International Journal of Science and Advanced Innovative Research
ISSN: 2536-7315 (Print) 2536-7323 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

# AN EVALUATION OF AN ATOM MOVING IN GEOMETRY FORMING IN A NONLINEAR FOCUS MEDIA ON FIELD BLOCKING RESPONSE

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**ABSTRACT**
The blocking of field as it passes through the media interface has been described. The formation of an atom moving in geometry at one side interface has been obtained. The solution of coupled nonlinear Schrödinger equation at one side form has been obtained and analyzed. It has been observed that the effect of field blocking is only possible at opposite signs of parameters. It has been analyzed the existence of stationary states at the field blocking effect.
**Key word:** Atom, Nonlinear, Schrödinger, Energy and field blocking.

## INTRODUCTION

In theoretical physics, the (one-dimensional) nonlinear Schrödinger equation (NLSE) is a nonlinear variation of the Schrödinger equation (Onorato et al., 2013). It is a classical field equation whose principal applications are to the propagation of light in nonlinear optical fibers and planar waveguides and to Bose-Einstein condensates confined to highly anisotropic cigar-shaped traps, in the mean-field regime (Malomed, 2005). Additionally, the equation appears in the studies of small-amplitude gravity waves on the surface of deep in viscid (zero- viscosity) water; the Langmuir waves in hot plasmas; the propagation of plane-diffracted wave beams in the focusing regions of the ionosphere; the propagation of Davydov's alpha-helix solitons, which are responsible for energy transport along molecular chains; and many others (Pitaevskii et al., 2003). More generally, the NLSE appears as one of universal equations that describe the evolution of slowly varying packets of quasi-monochromatic waves in weakly nonlinear media that have dispersion (Gurevich, 1978). Unlike the linear Schrödinger equation, the NLSE never describes the time evolution of a quantum state (except hypothetically, as in some early attempts in the 1970s, to explain the quantum measurement process) (Balakrishnan, 1985). The 1D NLSE is an example of an integrable model. In quantum mechanics, the 1D NLSE is a special case of the classical nonlinear Schrödinger field, which in turn is a classical limit of a quantum Schrödinger field (Bassi et al., 2013). Conversely, when the classical Schrödinger field is canonically quantized, it becomes a quantum field theory (which is linear, despite the fact that it is called "quantum nonlinear Schrödinger equation") that describes bosonic point particles with delta-function interactions — the particles either repel or attract when they are at the same point. In fact, when the number of particles is finite, this quantum field theory is equivalent to the Lieb–Liniger model. Both the quantum and the classical 1D nonlinear Schrödinger equations are integrable. Of special interest is the limit of infinite strength repulsion, in which case the Lieb–Liniger model becomes the Tonks– Girardeau gas (also called the hard-core Bose gas, or impenetrable Bose gas). In this limit, the bosons may, by a change of variables that is a continuum generalization of the Jordan– Wigner transformation, is transformed to system one-dimensional noninteracting spinless fermions

(Korepin et al., 1993). Multi-dimensional version replaces the second spatial derivative by the Laplacian. In more than one dimension, the equation is not integrable, it allows for a collapse and wave turbulence (Falkovich, 2011).

## MATERIALS AND METHODS

The stationary states with energy E reduces to stationary nonlinear Schrödinger equation for wave function $\Psi(x)$ in the following form

$$E\Psi = -\frac{1}{2m}\Psi" + \Omega\Psi - \gamma(x)|\Psi|^2\Psi + U(x)\Psi \quad 1$$

Here value of energy range edge $\Omega$ and effective mass $m$ of excitation are constant everywhere. The nonlinearity of the medium is characterized by a different absolute values of nonlinearity at the opposite sides of the interface

$$\gamma(x) = \begin{cases}\gamma_1, x < 0\\ \gamma_2, x > 0\end{cases} \quad 2$$

