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Combined Effects of Intense THz Laser Field and Applied Electric Field on Binding Energy of Exciton in GaAs/ GaAlAs Finite Spherical Quantum Dot

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ABSTRACT

In this paper,we study the combined effects of intense THz laser field and electric field on the ground state binding energy of heavy hole excitons confined in GaAs/ GaAlAs spherical finite quantum dots. The formulation is based on the model of "laser dressed potential" which combines Coulomb interaction and field effect in only one potential as reported in the literature. The calculation is performed by using the variational method in the framework of the single band effective mass theory. Our results show that (i) The laser field increases the electron and hole confinement energy that form the exciton in the QD until they reach a maximum, then they become almost constant for a intense laser field., (ii)the electric field and the laser field lowers the binding energy for all quantum dot radii making the exciton stabilized and clustered near the center of the dot,iii)the laser field increases the spatial extention of exciton but the electric field deacreses it linearly.

Key words : Binding Energy, Dressed Potential, Exciton, Electric Field, Laser Field, Quantum Dot, Variational Method.

1. INTRODUCTION

Recent advances in modern fabrication techniques have made it possible to grow the zero-dimensional semiconductor nanostructures; the so-called quantum dots (QDs). QDs are interesting due to the fact that the motion of the charge carriers are restricted in all three dimensions, which lead to new physics and to phenomena with potential optoelectronic device applications. QDs can be made into different forms such as cubic, spherical or cylindrical. Recently, some works were interested to combined of intense terahertz (THz) laser effects and applied electric field on binding energy of exciton .M.E. Mora-Ramos et al [1], were studied the direct and indirect exciton states in GaAs/ Ga_{1-x} Al_x As quantum dots under the effects of intense laser field and applied electric field, and found that the exciton binding energy behaves as a decreasing function of the laser field strength, as well as of the size of the quantum dot. The normalized photoluminescence peak energy increases with the laser field strength and behaves as a decreasing function of the dot's dimensions for fixed laser field intensity. Congxin Xia et al [2], were studied the Laser field and electric field effects on exciton states and optical properties in zinc-blende GaN/AlGaN quantum well. The result shows that the laser field reduces the exciton binding energy and oscillator strength in the QW. However, when the applied electric field is strong, the exciton binding energy and oscillator strength have a maximum with the variation of the laser field. Moreover, the laser field increases the interband transition energy and the energy position of the linear optical susceptibility peak. C. A. Duque et al [3] were studied the combined effects of intense laser field and applied electric field on exciton states in GaAs quantum wells and found that the exciton binding energy is a decreasing function of the intense laser field parameter and of the electric field. On the base of these applications is the large dependence of exciton binding energy on different and adjustable parameters: the radius of the dot, the effective masses ratio of the carriers, the height and the shape of the confining potential caused by the matrix material in which the exciton is embedded [4-5]. Various external actions such as magnetic field [6], electric field [7-8] and hydrostatic pressure [9] were also considered and provide interesting properties.

In the extension of these studies, the purpose of this work is to examine the case of combined effects of Intense THz Laser Field and applied electric field on binding energy of exciton in GaAs/ GaAlAs finite spherical quantum dot , which, to our knowledge, does not have been studied yet.

2. EQUATIONS

Let us consider an exciton *X(e,h)* confined in a spherical quantum dot of semiconductor material 1 (*i.e* GaAs) surrounded by a semiconductor material 2 (*i.e* GaAlAs) matrix. The Hamiltonian H_0 of the exciton writes:

$$H_0 = T_e + T_h + V_c + V_e + V_h \qquad (1)$$

Where $T_e(T_h)$ and $V_e(V_h)$ are respectively the kinetic energy and the confinement potential for the electron (hole) resulting of the band-offset between the two materials and V_C is the Coulomb interaction between the two particles. In the absence of any external action, these energy operators are given by the well-known expressions

$$V_{e,h}(\vec{r}_{e,h}) = \begin{Bmatrix} 0 & pour\ r_{e,h} < R \\ V_{e,h}^0 & pour\ r_{e,h} > R \end{Bmatrix} \qquad (2)$$

$$V_C = -e^2/4\pi\varepsilon r_{eh}$$

$$T_{e,h} = -\frac{\hbar^2}{2m_{e,h}}\nabla_{e,h}^2$$

$\vec{r}_{e,h}$ denotes the radial position of the carrier, R is the radius of the dot and ε is the dielectric constant of the host material (*i.e* material 1), m_e (m_h) is the effective mass of the electron (hole). In the two bands effective mass approximation, the terms involved in the Hamiltonian H_0 read:

