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Investigating the Invalidity of the Law of Energy Conservation Based on Waves Interference Phenomenon Inside a Ringed Waveguide

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Abstract**—**Law of energy conservation is one of the fundamental laws of physics. Energy is conserved, and the total amount of energy is constant. It can be transferred from one object to another and changed from one state to another. However, in the case of wave interference, this law faces important contradictions. Based on the presented mathematical relationship in this paper, it seems that validity of this law depends on the path of energy wave, like light, in which it is located. In this paper, by using some fundamental concepts in physics like the constancy of the electromagnetic wave speed in a specific media and wave theory of light, it will be shown that law of energy conservation is not valid in every condition and in some circumstances, it is possible to increase energy of a system with a determined amount of energy without any input.

Keywords**—**Power, law of energy conservation, electromagnetic wave, interference, Maxwell's equations.

I. Introduction

THE concept of energy is so broad that writing a clear definition of that is so difficult [1]. Technically, energy is a scalar quantity associated with the condition (or state) of one or several objects. Energy is a number that is associated with a system of one or multiple objects. If a force changes the status of an object by moving it, actually it changes the energy number [1]. Energy can be converted from one state to another, and transferred from one object to another, But the total amount of energy is constant (energy is conserved). Until today, no exception to this principle of energy conservation has ever been found. Work is the energy transferred to an object by means of a force applied to it. Measurement unit of work is same as energy and also it is a scalar quantity. The amount of work which is done by a force at the unit of time is called power due to the force. Light is a form of electromagnetic wave which is the carrier of energy [1].

In 1845, Michael Faraday discovered that the polarization plane of a linearly polarized electromagnetic wave is rotated when the wave travels through a magnetic field in the presence of a transparent dielectric. This effect was later named Faraday rotation. W. Bertozzi in 1964, accelerate electrons to different measured speeds, and shows the speed of electrons is limited. The kinetic energies had measured by an independent method [1]. This method discovered that when the force on a very fast electron is increased, the electron's measured kinetic energy increases toward very large values, but its speed does not increase considerably. Electrons have been accelerated in laboratories to at least 0.99999999995 times the speed of light but—close though it may be—that speed is still less than the ultimate speed $c \approx 3 \times 10^8\ m/s$ [1]. In 1964, physicists at CERN, the European particle-physics laboratory near Geneva, produced a beam of pions traveling at a speed of 0.99975 of the light speed with respect to the laboratory [1]. Scientists found that the speed of the light emitted by the pions was the same as it would be if the pions were at rest in the laboratory, namely C [1], [2]. Maxwell discovered that electromagnetic waves would travel through space at a constant speed [3].

Heinrich Hertz proofed Maxwell's opinion experimentally by producing and monitoring radio waves in the lab, and demonstrating that electromagnetic waves show, exactly, similar behavior like visible light. Also, electromagnetic wave has characteristics like reflection, refraction, diffraction, and interference [4]. Based on mentioned fundamental concepts, until today, there is no doubt on law of energy conservation. However, in the cause of wave interference there are important contradictions.

Many researchers try to explain these contradictions [5], [6]. Levine [5] believed that when electromagnetic waves cancel by destructive interference the wave impedance reflected to the source of wave energy changes so that the input power is reduced correspondingly. The mentioned reasoning is correct when a wave comeback to the source of the energy. Kirk T. McDonald [7] believes a one-dimensional wave that moves in one direction can only have a reference or source, and, only one wave can be present at a given point, therefore, the phenomenon of interference does not essentially have an existential meaning here.

Based on Kirk T. McDonald's description, from the mathematical point of view, the sum of two electromagnetic waves with the same energy and wavelengths but with π phase difference is zero, but this mathematical result does not have the physical concept that two distinct waves exist, each with nonzero energy. McDonald [7] also believes that the concept of wave interference applies only to waves from different sources, or, in the case of single source, the propagation in two or more dimensions of a wave.

When two sources exist, the waves cannot propagative only in the same direction; such waves must be counter-propagating if waves are one dimensional, or they propagate in two or more

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dimensions. The mentioned argument in the case of standing wave or two waves which interference in opposite directions is absolutely correct but in the case of two waves that interference in same direction, the claim is not acceptable. In the present study it will be shown that executing of putting two waves in one direction is possible. As well as, based on Drosd's [7] description, in the case of interference from two identical monochromatic in-phase wave sources, the intensity of the resulting waves from the two separated sources in any point of the space is four (not two) times greater than the intensity of one single source. This is a direct result of summation of the amplitudes, gives an increase of a factor of four for power. So, the total energy flow pass through any surrounding surface (which contain these two sources) is double the sum of individual energy flow that these two sources would have produced when each was alone. Drosd explicitly states that, "It is important to emphasize that the law of energy conservation does not require the equality of power radiation of two isolated sources as compared to when the waves are near one another" [7]. In fact, two in-phase wave sources generate greater power when since they now represent (effectively) a single source producing a wave of double amplitude. The increase in power of radiation is not a contradiction of the law of energy conservation but it is because of the additional work done by the two wave generators to generate the double amplitude for combined waves from two in-phase sources.