Values $\gamma_{1,2}$ are constant everywhere. The nonlinearity self consistent potential in the form

$$U(x) = \{U_0 + W_0|\Psi|^2\}\delta(x) \quad 3$$

The potential (3) describes the thin layer with nonlinear properties plane defect with nonlinear response (Joel, 1975). Introduce the two wave functions describing the excitation distributions on both sides from interface in the form

$$\Psi(x) = \begin{cases}\Psi_1, x < 0\\ \Psi_2, x > 0\end{cases} \quad 4$$

The nonlinear Schrödinger equation (1) with potential (3) reduce to solving two nonlinear Schrödinger equation

$$\frac{1}{2m}\Psi"_j + (E - \Omega)\Psi_j(x) + \gamma_j\left|\Psi_j\,(x)\right|^2\Psi_j\,(x) = 0 \quad 5$$

Here and further $j = 1$ corresponds to the left side from interface $(x < 0)$ and $j = 2$ corresponds to the right side from interface $(x > 0)$. The wave functions must satisfy to the conjugation boundary conditions on interface at the plane $x = 0$

$$\Psi_1 = \Psi_2 = \Psi_0 \quad 6$$

$$\Psi'_2 - \Psi'_1 = 2m\Psi_0\{U_0 + W_0|\Psi|^2\} \quad 7$$

Here $\Psi_0$ is the amplitude of the interface oscillations.

### Half space for the first type state

The first type state on the left side from interface for $x < 0$ for the positive nonlinearity $\gamma_1$ in the energy range $E < \Omega$ is described by periodic nonlinear Schrödinger equation solution

$$\Psi_1(x) = A_c cn(q_c(x - x_1), k) \quad 8$$

$$q_c^2 = \frac{2m(\Omega - E)}{(2k^2 - 1)} \quad 9$$

$$A_c^2 = \frac{k^2 q_c^2}{(m\gamma)} \quad 10$$

Where $A_c$ is the amplitude of the wave, $q_c$ is the wave number of the wave and $k$ is the modulus of elliptical function $cn$, $\frac{1}{2} < k^2 < 1$. The first type state on the right side from interface for $x > 0$ for the positive nonlinearity $\gamma_2$ in the energy range $E < \Omega$ is describe by equations

$$\Psi_1(x) = \frac{A}{\cosh(q(x - x_1))} \quad 11$$

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http://www.casirmediapublishing.com

$$q^2 = 2m(\Omega - E) = (2k^2 - 1)q_c^2 \quad 12$$

$$A^2 = \frac{q^2}{(m\gamma)} \quad 13$$

The function (11) is well known nonlinear Schrödinger equation of an atom for the case of positive nonlinearity (Joel, 1975). Substituting functions of equation (8) and (11) into the boundary conditions (6) and (7)

$$\eta k cn(q_c, x_1, k) = \frac{(2k^2-1)^{\frac{1}{2}}}{\cosh(qx_2)} \quad 14$$

$$q\left\{\frac{\tanh(qx_2) - (2k^2-1)^{\frac{1}{2}} sn(q_c, x_1, k) dn(q_c, x_1, k)}{cn(q_c, x_1, k)}\right\} = F(U_0, V_0) \quad 15$$

Where $\eta = \left(\frac{\gamma_2}{\gamma_1}\right)^{\frac{1}{2}}, V_0 = \frac{W_0}{\gamma_2}$ and $F(U_0, V_0) = 2\left\{\frac{mU_0 + V_0 q_c^2}{\cosh^2(qx_2)}\right\}$ .

The energy of the first type state is determined from dispersion relations (14) and (15).

