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Notes: The Strange Nature of Light

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Abstract

The purpose of this paper is to show that contrary to the conventional view of the nature of light, its behaviour is far stranger than has been considered. Here presented it is shown that time is frozen from the reference frame of a photon, that the phase velocity of light is superluminal. And also light is superluminal in the nearfield of the source of a transmitter, and that advanced waves have been detected. The principle of least action is reflected in lights behaviour in the quantum domain, and conservation laws may apply for advanced waves travailing into the past. These aspects of light, known by scientists, but presented all together show how strange the nature of light really is, and that a new model needs to be addressed on the behaviour of light.

Keywords: Advanced waves, Conservation laws, Phase velocity, Principle of least action, near field.

1. Introduction

Perhaps the conventional view on the nature of light has made many scientists to take it for granted, but considering previous research and experiments, demonstrates that the nature of light to be far stranger than has been considered before, leading to the need to address its nature and to build a new model on its behaviour.

It is generally known that time in the reference frame of a photon is frozen and also that velocity of light is superluminal. These aspects are known and perhaps taken for granted, but what is not is that due to experiments, light has been shown to be superluminal in the nearfield of the source of a transmitter, William D. Walker [1] has shown this in his experiments, as well as Takaaki Musha [2] which brings to the attention the possibility of causal violations and the violation of Einstein's Relativity. Such superluminal nature of light has been shown by others, E Recami [3] Chu and S. Wang at AT&T Bell labs [4] and Steinberg, Kwait and Chiao [5] and optical experiments at Princeton NEC [6]. All these scientists have results that proves the superluminal nature of light. Not only has this, for the first time in 2017 D.Bajlo [7] in a series of experiments detected advanced waves. Also shown is my suggestion that for an advanced wave travelling into the past, that energy may be conserved, both in the past and future that this shows that time is symmetrical and not asymmetrical as was once thought.

2. Properties of Light

1.1: Time is frozen in the reference frame of a photon, say travelling 10,000 light years, for that photon 10,000 light years is only an instant, but from our frame of reference, 10,000 years has past. We are so familiar with this in physics, that we may take such facts for granted. We must see such behaviour with fresh eyes. The above may be known, but it is still a remarkable fact.

1.2: The phase velocity of light is faster than light, where its group velocity is at the speed of light. In quantum mechanics particles also behave as waves with complex phase, the phase velocity is equal to the product of the frequency multiplied by the wavelength;

$$Vp = f\lambda$$

$Vp =$ Phase velocity

By the de Broglie hypotheses we see that:

$$Vp = \frac{\omega}{k} = \frac{E/h}{P/\hbar} = \frac{E}{P}$$

$P =$ Momentum

Using relativistic relation for energy and momentum we have:

$$Vp = \frac{E}{P} = \frac{mc2}{mv} = \frac{\gamma m°c2}{\gamma m°v} = \frac{c2}{v} = \frac{c}{\beta}$$

Where E is the total energy of the particle (i.e. the rest mass and kinetic energy in the kinematic sense) $P =$ momentum, $\gamma =$ the Lorentz factor, $c =$ the speed of light, and β the speed as a fraction of c.

The variable v can either be taken to be the speed of the particle or the group velocity of the corresponding matter wave. Since the particle speed $v < c$ for any particle, that has mass (according to special relativity) the phase velocity of matter waves always exceed the speed of light. And as we can see it, it approaches$c$, when the particle speed is in the relativistic range. The superluminal phase velocity does not violate special relativity, because phase propagation carries no energy.

Take the example of the phase velocity being faster than light for light, would the phase velocity Vp of light, then be propagated into its past, with effect arising before its cause? We can compare de Broglie's formula to Tolmans paradox.

$$f1 = f° \sqrt{1 - \frac{v2}{c2}}$$

de Broglie called this wave the phase wave, this was his basic matter wave conception, he noted that $Vp > c$ and believed the phase wave dose not transfer energy. For sending a signal

faster than light, we have following expressions of Tolmans paradox. Einstein's 1907 thought experiment of how faster than light signals lead to paradoxes of causality. For sending a signal faster than light,

$\Delta t = t - t^{\circ} = \frac{B-A}{a}$ The arrival at B is given by velocity a, and event A is the cause of B. This inertial frame moving with relative velocity v, the time of arrival at B is given according to the Lorentz transformation:

$$\Delta t' = t' - t^{\circ} = \frac{t^{\circ} - vB/c2}{\sqrt{1-v2/c2}} - \frac{t^{\circ} - vA/c2}{\sqrt{1-v2/c2}} = \Delta t' = \frac{1-av2/c2}{\sqrt{1-v2/c2}}\Delta t$$

In Tolmans paradox, where $a > c$ for certain values of v can make $\Delta t'$ negative, in other words the effect arises before the cause in this frame. So would it therefore be true of the phase wave of light $Vp > c$, being faster than light, that its effect arises before its cause in light? Dose it then travel into the past?