$$T_e = -\frac{\Delta_e}{1+\sigma_{1,2}}\ ; T_h = -\frac{\sigma_{1,2}\Delta_h}{1+\sigma_{1,2}}\ ;$$
$$V_C(0) = -\frac{2}{r_{eh}} \qquad (3)$$

where excitonic units (*e.u*) are used, namely: the 3D-exciton effective Bohr radius $a^* = \varepsilon_r\hbar^2/\mu k^2 e^2$ for length and the 3D-Rydberg $R^* = \mu\, k^2 e^4/2\varepsilon_r{}^2\hbar^2$ with $k = \frac{1}{4\pi\varepsilon_0}$ for energy with $\sigma_{1,2} = \frac{m_e^{1,2}}{m_h^{1,2}}$, $\mu = m_e^1 m_h^1/(m_e^1 + m_h^1)$, $m_e^{1,2}$ ($m_h^{1,2}$) is the electron(hole) effective mass in the material 1,2.

In the presence of intense laser field of amplitude F_0 and angular frequency ω at sufficiently high frequencies, F.M.S. Lima *et al* have established that the Coulomb interaction between electron and hole, in 3D exciton, is modified and yields the so-called "laser-dressed" potential $V_c(\alpha_0)$, which writes [10]:

$$V_c(\alpha_0) = -\left(\frac{1}{\left|\vec{r}_e - \vec{r}_h + \alpha_0\vec{k}\right|} + \frac{1}{\left|\vec{r}_e - \vec{r}_h - \alpha_0\vec{k}\right|}\right) \qquad (4)$$

where $\alpha_0 = eF_0/\mu\omega^2$ is the laser field parameter, which can be viewed as the excursion amplitude of the relative particle in its quiver motion in the laser field and $\vec{k}$ is the unity vector along the polarization direction of the field. For a given laser source, whose power is I (in kW/cm^2), the following practical formula is useful: $F_0(in\ kV/cm) \approx 0.868\sqrt{I}/\sqrt[4]{\varepsilon}$ [12].

The confinement potential for each carrier is also affected when the material is irradiated by the laser field as demonstrated by Lima *et al* in the case of confined electron in a quantum well [17]. In order to generalize the calculation made by these authors to the case of our interest *i.e* an electron (hole) confined in spherical quantum dot, we begin with the general expression of the one particle confinement potential in the presence of the field given by [17]

$$V(\vec{r}) = \frac{1}{T}\int_0^T V\left(\vec{r} + \alpha_0 sin\omega t\vec{k}\right) dt \qquad (5)$$

where $T = \frac{2\pi}{\omega}$ is the period of the radiation field. Making the substitution $u = \omega t$ and taking into account of equation (2), we obtain

$$V(\vec{r}) = \frac{V_0}{2\pi}\int_0^{2\pi} \Theta[(\alpha_0^2 sin^2 u + 2\alpha_0 z sinu + r^2) - R^2]\, dt \qquad (6)$$

It is clear, by studying the sign of the entity between hook, that this expression equals V_0 in the domain out of the dot ($r > R$). To obtain the expression of the confinement potential valid for $r < R$, we follow the procedure used by Lima *et al* [17] which consists in writing the integral as a sum of four integrals with equally spaced subintervals, that leads to :

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$$V(r,z) = \frac{V_0}{\pi}\int_{z-\alpha_0}^{z+\alpha_0} \frac{\Theta[|x|-\delta]}{\sqrt{\alpha_0^2-(x-z)^2}}dx \tag{7}$$

with $\delta = \sqrt{z^2+R^2-r^2}$. Note that $0 < \delta < R$. Now, starting from the comparison of δ with the limits of the integration interval and restricting ourselves to the condition $\alpha_0 > R$, that allows considerable simplification in evaluating (7), we have found (for $r < R$)

$$V(r,z) = \frac{V_0}{\pi}\left\{\Theta[(\alpha_0-(z+\delta)]arccos(\frac{\delta+z}{\alpha_0}) + \Theta[(\alpha_0-(\delta-z)]arccos(\frac{\delta-z}{\alpha_0})\right\} \tag{8}$$

Now, by studying the sign of the expressions between hooks and after some manipulations, we obtain:

$$V(r,z) = \begin{cases} \frac{V_0}{\pi}\left[arccos(\frac{\delta+z}{\alpha_0}) + arccos(\frac{\delta-z}{\alpha_0})\right] & \text{for} \quad |z| < z_0 \\ \frac{V_0}{\pi} arcco\,s\left(\frac{\delta-|z|}{\alpha_0}\right) & \text{for} \quad |z| > z_0 \end{cases} \tag{9}$$

with $z_0 = \frac{\alpha_0^2-R^2+r^2}{2\alpha_0} \geq 0$. Note the parity of $V(r,z)$with respect to z-coordinate.