## Half space for the second type state

The second type state on the left side from interface for $x < 0$ is described by periodic nonlinear Schrödinger equation solution for the positive nonlinearity $\gamma_1$ in the energy range $E < \Omega$

$$\Psi_1(x) = A_d dn(q_d(x - x_1), k) \quad 16$$

$$q_d^2 = \frac{2m(\Omega - E)}{(2-k^2)} \quad 17$$

$$A_d^2 = \frac{q_d^2}{(m\gamma)} \quad 18$$

Where $A_d$ is the amplitude of the wave, $q_d$ is the wave number of the wave and $k$ is the modulus of elliptical function $dn$, $0 < k^2 < 1$. The second type state on the right side from interface for $x > 0$ is describe by equations (11) – (13) (Joel, 1975). It is note that $q = q_d(2 - k^2)^{\frac{1}{2}}$

Substituting functions of equation (11) and (16) into the boundary conditions (6) and (7)

$$\eta dn(q_d, x_1, k) = \frac{(2-k^2)^{\frac{1}{2}}}{\cosh(qx_2)} \quad 19$$

$$q\left\{\frac{\tanh(qx_2) - (2k^2-1)^{\frac{1}{2}} sn(q_d, x_1, k) dn(q_d, x_1, k)}{dn(q_d, x_1, k)}\right\} = F(U_0, V_0) \quad 20$$

## Energy of the field blocking of the first type states

The exact solutions of dispersion equations (14) and (15) for three following case

Case $A: x_1 = 0$ and $x_2 = 0$

From equation (14) derive the elliptic function module

$$k = (2 - \eta^2)^{-\frac{1}{2}} \quad 21$$

From equation (15) it has been obtain the equation $F(U_0, V_0) = 0$. To find the wave number

$$q = \left(-\frac{mU_0}{V_0}\right)^{\frac{1}{2}} \quad 22$$

Using equation (21) from equation (12) to derive the exact energy level of field blocking

$$E = \Omega + \left(\frac{U_0}{2V_0}\right) \quad 23$$

Using equation (21) also to find the amplitude of the interface oscillation

$$\Psi_0 = \left(-\frac{U_0}{W_0}\right)^{\frac{1}{2}} \quad 24$$

From equation (21) see that $0 < \eta^2 < 1$. In such case the nonlinearity parameter of the media where field fades away on the right side from the interface should be less the nonlinearity parameter of the media where atom moving in geometry is formed on the left side from the interface: $\gamma_2 < \gamma_1$.

Case $B: x_1 = 0 \; and \;\; x_2 \neq 0$

From equation (14) and (15) find the wave number

$$q = q_{c0} \left\{1 \pm \left(1 - \frac{q_{c0}}{q_{c0}}\right)^{\frac{1}{2}}\right\} \quad 25$$

Where $q_{c0} = \frac{(2k^2-1)^{\frac{1}{2}} \; \{(2-\eta^2)k^2-1\}^{\frac{1}{2}}}{4V_0\eta^2k^2}$, $q_{ca} = \frac{4mU_0 \; (2k^2-1)^{\frac{1}{2}}}{\{(2-\eta^2)k^2-1\}^{\frac{1}{2}}}$

From equation (14) to obtain the atom moving in geometry center position with the substituting $q$ defined by equation (25)

$$x_2 = \frac{1}{q} \; \cosh^{-1}\left\{\frac{(2k^2-1)^{\frac{1}{2}}}{\eta k}\right\} \quad 26$$

Using equation (25) from equation (12) to derive the exact energy level of the field blocking

$$E = \Omega + \Omega_{c0}\left\{1 \pm \left(1 - \frac{q_{c0}}{q_{c0}}\right)^{\frac{1}{2}}\right\}^2 \quad 27$$

Where $\Omega_{c0} = \frac{q_{c0}^2}{2m}$. The field blocking effect for energy described by equation (27) can exist under conditions: $U_0 < \frac{\{(2-\eta^2)k^2-1\}}{16V_0\eta^2k^2}$ and $\eta^2 < 2 - k^{-2}$. The second one leads to $0 < \eta^2 < 1 \; (\gamma_2 < \gamma_1)$ .

