ISSN 1512-1461

UDC 537.3, 538.9

ABSORPTION OF MONOCHROMATIC WAVE ENERGY IN VACUUM

E.R. Hasanov [1,2] S.G. Khalilova [2] R.K. Mustafayeva [1]

1. Baku State University, Baku, Azerbaijan, egasanov065@gmail.com, ruhi-qrk@mail.ru
2. Institute of Physics, Baku, Azerbaijan, shahlaganbarova@gmail.com

Abstract. *Vacuum still remains a mysterious medium from a physical point of view, especially its physical properties. The passaging of a monochromatic wave is examined through a vacuum of size L in our work. A monochromatic wave has a certain energy, and when passing through a vacuum it should not lose energy. At different values of the vacuum size, according to the properties of the vacuum, there should be no loss of energy by the wave. If energy loss occurs as a wave passes through, the cause of the energy loss is inhomogeneity. The inhomogeneity of the vacuum proves the existence of some particles in the vacuum, i.e. vacuum is ordinary matter. We can say that a certain part of the energy of a monochromatic wave is absorbed by matter, i.e. vacuum. In this work, the energy of a monochromatic wave is calculated before and after passing through a vacuum of size L. It has been proven that the ratio of the energy of a monochromatic wave before passing through a vacuum is less than 1. This means that the monochromatic wave was scattered in elastically in a vacuum and vacuum is a dense medium. After the passage of the vacuum wave, the length of the monochromatic wave decreases. A monochromatic wave loses energy in a vacuum.*

Keywords: *vacuum, energy, inelastic interaction, monochromatic wave, absorption, inhomogeneity.*

Introduction

Quantum mechanics, as a mathematical method, is based on the wave function. In the one-dimensional case, the monochromatic wave function has the form

$$\psi(x,t) = ce^{i(kx-\omega t)} = ce^{i\left(kx-\frac{Et}{\hbar}\right)} \tag{1}$$

Here k -wave vector $k = \frac{2\pi}{\lambda} n, (n = 0, \pm 1, \pm 2, \ldots)$, λ -длина волны, K - energy of wave in vacuum, which is related to the wave vector as follows

$$E = \frac{\hbar^2 k^2 n^2}{2m_0}, \quad n = 0, \pm 1, \pm 2, \ldots \tag{2}$$

m_0 - free electron mass

Wave function (1) satisfies Schredinger equation

$$\frac{\partial \psi}{\partial t} = \frac{i\hbar}{2m_0} \frac{\partial^2 \psi}{\partial x^2} \tag{3}$$

Let's pretend that a monochromatic wave falls on vacuum with energy

$$E_{before} = \frac{2\pi^2 \hbar^2}{m_0 \lambda_0^2} \tag{4}$$

ISSN 1512-1461

Theory

In the view of classical physics, this wave should not change energy after leaving the vacuum with a length of L However, we will show that the energy (4) changes after leaving the vacuum as L. This means that the vacuum interacts with a monochromatic wave. So, there is interaction with the wave in vacuum. Using the Schrödinger equation (3), we calculate the energy in vacuum

From (1) we calculate $\frac{\partial\psi}{\partial t}$ and $\frac{\partial^2\psi}{\partial x^2}$

$$\frac{\partial\psi}{\partial t}=2\pi i\psi\left(-\frac{x}{\lambda^2}\frac{d\lambda}{dt}-\frac{\hbar}{m\lambda^2}+\frac{2\hbar t}{m\lambda^3}\frac{d\lambda}{dt}\right) \tag{5}$$

$$\frac{\partial^2\psi}{\partial x^2}=-4\pi^2\psi\left(\frac{1}{\lambda}-\frac{x}{\lambda^2}\frac{d\lambda}{dx}+\frac{2\hbar t}{m\lambda^3}\frac{d\lambda}{dx}\right)^2+2\pi i\psi\left[-\frac{2}{\lambda^2}\frac{\partial\lambda}{\partial x}+\frac{2x}{\lambda^3}\left(\frac{d\lambda}{dx}\right)^2-\frac{6\hbar t}{m\lambda^4}\frac{d\lambda}{dx}+\frac{2\hbar t}{m\lambda^3}\frac{d^2\lambda}{dx^2}\right] \tag{6}$$

Substituting (5) and (6) into (3) and separating real and imaginary part, we will get

$$2\frac{\partial\lambda}{\partial x}-\frac{2x}{\lambda}\left(\frac{d\lambda}{dx}\right)^2+\frac{6\hbar t}{m\lambda^2}\frac{d\lambda}{dx}=0 \tag{7}$$

$$\left(\frac{x}{\lambda^2}-\frac{2\hbar t}{m\lambda^3}\right)\frac{\partial\lambda}{\partial t}=\frac{\hbar}{m\lambda^2}-\frac{2\hbar t}{m\lambda^3}\left(1-\frac{x}{\lambda}\frac{d\lambda}{dx}+\frac{2\hbar t}{m\lambda^2}\frac{d\lambda}{dx}\right)^2 \tag{8}$$