3. SOLUTIONS

The next step consists in solving the Schrödinger equation for the ground state of the exciton:

$$H_{\alpha_0}\psi(\vec{r}_e,\vec{r}_h) = E\psi(\vec{r}_e,\vec{r}_h) \tag{10}$$

With,

$$H_{\alpha_0} = T_e + T_h + V_e + V_h + V_c(\alpha_0) + f(z_e - z_h) \tag{11}$$

We have introduced the dimensionless parameter $f = \frac{ea^*F}{R^*}$ which characterizes the electric field strength. The task of solving directly this equation(10) is so difficult because the variables cannot separate and then, approximation methods are required. To determine the binding energy of the exciton E_B, the variational method is used. It consists in minimizing the energy operator value $\langle\psi|H_{\alpha_0}|\psi\rangle$ with respect to a set of variational parameters associated to a suitable trial wave function ψ representing the ground state of the system. As illustration of the method, we give hereafter the formulation of the problem by using the following suitable and intuitive wave function:

$$\psi = N\varphi_e\,\varphi_h\big(1+\beta(z_e-z_h)\big)\varphi_{eh} \tag{12}$$

$r_{e,h}$ denotes the radial position of the carrier,

and $Z = z_e - z_h$, is the relative position between electron and hole along the polarization direction of the field, $\varphi(r)$ is the one particle wave function in the dot, N *is* the normalization coefficients given by $\int_{all\ space}\psi^2 = 1$ and $\varphi_{eh} = \exp(-\lambda r_{eh})$ is the term which describes the spatial correlation between electron and hole, λ and β are the variational parameters. The $(1+\beta Z\ )$ factor is introduced in order to take account of the distorsion caused by the laser field. The binding energy for the ground state of the exciton is then given by:

$$E_b = E_e + E_h - min_{\beta,\lambda}\frac{\langle\psi|H_{\alpha_0}|\psi\rangle}{\langle\psi|\psi\rangle} \tag{13}$$

where $E_e(E_h)$ is the energy of electron (hole) confined in the dot of radius R and potential confinement $V_{e,h}^0$ associated with the wave functions $\varphi_e(r_e)$ and $\varphi_h(r_h)$ respectively. These energies are obtained by solving the equation for one particle problem given by:

$$-k_{out}^i R = k_{in}^i R cotg(k_{in}^i R\ ) \tag{14}$$

With,

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$$k_{out}^{i} = \sqrt{\frac{2m_{out}^{i}(V_0^i - E_i)}{\hbar^2}} \quad ; \qquad i = e,h \tag{15}$$

$$k_{in}^{i} = \sqrt{\frac{2m_{in}^{i}E_i}{\hbar^2}}$$ corresponding to the wave function:

$$\varphi_i(r_i) = \frac{A_{0ut}}{r_i}\exp(-k_{0ut}r_i)\Theta(r_i - R) + A_{in}\frac{sink_{in}r_i}{r}\Theta(R - r_i) \tag{16}$$

Where the constants A_{0ut} and A_{in} are deduced from the normalization condition, which writes:

$$A_{in}^{i} = \left[2\pi\left(\frac{(k_{in}R - sink_{in}Rcosk_{in}R)}{k_{in}} + \frac{sin^2k_{in}R}{k_{0ut}}\right)\right]^{-1/2} \tag{17}$$

$$A_{out}^{i} = A_{in}^{i}sink_{in}^{i}\exp\left(k_{out}^{i}R\right)$$

m_{in}, m_{0ut} being the effective mass of the particle in the dot (material 1) and out of the dot (material 2) respectively. Now that the whole formulation and basic equations are set, we can proceed to the resolution of the problem. In that aim, we use of the complete Hylleraas [14] coordinates $\left(r_{e}, r_{h}, r_{eh}, z_{e}, z_{h}\right)$. In these coordinates, the elementary volume is given by:

$$d\tau = \frac{8\pi r_h dr_h r_e dr_e r_{eh} dr_{eh}\, dz_e dz_h}{\sqrt{4(r_e^2 - z_e^2)(r_h^2 - z_h^2) - (r_e^2 + r_h^2 - r_{eh}^2 - 2z_e z_h)^2}} \tag{18}$$

and the integration over the coordinates is done in domains: $0 < r_e, r_h \leq \infty$; $|r_e - r_h| \leq r_{eh} \leq r_e + r_h$; $-r_e \leq z_e \leq r_e$; $Z_1 \leq z_h \leq Z_2$ where Z_1 and Z_2 are the roots of the denominator expression in equation (18) with respect to z_h . Let us note that, according to the symmetry of the problem, the order of integration over *z*-coordinates can be inverted without affecting the result on the condition of interchanging *e* and *h* indices. After elementary transformations, $d\tau$ writes:

