



STRING QUANTUM MECHANICAL LASING DUE TO FRICTION

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ABSTRACT

Background: Lasers have numerous applications and can be considered as one of the main technological outputs of quantum physics. Due to string theory electrons in any atom behaves as a harmonic oscillator. Thus, it is natural to solve the Schrodinger equation for harmonic oscillator in the presence of friction Schrodinger equation. **Objectives:** The absence of a relation between frictional effects in quantum mechanics relativity and Laser amplification led to conduct a theoretical study so as to verify the Laser amplification due to friction. String theory treats particles as harmonic oscillators. **Methods** In this work Schrodinger equation for frictional medium is derived, and the Harmonic oscillator solved for resistive medium. **Results:** The results showed no change of energy per particle. This means that energy loss due to friction changes the number of particles and does not change the energy of a single particle. This resembles inelastic scattering, which leads to atomic excitation that changes their energy by an amount ($\hbar\omega$). Here the increase or decrease due to friction and collision is caused by the change of the number of excited atoms. **Conclusions:** The Schrodinger equation for frictional medium is derived; Harmonic oscillator solution for resistive medium shows the possibility of lasing within the framework of string theory.

Keywords: Friction, lasing, String theory, Harmonic oscillator, Schrodinger equation.

1. INTRODUCTION

In physics the discovery of the laser (light amplification by stimulated emission of radiation) was based on Einstein's theory of stimulated emission of radiation. However, it was only in the 1950's that this theoretical study led to the creation of lasers. Nowadays lasers found numerous applications and can be considered as one of the main technological outputs of quantum physics [1].

The most important features of quantum mechanics leading to laser theory were obtained already in the old quantum mechanics: i.e. the discrete structure of energy levels for atoms and the quantum structure of electromagnetic radiation; spontaneous and stimulated emission and absorption. Here the discrete structure of energy levels of atoms was simply postulated by Bohr to derive the stability of atoms. Then Einstein (motivated by Plank's study on black body radiation) postulated the quantum structure of radiation [2, 3].

By using the quantum structures for atoms and radiation and thermo dynamical considerations, he derived spontaneous and stimulated emissions and absorption which are fundamental in laser theory.

However, the "old fashioned considerations" in the spirit of Bohr and Einstein clarify the basic assumptions leading to the functioning of the laser in a more intuitive and less formal way [4, 5, 6].

Although quantum equations explain many subatomic phenomena; but it fails to account the effect of resistive medium. Some attempts were made by M. Dirar et al. (2015) and Lutfi et al. (2016), but they concentrate on the effects of friction on the time evolution of the physical system [7, 8]. Rare attempts to account for spatial effects. The principle objective of this study is to verify the Laser amplification due to friction.

2. LASER AMPLIFICATION

For any system moving with velocity v , the momentum is given by:

$$P = mv \tag{1}$$

Thus the total momentum for frictional medium is given by:

$$\tilde{P} = P - P_f \quad (2)$$

For the situation in which there is both a kinetic energy and a potential present, the total energy of the system in Newtonian mechanics (SR for low speed) is given by:

$$E = \frac{(P - P_f)^2}{2m} + V$$

Thus:

$$E = \frac{P^2}{2m} - \frac{PP_f}{m} + \frac{P_f^2}{2m} + V \quad (3)$$

Multiplying both sides of Eq. (3) by ψ , yields:

$$E\psi = \frac{P^2}{2m}\psi - \frac{PP_f}{m}\psi + \frac{P_f^2}{2m}\psi + V\psi \quad (4)$$

Relation (4) can be used to find Schrodinger equation for particles moving in a resistive medium.

Consider:

$$P_f = -\left(\frac{\hbar}{c\tau}\right) i \quad (5)$$

$$P\psi = \frac{\hbar}{i} \nabla\psi \quad (6)$$

From Eq.s (4), (6):

$$-\frac{\hbar^2}{2m} \nabla^2\psi + \frac{iP_f\hbar}{m} \nabla\psi + \frac{P_f^2}{2m}\psi + V\psi = E\psi \quad (7)$$

The wave function is given by:

$$\psi = e^{ikx}u(x) \quad (8)$$

$$\nabla\psi = ike^{ikx}u + e^{ikx}\nabla u \quad (9)$$

$$\nabla^2\psi = -k^2e^{ikx}u + 2ike^{ikx}\nabla u + e^{ikx}\nabla^2u \quad (10)$$

Substituting Eq.s (5), (9) and (10) in Eq. (7), yields:

$$\frac{\hbar^2k^2}{2m}u - \frac{ik\hbar^2}{m}\nabla u - \frac{\hbar^2}{2m}\nabla^2u + \frac{ik\hbar^2}{m\tau}u + \frac{\hbar^2}{m\tau}\nabla u + \frac{\hbar^2}{2m\tau^2}u + Vu = Eu \quad (11)$$

This equation can be made reduced to Schrodinger equation by assuming:

$$\frac{ik\hbar^2}{m} = \frac{\hbar^2}{m\tau}$$

Thus:

$$k = -\frac{i}{c\tau} \quad (12)$$

Which can be written:

$$-\frac{\hbar^2}{2m} \nabla^2u + \left(\frac{\hbar^2k^2}{2m} - \frac{\hbar^2k^2}{m} - \frac{\hbar^2k^2}{2m}\right)u + Vu = Eu$$

$$-\frac{\hbar^2}{2m} \nabla^2u + Vu = \left(E + \frac{\hbar^2k^2}{m}\right)u \quad (13)$$

From Eq.s (8) and (12):

$$\psi = e^{\frac{1}{c\tau}x} u(x) \quad (14)$$

Thus the numbers of electrons are given by:

$$n = |\psi|^2 = \psi\bar{\psi}$$

$$n = \left(e^{\frac{1}{c\tau}x} u \right) \left(e^{\frac{1}{c\tau}x} u \right) = e^{\frac{2}{c\tau}x} u^2 \quad (15)$$

We assume that n is the number of excited electrons, then the number of emitted photons n_p is proportional to it. Hence:

$$I = n_p c = c u^2 e^{\frac{2x}{c\tau}} \quad (16)$$

Comparing with laser amplification condition:

$$I = I_0 e^{\beta x} \quad (17)$$

$$\beta = \frac{2}{c\tau}$$

This lasting can take place.