From (7) we will get

$$\frac{\partial\lambda}{\partial x}=\frac{\lambda\left(2+\frac{6\hbar t}{m\lambda^2}\right)\hbar}{x} \tag{9}$$

Substituting (9) into (8) we will get:

$$\frac{\partial\lambda}{\partial x}=-\frac{2\pi\hbar}{m\lambda A(t)}\left[1+\frac{2\lambda}{x}uA(t)+\left(\frac{\lambda}{x}\right)^2(Au)^2\right] \tag{10}$$

Here $A(t)=\frac{2\hbar t}{m\lambda^2}-\frac{x}{\lambda}$, $u=2+\frac{6\hbar t}{m\lambda^2}$

To integrate equation (10), we assume

$$\frac{2\hbar t}{m\lambda}<x,\ A=-\frac{x}{\lambda},\ u=2 \tag{11}$$

Substituting (11) into (10) we will get:

$$\frac{\partial\lambda}{\partial t}=\frac{2\pi\hbar}{mx} \tag{12}$$

From

$$\lambda=\lambda_0+\frac{2\pi\hbar t}{mx}=\lambda_0\left(1+\frac{2\pi\hbar t}{mx\lambda_0}\right) \tag{13}$$

When obtaining equation (12), we discarded the member $\frac{\partial^2\lambda}{\partial x^2}$ and this is quite justified, because, λ depends on the coordinates like a linear way. Thus, the final energy of the wave after leaving the vacuum with size $x=L$:

ISSN 1512-1461

$$E_{после} = \frac{2\pi^2\hbar^2}{m_0\lambda_0^2} \cdot \frac{1}{\left(1 + \frac{2\pi\hbar t}{m_0\lambda_0 L}\right)^2}$$

That is why

$$\frac{E_{before}}{E_{after}} = \frac{1}{\left(1 + \frac{2\pi\hbar t}{m_0\lambda_0 L}\right)^2} << 1 \qquad (14)$$

Expression (14) have gotten from solving equation (10) with values for (11) A and u. For values $A = 0$ and $u = 0$ $\lambda \to \infty$ and this is the classic area where the wave turns into a line. For values

$$A = \frac{2\hbar t}{m_0\lambda^2}, \quad u = \frac{6\hbar t}{m_0\lambda^2} \qquad (15)$$

Solution of equation (10) is more complex.

Substituting (15) into (10) for wavelength we will get:

$$\lambda = \lambda_0 \left[1 - 2\left(\frac{2\hbar\tau}{m_0\lambda_0^2}\right)^2 \left(\frac{3\lambda_0}{L}\right)^2\right]^{1/6} \qquad (16)$$

And

$$\frac{E_{before}}{E_{after}} = \frac{1}{\left[1 - 2\left(\frac{\hbar\tau}{m_0\lambda_0^2}\right)^2 \left(\frac{3\lambda_0}{L}\right)^2\right]^{1/6}} \qquad (17)$$

Here, τ - the time of passing of wave through vacuum with size L.

Thus, a monochromatic wave, passing through a vacuum of length L, decreases its energy. This is the inelastic interaction of the wave with the vacuum. This means that the vacuum is not an empty means

Conclusion

It has been proven that a monochromatic wave, passing through a vacuum of size L, loses part of its energy. Losing energy occurs with different values of L in different ways. Vacuum is matter and has inhomogeneity. This inhomogeneity leads to losing energy of the monochromatic wave.

A wave with a longer wavelength loses more energy than a wave with a short wavelength. In addition, the wave losing energy leaves the vacuum, which means that the vacuum behaves like a massive medium in which inelastic interaction with the wave occurs. However, unfortunately, it is not known what kind of elementary particles the vacuum is filled with and they move by what law. Vacuum (emptiness) is a mysterious object in the sense of physical understanding. The properties of vacuum are not clearly defined and are closed to people

References

1.Landau L. D., Lifshitz E. M. Quantum Mechanics. Non-Relativistic Theory. Series: Theoretical physics, Moscow: Nauka, 1984, pp.13-37

2.Landau L. D., Lifshitz E. M. Quantum Mechanics. Non-Relativistic Theory. Series: Theoretical physics, Moscow: Nauka, 1984, pp.42-66

3.Landau L. D., Lifshitz E. M. Quantum Mechanics. Non-Relativistic Theory. Series: Theoretical physics, Moscow: Nauka, 1984, pp.70-100

Article received 2024-02-29