We can consider the de Broglie's relations:

$$\lambda = \frac{h}{\gamma m^{\circ} v} = \frac{h}{m^{\circ} v}\sqrt{1 - v2/c2}$$

$$f = \frac{\gamma m^{\circ} c2}{h} = \frac{m^{\circ} c2}{h}\sqrt{1 - v2/c2}$$

Where $\gamma =$ Lorentz factors the faction by which time, length and relativistic mass changes for an object, while that object moving, especially in discussions of superluminal motion. Again we can compare de Broglie's relation with his relativistic relation and momentum for phase velocity;

$$Vp = \frac{E}{P} = \frac{mc2}{mv} = \frac{\gamma m^{\circ} c2}{\gamma m^{\circ} v} = \frac{c2}{v} = \frac{c}{\beta}$$

It can be true for the phase velocity of light to be greater than the speed of light, this makes the nature of light very strange indeed. One aspect of light, for a wave packet at the speed of light, time is frozen, then its reference frame for light would be zero, its space contracts down to a dead stop, but that its phase velocity is faster than the speed of light and for the effect of the phase velocity according to Tolmans paradox its effect may arise before its cause. We have here a strange view of light, frozen in time with its phase velocity propagating into its own past?

1.3: Light is superluminal in the near field of a transmitter. The work of William D. Walker[1] and Takaaki Musha[2], in both their papers, it is shown that light can be superluminal. His abstract in his own paper, Walker says, that the fields generated by an electric dipole and a gravitational quadrapole are shown to propagate superluminally in the nearfield of the source and reduce to speed of light as the fields propagate into the far field. An experiment using simple dipole antennas is also presented which verifies [his] theoretically expected superluminal propagation of transverse electromagnetic fields in the nearfield of the source. The phase speed, group speed, and information speed of these systems are compared and shown to differ. He says further that provided the noise of the

signal is small and the modulation method is known, it is shown that the information speed can be approximately the same as the superluminal group speed. According to relativity theory, it is known that between moving reference frames, superluminal signals can propagate backwards in time, enabling violations of causality.

This is in general what Walker says in his abstract of his paper, but he experimentally proves that light can be superluminal in the nearfield. In a paper by Takaaki Musha [2] he also shows that photons can travel superluminal speeds, he says in his abstract, 'The possible existence of superluminal particles, which are forbidden by well-known laws of physics, has been studied by many physicists. Some of them confirmed superluminal speeds by their experiments.' He says further, 'Using the Klein-Gordon wave equation for photons, [Takaaki Musha] shows that the photon travels at a superluminal speed in an electromagnetic nearfield of the source and they reduce to the speed of light as they propagate into the farfield'. There have been others also who have shown in their experiments the superluminal speed of light, E. Recami[3], Chu and S. Wong[4], Steinberg, Kwait and Chiao[5], and optical experiments at Princeton NEC have verified that superluminal pulse propagation can occur in transparent media[6]. It seems here that Einstein's Relativity is violated and must be brought into question.

1.4: Advanced waves. Around 2019, I obtained the papers of experiments of Darko Bajlo [7][10]. On the measurement of advanced electromagnetic radiation, who appears to be the first person to have detected advanced waves? Retarded waves are normal radio waves that travel at the speed of light. Advanced waves by contrast travel into the past. Maxwell equation's for electromagnetic waves predict two solutions, advanced waves and retarded waves.

As Bajlo says in his paper, detecting advanced electromagnetic radiation predicted by Wheeler-Feynman absorber theory for the case of incomplete absorption of retarded electromagnetic radiation, pulses in duration of 6ns to 24ns, wavelength from 91cm to 200cm where supplied to three different transmitting antennas. Detection was done with a monopole antenna in the advanced time window at a time 2r/c before the arrival of the centre of the retarded pulse. At distances ranging from 430cm to 18m, advanced signals were measured in the SNR range from 15.4 to 30.9. From the period from 10th April 2016 to 30th August 2016 at 2000 runs no statistically significant signal above the level of noise was detected. From the period from 3rd December 2016 to 5th January 2017 at wavelengths ranging from 91cm to 200cm was used. First clear signal was observed on the 2rd day after which tests were carried out with the purpose of detecting a possible source of systematic error.