$$d\tau = d\tau_r d\tau_z \tag{19}$$

with,

$$d\tau_r = 4\pi r_h dr_h dr_e r_{eh} dr_{eh} \tag{20}$$

$$d\tau_z = \frac{dz_e dz_h}{\sqrt{(z_h - Z_1)(Z_2 - z_h)}} \tag{21}$$

and

$$Z_1 + Z_2 = S_h = z_e\left(1 + \frac{r_h^2 - r_{eh}^2}{r_e^2}\right) \tag{22}$$

$$Z_1 Z_2 = P_h = \frac{r_e^2}{4z_e^2}S^2 - \left(1 - \frac{z_e^2}{r_e^2}\right)r_h^2$$

1.Kinetic energy

The kinetic operator reads:

$$T = -\frac{1}{1+\sigma}(T_{re} + \sigma T_{rh}) - \frac{1}{1+\sigma}(T_{ze} + \sigma T_{zh}) \tag{23}$$

where (i=e,h) and $\sigma = \frac{m_e}{m_h}$

$$T_{ri} = \frac{\partial^2}{\partial r_i} + \frac{2}{r_i}\frac{\partial}{\partial r_i} + \frac{\left(r_i^2 + r_{ij}^2 + r_j^2\right)}{r_i r_{ij}}\cdot\frac{\partial^2}{\partial r_{ij}\partial r_i} + \frac{2}{r_{ij}}\frac{\partial}{\partial r_{ij}} \tag{24}$$

$$T_{zi} = \frac{\partial^2}{\partial z_i^2} + \frac{2z_i}{r_i}\frac{\partial^2}{\partial z_i \partial r_i} + 2\frac{(z_i - z_j)}{r_{ij}}\frac{\partial^2}{\partial r_{ij}\partial z_i} \tag{25}$$

2 Coulomb energy

Let us consider at first the coulomb potential term of equation (4). It writes:

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$$V(Z) = -\left(\frac{1}{\left|\vec{r}_e - \vec{r}_h + \alpha_0 \vec{k}\right|} + \frac{1}{\left|\vec{r}_e - \vec{r}_h - \alpha_0 \vec{k}\right|}\right) \qquad (26)$$

We obtain, after laborious mathematics

$$V_c(\alpha_0) = -A^{-\frac{1}{2}}\left[(1+z)^{-\frac{1}{2}} + (1-z)^{-\frac{1}{2}}\right] \qquad (27)$$

where

$$A = r_{eh}^2 + \alpha_0{}^2\,;\, z = \frac{2\alpha_0}{A} Z;\; r_{eh} = |\vec{r}_e - \vec{r}_h|\,;$$
$$Z = z_e - z_h$$

Because of $0 \leq z < 1$, power series development of the term between hooks around *z=0* may be used and, practically, the 10th order of the development has proved to be sufficient to obtain quite accurate result.
power series development give:

$$V_c(\alpha_0) = -A^{-\frac{1}{2}} \sum_{k=0}^{\infty} 2\frac{(4k)!\, z^{2k}}{4^{2k}(2k)!^2} \qquad (28)$$

Then we have:

$$\langle\Psi|V_c|\Psi\rangle = \int_0^\infty \int_0^\infty \int_{|r_e-r_h|}^{r_e+r_h} \int_{-r_e}^{r_e} \int_{z1}^{z2} \varphi_h^2\,(r_h)\,\varphi_e{}^2(r_e) V_c(\alpha_0)[1+\beta(z_e-z_h)]^2\, e^{-2\lambda r_{eh}} 4\pi\, r_h r_{eh} dr_e dr_h dr_{eh} \frac{dz_e dz_h}{\sqrt{(z_h-z1)(z2-z_h)}} \qquad (29)$$

The calculation of the potential energy $\langle\psi|V_c(\alpha_0)|\psi\rangle$ is then solved by computing analytically integrals over *z*-coordinates in terms of elementary mathematics.

