Lo , S.-K Hwang , and S.Donati , Optical feedback stabilization of photonic microwave period – one nonlinear dynamics of semiconductor lasers , Optics Express , 22 , 18648 - 18661 (2014)

12- A.A.Aguado , Experimental study of feedback – induced dynamics in semiconductor lasers : From symbolic analysis to sub wavelength position , PhD thesis ,computational aplicada por La Universitat , Politecnica de Catalunia , Spain (2014) .

13- T.Sorrentino,A.Aragoneses , S.Perrone , D.J.Gauthier ,M.C.Torreut and C.Masoller , Experimental study of the complex dynamics of semiconductor lasers with feedback via symbolic time series analysis , Semiconductor lasers and laser dynamic VI , Proc . SPIE , 9134 ,91340-L (2014)

14- J. Ohtsubo ,Semiconductor lasers ,stability ,instability and chaos ,Springer-Verlag Berlin Heidelberg (2008) .

15-T.Sano ,Antimode dynamics and chaotic itinerancy in the coherence collapse of semiconductor lasers with optical feedback ,Phys.Rev.A,50,2719-2726(1994) .

16-D.W.Sukow,J.R.Gardner,and
D.J.Gauthier, Statistics of power –dropout events in semiconductor lasers with –delayed optical feedback ,Phys.Rev.A,56,R3370-R3373(1997).

17-K.S.Thornburg,Jr,M.Moller ,and R.Roy ,Chaos and coherence in coupled lasers ,Phys.Rev.E,55,3865-3869(1997).

18-J.Ye,H.Li and J.G.McInerney , Period doubling route to chaos in semiconductor laser with weak optical feedback , Phys.Rev.A,47,2249-2252(1993).

19-"Semiconductor nanostructure for optoelectronic applications" T.Steiner,ed., Artech House ,Inc. Boston .London(2004).

20- K. Lüdge and E. Scholl, “Quantum-dot lasers—desynchronized nonlinear dynamics of electrons and holes,”IEEE J.QE, 45, 1396– 1403, Nov. (2009).

21-"Nonlinear laser dynamics ", Ed .K . Ludge ,Wiley –VCH Verlag GmBH and Co. KGaA ,Germany (2012) .

22- C.Otto ,K.Ludge and E.Scholl , Modeling quantum dot lasers with optical feedback :Sensitivity of bifurcation scenarios. Phys. Stat. solid. B ,247,829-845(2010).

23-C.Otto,B.Globisch,K.Ludge , and E.Scholl ,Complex dynamics of semiconductor quantum dot lasers subject to delayed optical feedback ,Int .J.Bifurcation and Chaos ,World Scientific Publishing Company (2012).

24- G.R.Gray ,A.T.Ryan ,G.P.Agrawal ,and E.C.Gage,Control of optical –feedback –induced laser intensity noise in optical data recording ,Opt.Eng.,32,739-745(1993).

حركيات ليزر شبه الموصل InAs/InGaAs نوع النقطة الكمية بتأثير التغذية العكسية البصرية

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مستخلص :

اختبر ليزر شبه الموصل InAs/InGaAs نوع النقطة الكمية بتأثير التغذية العكسية البصرية . درس تأثير بعض عوامل السيطرة وهي شدة أو مستوى التغذية العكسية ومعامل تعزيز عرض الخط وزمن التأخير وعامل الحصر البصري .لوحظت حركيات غنية امتدت من الخرج المستقر والمتذبذب على شكل دورة واحدة ودورتين إلى الخرج الفوضوي .