To satisfy this increase in amplitude, the wave sources will each produce more power from their supplies. If the supplies are not capable of producing this additional power, then the combined wave amplitude will never satisfy the value of double amplitude at the first point [7]. As well, in condition that sources are in anti-phase, sources would each produce a net energy flow to the medium, but when the two sources are located in the same place, it is expected zero energy transfer to the medium. Each of the sources will do zero work (because of the zero amplitude of the combined waves) and so will require zero energy from their sources and once again, there is no contradiction of the conservation of energy [7]. It seems that the reasoning in the argument of Drosd [7] is not acceptable. Because for the instance that two separated sources generate energy, sources act completely independent and future interference do not change their power.

In present paper it will be shown that based on fundamental concepts in physics, there is a serious contradiction for law of energy conservation. Mathematically, it will be shown that law of energy conservation is not valid in all conditions and in some special circumstances energy can be generated without adding energy to a system.

II. Problem Definition

In the described problem, according to the basic definitions of the field of power and energy, some contradictions are observed in fundamental principles such as the law of energy conservation and the fact that speed of light is constant. It is assumed that an electromagnetic wave (Here, it is possible to use a charged wave like Electron-Beam because makes it possible to bend the wave) with (1) and Fig. 1, which is a solution for Maxwell's Equations [8].

$$E(x,t) = \vec{y}E_0\cos(kx-\omega t)$$
$$B(x,t) = \vec{z}B_0\cos(kx-\omega t) \tag{1}$$

where E_0 and B_0 are amplitude of electric and magnetic field respectively, $k=2\pi/\lambda$ is the wavenumber, $\omega=2\pi f$ is the angular frequency, λ is the wavelength and f is the frequency of the wave.

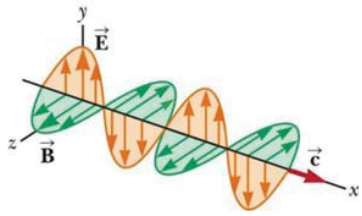

Fig. 1 An electromagnetic wave

Also, it is assumed that wave equation (1) is placed inside a frictionless ring waveguide with cross-section A like Fig. 2. The characteristic of the ring waveguide is that the wave interferences with itself each time it spins.

Bending of electromagnetic wave at the free space by gravity has been predicted by Einstein. Einstein explained bending of light based on the equivalence principle [9]. Also, Kaminer et al. [10] have shown nondiffracting spatially accelerating solutions of the Maxwell equations. These beams accelerate in a circular trajectory without any external field. In addition, there are many waveguides that bend light like coupled-resonator optical waveguide (CROW) [11].

Another candidate for the efficient propagation through sharp bends is a chain of metallic nanoparticles guiding the electromagnetic energy via localized surface plasmon resonances [12]. Theoretical studies in the quasistatic single-dipole approximation suggested an efficient power transmission through sharp bends in such waveguides [13]. Waveguiding along the chain of gold nanoparticles with large bend radii on metal surface was considered in [14]. The CROW-type structures with the sub wavelength guiding and low losses have been demonstrated with arrays of dielectric nanoparticles with high values of the refractive index [15]. Such dielectric nanoparticles simultaneously support both magnetic dipole (MD) and electric dipole (ED) resonances [16], which give an additional control parameter over the light scattering [17], [18].

By putting the plane electromagnetic wave equation (1) in wave guide with cross-sectional area $A = \pi d^2/4$ (Where d is diameter of the cross-section), Fig. 2, the electromagnetic wave that is produced by the n interferences with previous waves in the ringed waveguide with length $L = m\lambda$, where m is an integer, is:

$$E(x,t)_n = \vec{y}nE_0\cos(kx-\omega t)$$
$$B(x,t)_n = \vec{z}nB_0\cos(kx-\omega t) \tag{2}$$

It should be mentioned that for preventing undesirable destructive and constructive interference at first touch point of waves, point F in Fig 2, first touch angle θ should be near to zero. For first touch angle θ, it can be written:

$$\theta = \cos^{-1}\left(1 - \frac{d}{D/2}\right) \tag{3}$$

where D is waveguide diameter. So, due to (3), D should be much great than d, $D \gg d$. The energy stored per unit volume in an electromagnetic wave is given by [19]:

$$w = \frac{\varepsilon_0 E^2}{2} + \frac{B^2}{2\mu_0} \tag{4}$$

where ε_0 and μ_0 are the permittivity and permeability respectively. Since, $B = E/c$ and $c = 1/\sqrt{\varepsilon_0\mu_0}$ (speed of wave), (4) yields [19]:

$$w = \varepsilon_0 E^2 \tag{5}$$

If it is considered a cross-sectional area A at the x-axis, then in a time dt the wave passes through a volume dV of space, where $dV = Acdt$. The amount of energy filling this volume is:

$$dW = w dV = \varepsilon_0 E^2 Acdt \tag{6}$$

From the definition of power P, the power carried by the wave is given [6]:

$$P = \frac{dW}{dt} = \varepsilon_0 E^2 Ac = KE^2 = KE_0^2 cos^2(kx - \omega t) \tag{7}$$

where $K = \varepsilon_0 Ac$.