3. <u>Confinement energy and electric field</u>

The electron confinement potential writes:

$$\langle\Psi|V_e|\Psi\rangle = \int_0^\infty \int_0^\infty \int_{|r_e-r_h|}^{r_e+r_h} \int_{-r_e}^{r_e} \int_{z1}^{z2} V_e \varphi_e^2\,(r_h)\,\varphi_h{}^2(r_e)[1+\beta(z_e-z_h)]^2\, e^{-2\lambda r_{eh}} 4\pi\, r_h r_{eh} dr_e dr_h dr_{eh} \frac{dz_e dz_h}{\sqrt{(z_h-z1)(z2-z_h)}} \qquad (30)$$

And the hole confinement energy writes:

$$\langle\Psi|V_h|\Psi\rangle = \int_0^\infty \int_0^\infty \int_{|r_e-r_h|}^{r_e+r_h} \int_{-r_e}^{r_e} \int_{z1}^{z2} V_h \varphi_{out}^2\,(r_h)\,\varphi_{out}{}^2(r_e)[1+\beta(z_e-z_h)]^2\, e^{-2\lambda r_{eh}} 4\pi\, r_h r_{eh} dr_e dr_h dr_{eh} \frac{dz_e dz_h}{\sqrt{(z_h-z1)(z2-z_h)}} \qquad (31)$$

Meanwhile, the term of electric field is given by:

$$\langle\Psi|f(z_e-z_h)|\Psi\rangle =$$
$$\int_0^\infty \int_0^\infty \int_{|r_e-r_h|}^{r_e+r_h} \int_{-r_e}^{r_e} \int_{z1}^{z2} (f(z_e-z_h)\,\varphi_h^2\,(r_h)\,\varphi_e{}^2(r_e)[1+\beta(z_e-z_h)]^2\, e^{-2\lambda r_{eh}} 4\pi\, r_h r_{eh} dr_e dr_h dr_{eh} \frac{dz_e dz_h}{\sqrt{(z_h-z1)(z2-z_h)}} \qquad (32)$$

Because of computing complications introduced by the effect of the laser field on the confinement potential (Eq.9), we have restricted calculation to the simplified expressions of the confinement given by expressions (2) having in mind more development in further studies.

3. RESULTS AND DISCUSSION

We have calculated the binding energy for an exciton in a spherical GaAs/ Ga_{1-x} Al_xAs QD in the presence of an intense, high frequency laser field and electric field for finite barrier potential models, following a variational method within the effective mass approximation. The numerical results shown below are presented in units of an effective Rydberg energy *R** and of an effective Bohr radius *a** above defined (excitonic units) For GaAs/ Ga_{1-x} Al_xAs QD, these units are *a**=99.6 *Å* and *R** =6.6 meV, respectively for aluminum concentrtion x=0.3.

The calculations were performed for the case of GaAs/ Ga_{1-x} Al_xAs material characterized by its $\sigma_{1,2}$ ($\sigma_1 = 0.147, \sigma_2 = 0.193$) parameters and its excitonic units R^* and a^*. Integrations over r_e, r_h and r_{eh} were calculated by using Gauss-Legendre method within Maple platform. For minimizing energy, several standard numerical methods (Conjugate directions descent, Simulated annealing, Powell, Hooke Jeeves, quasi gradient) were tested and lead to the same results. The binding energy of the QD-exciton under field was then computed for different values of the field intensity parameter α_0 from 0 up to 10 e.u. and for various radius values *R* ranged between $0.5a^*$ (the strong confinement regime) and $3a^*$ (quasi bulk exciton).

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As seen in Figure1, the exciton binding energy decreases with increase of α_0 , since the Coulombic interaction between the electron and hole decreases. For large enough dot dimensions, the laser field sensitivity of the binding energy is observed to be very weak. We can explain this behavior of the curves in Figure1 as follows: geometric confinement has a major effect on the exciton in narrow quantum dot. For this reason, any change in the geometric confinement significantly affects the binding energy of exciton. We notice that the allure obtained in this case differs from that obtained in our previous work [16] for the infinite confinement and in which the curves of E_b and V_c are symmetrical. This symmetry is not verified in the current case of finite confinement (figures 1 and 3). For the limiting case α_0 = 0 (without effect of the laser field) and R = 3 (weak confinement) one notes that Eb≈2.1 which is in good agreement to the value Eb≈2.5 obtained by Qu Fanyao et al [15].These results show that the exciton remains stabilized against the field ionization even for increasing values of the laser dressed parameter. The same behavior was repored for bulk exciton [10] and for quatum well confined exciton [13]. This important trend which predicts a red shift of photoluminescence spectra near absorption edge of the material irradiated by the laser deserves to be exploited in practical purposes mainly in optoelectronics based on quantum dots. Furtheremore, by drawing the variations of the spatial extension of the exciton r_{eh} versus the field intensity as shown in figure 2 ,□□□we notice that the shape of the exciton, increases when increasing the quantum dot radii and when increasing field intensity from 0 to 2 ,then stablizes for higher values of the field intensity making electron and hole more distant as has been observed for bulk excitons [10]. On the other hand, we have calculated the relative contribution of the kinetic energy T ,the dressed potential V_c to the ground state energy of the exciton. Fig. 3 shows how the dressed potential varies with increasing intensity of the field. In this figure, we notice that the Coulomb interaction potential V_c increases when R and α_0 increases, and tends towards the limit V_c = 0, when α_0 tends towards ∞. The same result is obtained in reference [16]. Figure 4 shows that the kinetic energy T of the exciton decreases when the radius R of QD increases, and decreases almost linearly when α_0 <1, and remains almost constant when the laser field is more intense (α_0> 1). Figures 5 and 6 show how the confinement energy V_e and V_h vary, respectively, in the case of strong geometric confinement (R = 0.5). These figures show that V_e and V_h, increases almost linearly when α_0 <2. And for α_0> 2 they become almost constant, and take the maximum values V_e = 0.32 and V_h = 0.185 for R=0.5, which shows that the confinement energy is insensitive to the intense laser field. Figure 7 shows the variation in the binding energy of the exciton as a function of the electric field for different value of the laser field (α_0 = 0,1,2,3,4,5) and for quantum dot radii (R = 1). In this figure we notice that the binding energy of the exciton decreases when the intensity of the laser field increases, and this energy decreases linearly as a function of the electric field whatever the value of the laser field. Figure 8 illustrates the variation of the spatial extension (r_{eh}) of the exciton as a function of the electric field for different values of the laser field and for R = 1. In this figure we notice that the spatial extension r_{eh} increases when the laser field increases, and decreases linearly as a function of the electric field parameter (f) as reported in the literature.