In the case of interface without nonlinear response when $W_0 = 0 \;\; and \;\; U_0 \neq 0$ it is obtain $q_{c0} = \frac{q_{c0}}{2}$ and the energy

$$E = \frac{\Omega - 2mU_0^2(2k^2-1)}{\{(2-\eta^2)k^2-1\}} \quad 28$$

In the case of interface without nonlinear response when $U_0 = 0 \;\; and \;\; W_0 \neq 0$ it is obtain $q = 2q_{c0}$ and the energy

$$E = \frac{\Omega - (2k^2-1)\{(2-\eta^2)k^2-1\}}{8m\,V_0^2\;\eta^2k^2} \quad 29$$

The case of nonlinear interface the characteristic width of excitation localization is proportional to the interface nonlinearity.

Case $C: x_1 \neq 0 \; and \;\; x_2 = 0$

From equation (14) and (15) find the wave number

$$q = q_{cl} \left\{-1 \pm \left(1 - \frac{q_{cb}}{q_{cl}}\right)^{\frac{1}{2}}\right\} \quad 30$$

Where $q_{cl} = \frac{a_c(\eta,k)}{4V_0}$, $q_{cb} = \frac{4mU_0}{a_c(\eta,k)}$

$$a_c(\eta, k) = \frac{\{(2-\eta^2)k^2-1\}^{\frac{1}{2}}\{1-\eta^2-(2-\eta^2)k^2\}^{\frac{1}{2}}}{\eta\;(2k^2-1)}$$

Using equation (30) from equation (12) to derive the exact energy level of the field blocking

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ISSN: 2536-7315 (Print) 2536-7323 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

$$E = \Omega - \Omega_{cl}\left\{-1 \pm \left(1 - \frac{q_{cb}}{q_{cl}}\right)^{\frac{1}{2}}\right\}^2 \qquad 31$$

Where $\Omega_{c0} = \frac{q_{cl}^2}{2m}$. The field blocking effect for energy described by equation (31) can exist under conditions: $U_0 < \frac{a_c^2(\eta,k)}{16V_0}$ and $\eta^2 < 2 - k^{-2}$.

In the case of interface without nonlinear response when $W_0 = 0$ *and* $U_0 \neq 0$ it is obtain $q = -\frac{q_{cb}}{2}$ and the energy

$$E = \frac{\Omega - 2mU_0^2}{a_c^2(\eta,k)} \qquad 32$$

In the case of interface without nonlinear response when $U_0 = 0$ *and* $W_0 \neq 0$ it is obtain $q = -2q_{c0}$ and the energy

$$E = \frac{\Omega - a_c^2(\eta,k)}{8m\,V_0^2} \qquad 33$$

The characteristic width of excitation localization is proportional to the interface nonlinearity.

## Energy of the field blocking of the second type states

The exact solutions of dispersion equations (19) and (20) for three following case

Case $A$: $x_1 = 0$ *and* $x_2 = 0$

From equation (14) derive the elliptic function module

$$k = (2-\eta^2)^{-\frac{1}{2}} \qquad 34$$

Note that the product of ellipitic modules specified by equation (21) and (34) is equal to untiy (Joel, 1975).

From equation (32) it has been derive that $1 < \eta^2 < 2$. In such case the nonlinearity parameter of the media where field fades away on the right side from the interface should be less the nonlinearity parameter of the media where atom moving in geometry is formed on the left side from the interface: $\gamma_1 < \gamma_2 < 2\gamma_1$.

Case $B$: $x_1 = 0$ *and* $x_2 \neq 0$

From equation (19) and (20) find the wave number

$$q = q_{d0}\left\{1 \pm \left(1 - \frac{q_{da}}{q_{d0}}\right)^{\frac{1}{2}}\right\} \qquad 35$$

Where $q_{d0} = \frac{(2k^2-1)^{\frac{1}{2}}\ \{(2-\eta^2)k^2-1\}^{\frac{1}{2}}}{4V_0\eta^2k^2}$, $q_{da} = \frac{4mU_0\ (2k^2-1)^{\frac{1}{2}}}{\{(2-\eta^2)k^2-1\}^{\frac{1}{2}}}$

From equation (19) to obtain the atom moving in geometry center position with the substituting $q$ defined by equation (35)

$$x_2 = \frac{1}{q}\ \cosh^{-1}\left\{\frac{(2k^2-1)^{\frac{1}{2}}}{\eta k}\right\} \qquad 36$$