The fact that:

$$\beta \sim \frac{1}{\tau}$$

Is related to the fact that smaller relaxation time τ means very small distances between adjacent atoms. Which means existence of more intensive excited states.

For harmonic oscillator:

$$-\frac{\hbar^2}{2m} \nabla^2 u + V = E_0 \psi \quad (18)$$

Where:

$$V = \frac{1}{2} k_0 x^2 \quad (19)$$

$$E_0 = \left(n + \frac{1}{2} \right) \hbar \omega \quad (20)$$

Thus comparing Eq.(13) and(14) yields:

$$E_0 = \left(n + \frac{1}{2} \right) \hbar \omega = E + \frac{\hbar^2 k^2}{2m} \quad (21)$$

For

$$i\hbar \frac{\partial \psi}{\partial t} = -\frac{\hbar^2}{2m} \nabla^2 \psi + V\psi \quad (22)$$

$$E\psi = -\frac{\hbar^2}{2m} \nabla^2 \psi - \frac{\hbar^2 \gamma}{m^2 c} \nabla \psi - \frac{\hbar^2 \gamma^2}{2m^3 c^2} \psi + V\psi \quad (23) [9].$$

But comparing Eq.s (4), (6), (13), (21) and (23) yields:

$$i\hbar \frac{\partial \psi}{\partial t} = E\psi \quad (24)$$

Let:

$$\psi = g(x)u(x) \quad (25)$$

To get:

$$i\hbar \frac{\partial \psi}{\partial t} = E\psi \quad (26)$$

The solution for ψ gives:

$$\psi = \psi_0 e^{-\frac{iEt}{\hbar}} = e^{-i\omega t} \quad (27)$$

The periodicity condition for harmonic oscillator yields:

$$\psi(t + T) = \psi(t) \quad (28)$$

$$e^{-i\omega T} = 1 \quad (29)$$

$$\cos \omega T + i \sin \omega T = 1$$

Thus:

$$\cos \omega T = 1$$

$$\sin \omega T = 0$$

Hence:

$$\omega T = 2n_0\pi \quad (30)$$

Thus:

$$\omega = \frac{2\pi n_0}{T} = 2\pi f_0 n_0 = n_0 \omega_0 \quad (31)$$

$$n_0 = 1, 2, 3, \dots$$

From Eq.(27) and Eq. (31):

$$E = \hbar\omega = n_0 \hbar\omega_0 \quad (32)$$

Thus from (21) and (32):

$$\begin{aligned} \frac{\hbar^2 K^2}{2m} &= \frac{P^2}{2m} = E_0 - E = \left(n + \frac{1}{2}\right) \hbar\omega - \hbar\omega = \left(n - \frac{1}{2}\right) \hbar\omega \\ &= \left(n - \frac{1}{2}\right) \hbar_0 \omega_0 \end{aligned} \quad (33)$$

3. DISCUSSION

Due to string theory electrons in any atom behaves as a harmonic oscillator. Thus, it is natural to solve the Schrodinger equation for harmonic oscillator in the presence of friction Schrodinger equation becomes in the form Eq.(11). The effect of friction on Schrodinger equation leads to describing the inelastic scattering process. The wave number K is imaginary as shown by Eq.(12). Thus the wave function and the number of particles increases with x as Eq.s(14) and (15) indicates. This means that amplification can take place according to Eq. (16). This is since the number of emitted photons n_p is proportional to the number of excited electrons n given by Eq. (15). This means that resistive medium can induce laser. This is due to the fact that collision process takes place in a resistive medium. This collision leads to electrons excitation. The smaller collision time τ the larger the number of excited electrons, which causes a larger number of photons to be emitted. Thus amplification factor β should increase as τ decreases. This is strictly what is Eq. (17) stated. It is very interesting to note that the wave number as well as the momentum is quantized as shown by Eq. (33).

This a study agrees with some attempts, one of them is proposed by Lutfi Mohammed AbdAlgadir and others [8]. It is a Schroedinger quantum equation from classical and quantum harmonic oscillator, from this model shows Schrödinger equation and energy Eigen equations are affected by friction. Another attempt was also made by Mobarak Ibrahim and others to construct a quantum relativistic equation and string mass quantization, this expression includes mass energy beside potential energy, with energy conserved. The special relativistic energy in the presence of friction is found. Treating particles as vibrating string the mass is quantized [7]. But no one of them uses this equation to construct a quantum equation that accounts for lasing

4. CONCLUSION

The spatial quantum effect on particles and quantum systems manifests themselves via the momentum. The Schrodinger equation for frictional medium is derived; Harmonic oscillator solution for resistive medium shows possibility reference of lasing.

This study concludes that atomic excitation that changes their energy by an amount ($\hbar\omega$). Here the increase or decrease due to friction and collision is caused by the change of the number of excited atoms.

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