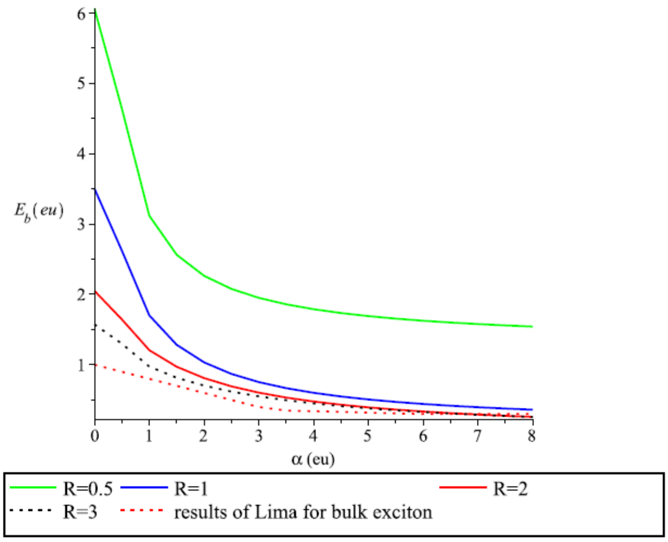

Figure 1. Binding energy of the exciton in GaAs/ Ga_{1-x} Al_xAs vs. the field parameter α_0 for various radii of the quantum dot (e.u.) for x=0.3 and f=0.

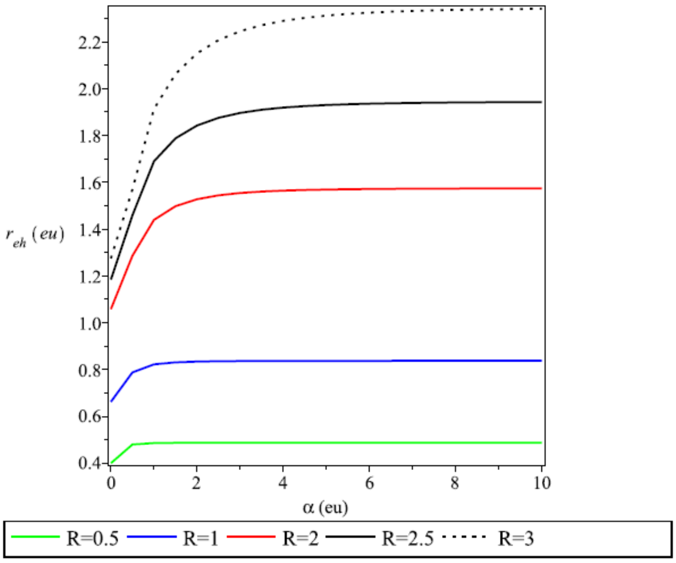

Figure 2. Variations of the spatial extension of the exciton (*r*eh) vs. the field parameter (α_0) for various radii of the dot in GaAs/ Ga_{1-x} Al_x As for x=0.3 and f=0.