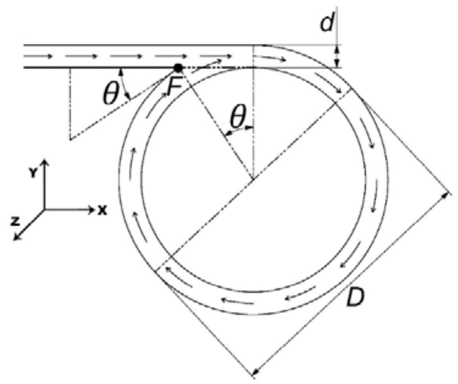

Fig. 2 Circular path for interference a wave with itself

Now it is assumed that a wave interferences n times in the ringed waveguide. After n times (n is integer), that $n > 1$, the amplified wave inside the ringed waveguide can be represented as (2). Therefore, the power of amplified wave inside the waveguide can be written as bellow:

$$P_{circle} = Kn^2 E_0^2 cos^2(kx - \omega t) \tag{8}$$

Now it is assumed that it is possible to exit the wave from the ringed waveguide. The time required to exit the wave from the waveguide is $t = \frac{L}{c} = mT$, where T is wave time period. With regarding that the amount of power and the applying time is given, it is possible to calculate output energy from system that is shown in Fig. 3.

$$E_{out} = \int_0^{\frac{L}{c}=mT} P_{circle} dt = \int_0^{mT} Kn^2 E_0^2 \, cos^2(kx - \omega t)\, dt = \frac{Kn^2 E_0^2}{2} mT \tag{9}$$

Also, the time required for n interferences in the ringed waveguide is $\tau = \frac{nL}{c} = nmT$. Actually τ is duration that energy is pumped to the system Fig. 3. According to Fig. 3, the amount of input energy E_{in} to the system for the duration T is expressed as follows:

$$E_{in} = \int_0^{\frac{nL}{c}=nmT} P dt = \int_0^{nmT} KE_0^2 \, cos^2(kx - \omega t)\, dt = \frac{KE_0^2}{2} nmT \tag{10}$$

By rewriting the law of energy conservation for system Fig. 3 and equating input and output energy, it can be written:

$$E_{out} = E_{in}\, , \frac{Kn^2 E_0^2}{2} mT = \frac{KnE_0^2}{2} mT \Rightarrow n = 1 \tag{11}$$

The result obtained in (10) absolutely is false, because, at first, it was assumed that $n > 1$.

Based on obtained result from (11), it can be concluded that there is energy generation in the waveguide and amount of energy is increasing in each interference.

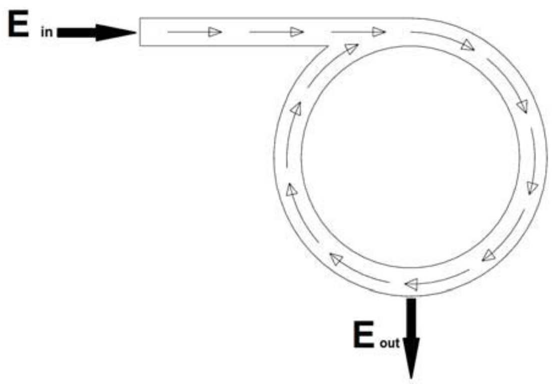

Fig. 3 Outlet and inlet energy in the ringed waveguide

III. Conclusion

According to (11), one of the three following results can be extracted:

1. The energy conservation law is wrong and the amount of energy of a given wave, depending on the path in which it is located, can be increased over the time. This can be shown as follows:

$$E_T = nE \tag{12}$$

where in (12), E is the energy of a moving wave in a nonrepeat path and n is the number of interferences of a wave in the ringed waveguide. Therefore, the total energy of a particle with mass m and speed c can be expressed as follows:

$$E_T = nmc^2 \quad (13)$$

2. The wave speed is not constant and is linearly proportional to the number of interferences in the ringed waveguide. This means that the wave speed increases at each interference and can be expressed as follows:

$$c_n = nc \quad (14)$$

If the result of (14) is accepted, the energy conservation law still remains true. By replacing (14) in (9), the output and input energy will be equal, and the energy conservation law is still correct.

3. Waves are intelligent, and they know how to interference with each other in the waveguide until the law of energy conservation has remained valid.

In the presented case study, the wave exits from the unique source and there is no way for returning wave to the source. So, interference doesn't have effect on the power of the energy source. Also, it seems that to setup an experimental test for the presented case study is visible.

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