Using equation (35) from equation (12) to derive the exact energy level of the field blocking

$$E = \Omega - \Omega_{d0}\left\{1 \pm \left(1 - \frac{q_{da}}{q_{d0}}\right)^{\frac{1}{2}}\right\}^2 \qquad 37$$

Where $\Omega_{d0} = \frac{q_{d0}^2}{2m}$. The field blocking effect for energy described by equation (37) can exist under conditions: $U_0 < \frac{\{(2-\eta^2)k^2-1\}}{16V_0\eta^2k^2}$ and $\eta^2 < 2 - k^{-2}$. The second one leads to $1 < \eta^2 < 2$ $(\gamma_1 < \gamma_2 < 2\gamma_1)$ .

In the case of interface without nonlinear response when $W_0 = 0$ *and* $U_0 \neq 0$ it is obtain $q_{d0} = \frac{q_{d0}}{2}$ and the energy

$$E = \frac{\Omega - 2mU_0^2(2k^2-1)}{(2-k^2-\eta^2)} \qquad 38$$

In the case of interface without nonlinear response when $U_0 = 0$ *and* $W_0 \neq 0$ it is obtain $q = 2q_{d0}$ and the energy

$$E = \frac{\Omega - (2-k^2)(2-k^2-\eta^2)}{8m\,V_0^2\,\eta^4} \qquad 39$$

The case of nonlinear interface the characteristic width of excitation localization is proportional to the interface nonlinearity.

Case $C: x_1 \neq 0$ *and* $x_2 = 0$

From equation (19) and (20) find the wave number

$$q = q_{dl}\left\{-1 \pm \left(1 - \frac{q_{db}}{q_{dl}}\right)^{\frac{1}{2}}\right\} \qquad 40$$

Where $q_{dl} = \frac{a_d(\eta,k)}{4V_0}$, $q_{db} = \frac{4mU_0}{a_c(\eta,k)}$

$$a_d(\eta,k) = \frac{(2-k^2-\eta^2)^{\frac{1}{2}}\{2-k^2-\eta^2(1-k^2)\}^{\frac{1}{2}}}{\eta\,(2-k^2)}$$

Using equation (40) from equation (12) to derive the exact energy level of the field blocking

$$E = \Omega - \Omega_{dl}\left\{-1 \pm \left(1 - \frac{q_{db}}{q_{dl}}\right)^{\frac{1}{2}}\right\}^2 \qquad 41$$

Where $\Omega_{d0} = \frac{q_{dl}^2}{2m}$. The field blocking effect for energy described by equation (41) can exist under conditions: $U_0 < \frac{a_d^2(\eta,k)}{16V_0}$.

In the case of interface without nonlinear response when $W_0 = 0$ *and* $U_0 \neq 0$ it is obtain $q = -\frac{q_{db}}{2}$ and the energy

$$E = \frac{\Omega - 2mU_0^2}{a_d^2(\eta,k)} \qquad 42$$

In the case of interface without nonlinear response when $U_0 = 0$ *and* $W_0 \neq 0$ it is obtain $q = -2q_{d0}$ and the energy

$$E = \frac{\Omega - a_d^2(\eta,k)}{8m\,V_0^2} \qquad 43$$

The characteristic width of excitation localization is proportional to the interface nonlinearity.

## RESULTS AND DISCUSSIONS

The wave functions of the localized state have the form

$$\Psi_1(x) = \frac{A}{ch(q(x-x_j),k)} \qquad 44$$

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ISSN: 2536-7315 (Print) 2536-7323 (Online)
Volume 4, Number 1, March 2019
http://www.casirmediapublishing.com