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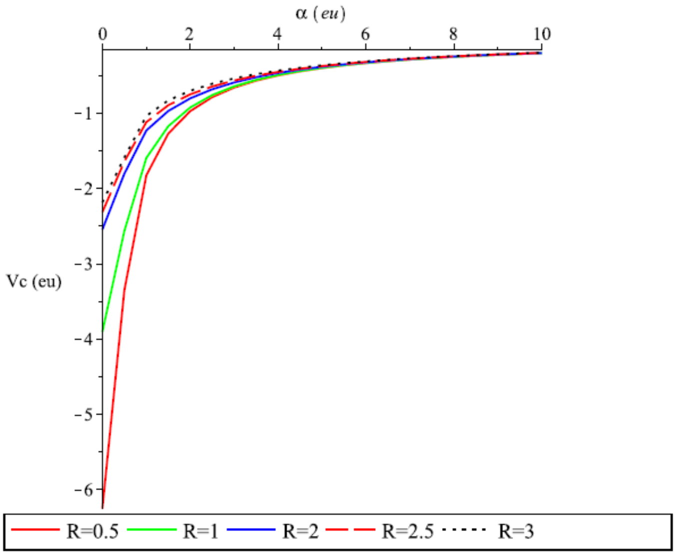

Figure 3. Dressed potential of the exciton vs. the field parameter (α_0) in GaAs quantum dot for various radii of the dot (e.u.) and f=0.

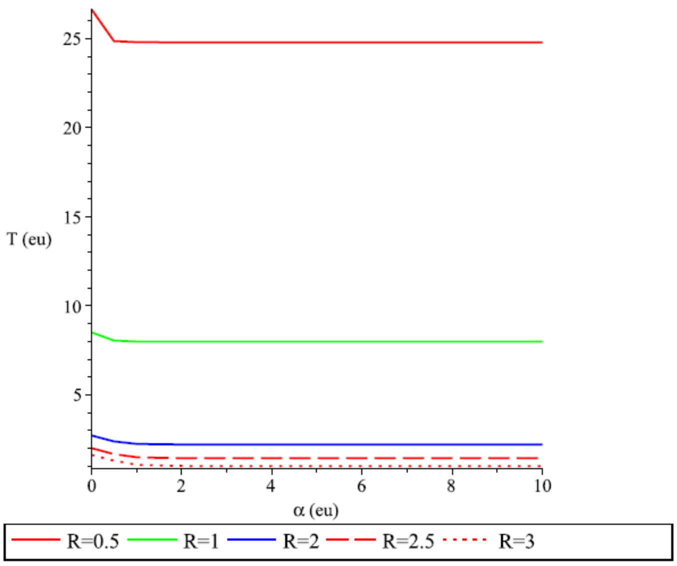

Figure 4. Variation of kinetic energy with laser field for different quantum dot radii and f=0.

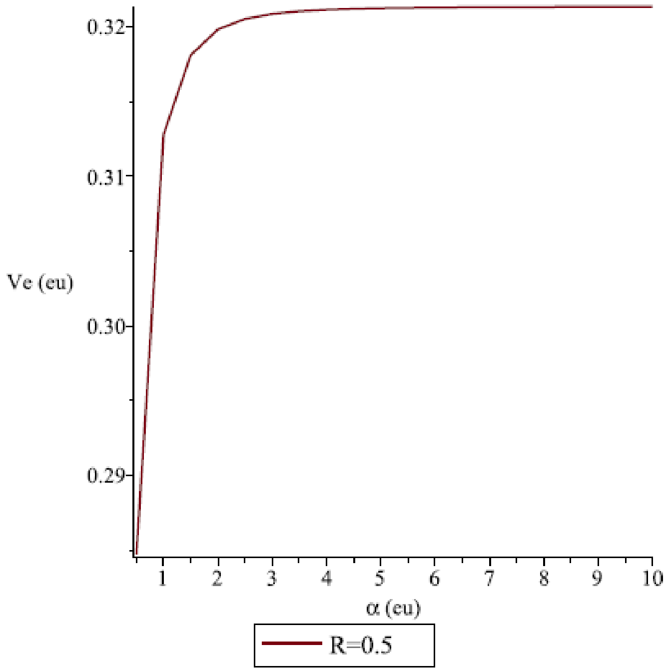

Figure 5. Variation of the confinement potential Ve with laser field parameter α_0 for R=0.5 and f=0.