As Bajlo explains the fact that he detected advanced waves, was only possible, because the receiving antenna had to be smaller than the transmitting antenna, the fact that advanced waves are not usually detected, in that the retarded signal usually cancels out the advanced waves, but by using a smaller receiving antenna the advanced waves are not cancelled out, this explains why advanced waves are not usually detected. As Bajlo says in his own words, page 5 of his paper [10]: The solution to this measurement problem is to minimize the influence of the measuring instrument on the phenomenon being measured. This can be easily

achieved with the meter and decimetre radio waves by using a small enough receiving antenna for detection, where its advanced waves cannot completely cancel advanced waves from the transmitting antenna, if the results of the recent experiment represents the real signal and not some systematic error. Then the advanced radiation can actually be detected with a receiving antenna twenty times smaller than the wavelength of emitted electromagnetic pulse [10].

1.5: The principle of least action and the behaviour of light and energy. In regard to reflection and refraction of a light ray at the interface between two media, the medium having the higher refractive index, follows the principle of least action. A light ray being reflected would take the shortest possible path, while a light ray refracted will take the fasted path. According to Fermat's principle of the speed of light, light takes the fastest route according to the principle of least action. If light takes the shortest route, then it can go through two slits at the same time in a quantum diffraction experiment, with the resulting interference pattern on a screen. This is or must be the way energy behaves. It's the same with macroscopic objects, if a body of mass, say a ball thrown into the air, it will take a parabola, this is in accord with the principle of least action, and it’s the way energy behaves.

3. Discussion

With regard to 1.1, that time does not exist for a photon, that time is frozen from the frame of reference of a photon, it can also be stated that the speed of light is the speed of causality. That's why theoretically speaking anything going faster than light, goes backward in time and causality is violated. But in regard to 1.2 where the phase velocity of light is faster than light, perhaps travelling into the past, and time being frozen for the photon; when all these different aspects of light are considered, we get a more strange impression of the nature of light. And in regard to 1.3, the superluminal speed of light in the nearfield, it seems here that relativistic law of Einstein that the speed of light be 3.00x10^8 ms-1 is clearly violated. And not only that, as Walker has shown that the information speed of light can be superluminal, meaning that you get violation of causality. At the end of his paper, Walker addresses the problem of causality being violated, he argues that if relativity theory is correct, then information can be sent backwards in time. He introduces the Hawking chronology protection conjecture [8], that nature will intervene in any attempt to use information to change the past. But I wonder if these are just ideal dreams of Hawking's fears? Another possibility of Walker is that he considers is that according to the many worlds interpretation of quantum mechanics [9], accepted that multiple universes are created any time an event with several possible outcomes take place, thereby preserving the past, of the universe from which the signal was transmitted.

But it seems here from the findings of Walker and Takaaki Musha and others, of the superluminal speed of light in the nearfield, that it must be accepted that Einstein's speed limit of light has been violated, and that a new model of light be developed and more research into these aspects of light, be conducted. It is still not known specifically why light is superluminal in the nearfield of a transmitter, but the fact of this is not in doubt.

Advanced waves; Bajlo has expressed in his paper[10], that from the human perspective, the cause of advanced waves lies in the future, the effect precedes the cause,[an effect he had in his experiment detecting advanced waves], and says this is just a matter of perspective. That humans are creatures that move along the time dimension in one direction. So the view of time-symmetrical process is necessarily distorted when viewed from the human perspective.

The only way to avoid such distortion, is to move away and see things from a non-anthropocentric perspective, from nowhen, outside the block of space-time, in which all dimension and directions are equal. He says further, the view from nowhen, of the process of emission of electromagnetic waves in free space, advanced waves that spread from the antenna towards the past, retarded waves that spread out towards the future; both waves originate from the antenna at the moment of emission. Both waves are outgoing. A confused human being who's psychological experience of time has a preferred direction, misinterprets the advanced waves as incoming waves, that emerge from infinity without causation and converge to the point at the location of the antenna, exactly at the moment of emission.

From the fact that Bajlo detected experimentally for the first time advanced waves, shows that time is symmetrical in both and the future and past and not asymmetrical as when that view was held before the discovery of advanced waves, because now there is evidence for this.