Here, the wave number $q$ is defined by equation (12) and the amplitude of nonlinear localized state $A$ is defined by equation (13)
Substituting into equation (14) or equation (19) $k = 1$ to obtain

$$\frac{\eta}{\cosh(q\,x_1)} = \frac{1}{\cosh(q\,x_2)} \qquad 45$$

Substituting into equation (20) or equation (24) $k = 1$ to obtain the dispersion relation of localized on both sides from defect states:

$$q = \{\tanh(q\,x_2) - \tanh(q\,x_1)\} = 2\left\{\frac{mU_0+V_0q^2}{\cosh^2\,(q\,x_2)}\right\} \qquad 46$$

Analyze the solutions of dispersion equation (45) and (46) in four following cases.
Case $A$: $x_2 = -x_1 = x_0$
From equation (45) find $\eta = 1$. In the case considered the nonlinearity parameters are equal to each other: $\gamma_1 = \gamma_2 = \gamma$.
The amplitude of interface oscillation has the form

$$\Psi_0 = \frac{q}{(m\gamma)^{\frac{1}{2}}\ \cosh^2\,(q\,x_0)} \qquad 47$$

The dispersion equation (46) takes the form

$$q\ \tanh(q\ x_0) = \frac{mU_0+V_0q^2}{\cosh^2\,(q\,x_2)} \qquad 48$$

From equation (48) for $V_0 = 0$ and $U_0 \neq 0$ it has been obtaining the dispersion equation analyzed in the case of defect without nonlinear response in focusing medium.
From dispersion equation (28) to obtain the wave number

$$q^2 = \frac{m\,U_0}{(x_0-V_0)} \qquad 49$$

and the energy of long wave excitations

$$E = \frac{\Omega - U_0}{2(x_0-V_0)} \qquad 50$$

Localized long wave states with energy (50) can exist when one of the pairs of conditions is fulfilled: 1) $U_0 > 0$ *and* $W_0 < \gamma x_0$ ,2) $U_0 < 0$ *and* $W_0 > \gamma x_0$
Case $B$: $x_1 = x_2 = x_0$
From equation (45) find the same in the case $A$ result: $\gamma_1 = \gamma_2$.
The dispersion equation (46) takes the form

$$\frac{q^2}{\cosh(q\,x_0)} = \frac{-\,m\,U_0}{V_0} \qquad 51$$

From equation (48) see the localized state in the case considered can exist only for the opposite signs of interface parameters in independence of sign of $x_0$.
From equation (51) to obtain the energy of long wave excitations $(q\,x_0 \ll 1)$

$$E = \frac{\Omega - \left\{1 \pm \left(\frac{1+4m\,x_0^2\,U_0}{V_0}\right)^{\frac{1}{2}}\right\}}{4m\,x_0^2} \qquad 52$$

Localized long wave states with energy (51) can exist under condition: $U_0 > -\frac{W_0}{4m\,x_0^2\gamma}$.
Case $C$: $x_1 = 0$ *and* $x_2 \neq 0$
In the limit $k = 1$ to obtain the wave number in the form (25) or (35) with

$$q_{c0} = q_{d0} = \frac{(1-\eta^2)^{\frac{1}{2}}}{4V_0\eta^2} \qquad 53$$

$$q_{ca} = q_{da} = \frac{4m\,U_0}{(1-\eta^2)^{\frac{1}{2}}} \qquad 54$$

To obtain the movement of the atom at the center position from equation (36)

$$x_2 = \frac{1}{q}\ \cosh^{-1}\left(\frac{1}{\eta}\right) \qquad 55$$

The exact energy localized level has the form (30) or (40) with parameter defined by equations (53) and (54)

Case $D$: $x_1 \neq 0$ *and* $x_2 = 0$

In the limit $k = 1$ to obtain the wave number in the form (25) or (35) with

$$q_{c1} = q_{d1} = \frac{(\eta^2-1)^{\frac{1}{2}}}{4V_0\eta} \qquad 56$$

$$q_{db} = \frac{4m\,U_0}{(1-\eta^2)^{\frac{1}{2}}} \qquad 57$$

To obtain the movement of the atom at the center position

$$x_1 = \frac{1}{q}\ \cosh^{-1}(\eta) \qquad 58$$

The exact energy localized level has the form (31) or (41) with parameter defined by equations (53) and (54)