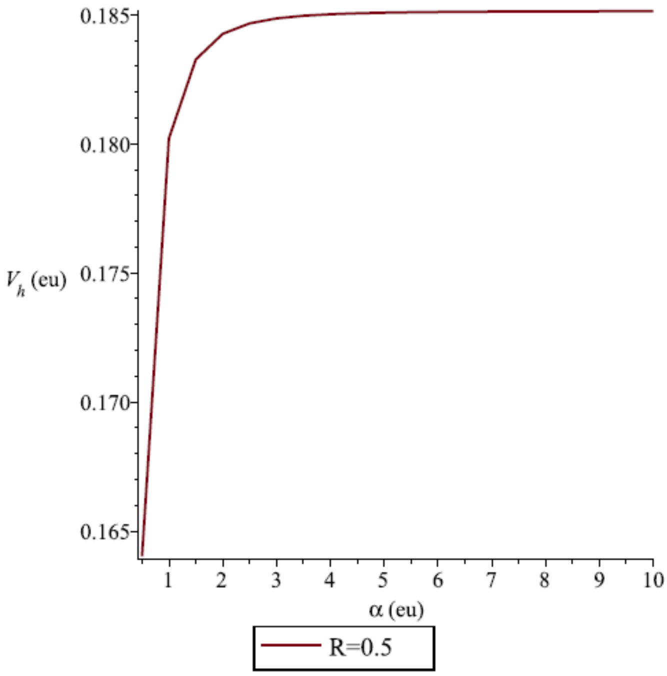

Figure 6. Variation of confinement the potential V_h with laser field parameter α_0 for quantum dot radii R=0.5 and electric field parameter f=0.

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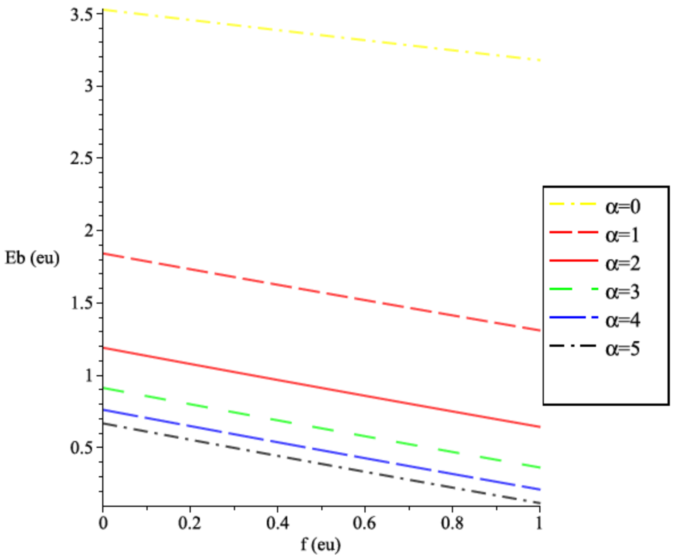

Figure 7. Variation of the binding energy with electric field parameter (f), for different laser field parameter α_0 and for quantum dot radii R=1.

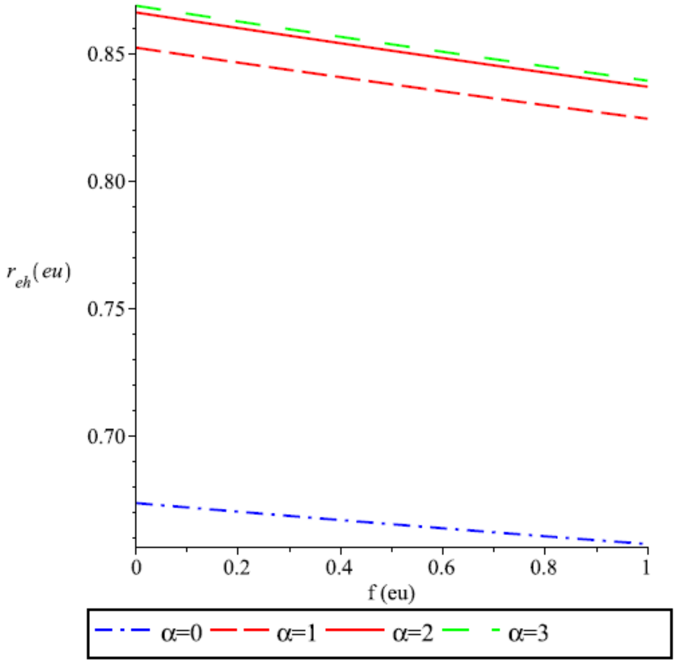

Figure 8. Variations of the spatial extension of the exciton (*r*eh) with electric field parameter (f), for different laser field parmeter α_0 and for R=1

4. Conclusion

We have studied the combined effect of the intense laser field and electric field on the exciton confined in GaAs/GaAlAs spherical finite quantum dot, using the variational method in the framework of the approximation of the effective mass theory. The results show that the laser field increases the of the electron and hole confinement energy that form the exciton in the QD, until they reach a maximum, then they become almost constant for a higher laser field.The combined effect of laser field and electric field lowers the binding energy for all quantum dot radii , and the laser field increases the spatial extention of exciton but the electric field deacreses it linearly making the exciton stabilized and clustered near the center of the dot. This results reveal that the intense laser field creates an additional geometric confinement on the excitonic states in the QD

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