From the effect of having advanced waves converge to a point on the antenna before the arrival of the retarded wave, the advanced wave would already have travelled out into free space already into the past. Only to have come back from infinity to a point on the antenna, but this is due to the forward flow of time in our dimension. But from the backward flow of time, the advanced wave has to be outgoing into the past and already at infinity far out long before the advanced wave is detected by the antenna. But it's a outgoing wave. Thought of in these terms, I begin to understand Bajlo’s point of view of the symmetry of time being distorted in our forward flow of time. The paradox of advanced waves behaviour can be resolved if we consider that there has to be two flows of time, one into the past and one into the future.

I thought if one travelled with an advanced wave travelling into the past, what one would see from this frame of reference. Then I was reminded what Einstein had said[11] 'If one runs after a light wave with a velocity equal to the light velocity, then one would encounter a time independent wavefield. However something like that does not exist'. But the speed of light is the speed of causality, time is frozen for a photon and time does not exist for a photon in this frame of reference, perhaps Einstein is right and perhaps he is wrong in saying that something like that does not exist. But what would you see travelling with a advanced wave travelling into the past.

Now to 1.5, the principle of least action and the behaviour of light and energy, of lights quantum behaviour in a diffraction grating, passing through two slits at the same time. We can ask why dose energy behave in this way? Fermat's principle, and the principle of least action, may explain lights behaviour through a diffraction grating and why it goes through

two slits at the same time. And the principle of least action and Fermat's principle must also apply to advanced waves travelling into the past. Regarding Noether's Theorem, and the origin of inertia. In 1918, the German mathematician Emmy Noether proved the following fundamental connection; that every continuous symmetry of a physical system corresponds to a conservation law. One could say from this, that this applies to time, the forward flow of time and the backward flow of time, that time is symmetrical in relation to the past and the future, that one can apply Emmy Noether Theorem to advanced waves moving into the past, or energy moving into the past. That conservation laws applies for energy and advanced waves moving into the past, and the principle of least action also applies here. I think this is a important point, that must be considered. And also the principle of least action and Fermat's principle is the way it is, because of the conservation of energy due to Emmy Noether's Theorem. And according to this, the fact that equations don't change is called time invariance, that there is a reason why energy is conserved, that it's because of time invariance. We assume then that energy must be conserved in both the past and in the future.

Now I want to consider the conservation of energy in relation to the superluminal nature of light. In experiments by Robert Boyd [12], a professor of optics at the University of Rochester, sent a light pulse through an optical fibre and the pulse exits the fibre before it enters it. He found that as the light pulse approaches the fibre, two other pulses spontaneously from at the other end, one exiting the fibre and the other going backwards to meet the original pulse and to annihilate it. They explained it that as the initial pulse of light approaches the glass, a new pulse forms at the far end. The new pulse splits in two, one travelling backward in the glass, the other exiting. The backward pulse meets and cancels out the initial pulse and only one final pulse remains. At the time this had some of the world's experts scratching their heads over this, said Robert Boyd.

I think part of the puzzle to this is to why the new pulse appears first, that I think it's to do with how advanced energy is superluminal. The 2rd puzzle of why the backward moving pulse is sent back to self-cancel with the initial pulse, is to do with the conservation of energy. If the backward pulse was not sent backward, and had not appeared to then cancel the initial pulse, then two pulse's would leave the optical fibre with double the amount of energy, this extra pulse of energy appearing from nowhere! This would violate the conservation of energy to have two pulse's exiting the optical fibre. But this is not what happens, a new pulse appears in the optical fibre and splits in two, one exiting the fibre, the other a backward pulse sent back through the fibre to self-cancel the initial pulse and only the exiting pulse leaving the fibre. So this effect might be understood as being due to the conservation of energy.

In review of all these aspects on the nature of light, I feel now is the time to reconsider the conventional view of light. We need to build a new model of light that takes account of all the aspects of it that I have outlined in this paper. New research needs to be done, indeed it has been shown in this paper that the nature of light is far stranger than is generally thought, even though scientists are aware of these different aspects of light that I have presented here. We need a new outlook, the speed of light is violated in certain conditions, a violation of Einstein's Relativity, and advanced waves have been discovered besides other things, all these different aspects presented in this paper of the nature of light, must be addressed.

4. Conclusions

As has been shown in this paper, from the reference frame of a photon, time is frozen, and the phase velocity of light is superluminal, and may travel into the past of its source. That light is superluminal in the nearfield and that information may be sent faster than light, leading to causal violations. That advanced waves have been detected and that the principle of least action apples to the paradoxes of quantum physics in the nature of light. That energy must be conserved for advanced waves travelling into the past. This shows how strange light really is, and how a new model of light needs to be addressed.

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