The $\Psi_0$as a free parameter then is derive from equation (48) the dispersion equation in the form

$$\left(q^2 - m\gamma\,{\Psi_0}^2\right)^{\frac{1}{2}} = m\left(U_0 + W_0{\Psi_0}^2\right) \qquad 59$$

To find the wave number as exact solution of dispersion equation (59)

$$q^2(\Psi_0) = m\left\{\gamma{\Psi_0}^2 + m\left(U_0 + W_0{\Psi_0}^2\right)^2\right\} \qquad 60$$

Using equation (60) to obtain the exact energy level of localized state in the form

$$E = \frac{\Omega - m\left\{\gamma{\Psi_0}^2 + m\left(U_0 + W_0{\Psi_0}^2\right)^2\right\}}{2} \qquad 61$$

From equation (40) to find the movement center position of atom

$$x_0(\Psi_0) = \frac{\cosh^{-1}\left\{\frac{\left[m\left\{\gamma{\Psi_0}^2 + m\left(U_0 + W_0{\Psi_0}^2\right)^2\right\}\right]^{\frac{1}{2}}}{\Psi_0\,(mg)^{\frac{1}{2}}}\right\}}{\left[m\left\{\gamma{\Psi_0}^2 + m\left(U_0 + W_0{\Psi_0}^2\right)^2\right\}\right]^{\frac{1}{2}}} \qquad 62$$

The equations (60)-(62) totally define the parameters of localized state described by functions

$$\Psi_j(x) = \frac{A}{\cosh(q(|x| + x_0))} \qquad 63$$

Equations (60) and (61) can be simplify for the case of small amplitude oscillations when ${\Psi_0}^2 \ll \left|\frac{U_0}{W_0}\right|$. From equation (60) the wave number of small amplitude localized oscillations can be obtain in the form

$$q(\Psi_0) = q_{L0} + \alpha{\Psi_0}^2 \qquad 64$$

Where $q_{L0} = m|\,U_0|$, $\alpha = \frac{(2m\,U_0\,W_0 + \gamma)}{2|\,U_0|}$.

To obtain from equation (61) the energy of small amplitude localized oscillation in the form

$$E(\Psi_0) = E_{L0} + \alpha\,|\,U_0|{\Psi_0}^2 \qquad 65$$

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ISSN: 2536-7315 (Print) 2536-7323 (Online)
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http://www.casirmediapublishing.com

Where $E_{L0} = \frac{\Omega - q_{L0}^2}{2m}$.
In this case the wave function equation (63) takes the well know form
$\Psi(x) = \Psi_0 expt\ (-q|x|)$ 66
From equation (60) to derive the damping space factor of localized in linear media states
$q = q_{L0} = -m\ U_0$ 67
and from equation (66) the energy can be derive
$E = E_{L0} = \frac{\Omega - m\ U_0}{2m}$ 68
The nonlinear potential with cubic nonlinearity for mathematical formulation of the model it has been used to describe the defect with nonlinear properties. The solution and derived equation of the formulated problem define the nonlinear energy. The field blocking effect described by the first type stationary states the nonlinearity parameter of the media where field fades away should be less the nonlinearity parameter of the media where atom moving in geometry is formed $(\gamma_1 < \gamma_2)$. also the field blocking effect described by the second type stationary state the nonlinearity parameter of the media where fields decays is fulfilled the condition: $\gamma_1 < \gamma_2 < 2\gamma_1$.

## CONCLUSION

The proposed equation describes the field localization at both sides from the interface in the limit $k \rightarrow 1$ when elliptic functions transform into hyperbolic. The case of nonlinear interface the characteristic width of excitation localization proportional to the interface nonlinearity and the energy of small amplitude nonlinear localized excitations depends on square of the amplitude of the plane defect oscillations it has been derived. The new types of stationary states have been found in the form coupled and the atom moving in geometry nonlinear Schrödinger equation solution due to the presence of nonlinear defect.

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