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Research Article

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About the Possible Changes in Quantum Physics And photonics

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Abstract

The work relates to the basics of quantum physics and photonics, in particular to the formation of photons in two states: elementary particles and their electromagnetic radiation. The study of these problems is an urgent and important task that has not been fully resolved for their energy and mass indicators. Solving the problem of experimentally determining the mass of a photon on the basis of reliable physical laws and regularities and developing a method and device for its measurement is the main goal of the work being performed.

Work Results

At present, it is generally accepted that a photon has zero mass, since its presence contradicts the principles of relativism, in which, when the speed of light is reached, an object and its mass tends to infinity.

However, the principles of relativism can be questioned, since it is substantiated that nothing in the Universe cannot be compressed to a size smaller than the Planck length $lP = (hG/c^3)^{0,5} = 4.05 \cdot 10^{-35}$ m, which is justified by a strict physical dependence obtained on the basis of the fundamental physical constants c, h, G.

Therefore, a contradiction arises between the principles of relativism, which have not been fully verified in the zone of velocities close to the speed of light c, and repeatedly verified physical constants c, h, G. In this case, the hypothesis of a non-zero photon mass has the right to exist, and the rest mass of the photon $m = h/(Tc^2)$, where T is the oscillation period of its waves, is the relativistic mass of the photon. However, only reliable experimental studies can serve as a criterion for its verification.

The main goal of this work is to develop a method and device for determining the mass of a photon.
It is based on the experiments of Professor Lebedev on measuring the pressure of light. If a similar device with a pair of balanced measuring petals is placed horizontally, one of them is covered with a screen, and the other is irradiated with laser light from above and below to balance the pressure, then photons can accumulate on this petal. After some time, they will change the equilibrium of the pair if the accumulated photons have mass.

Preliminary calculations show that the energy consumption for the creation of light by a laser, the total mass of photons is 10^{-8} kg, will be about 1 MW, and the result will be noticeable after 0.5 years of irradiation. It is proposed to conduct such an experiment by everyone who has such technical and economic capabilities. A complete description
of the experiment is available.

Conclusion: *Revealing the photon mass will have a significant impact on the development of knowledge about the material world and the Universe as a whole.of the experiment is available.*

Keywords: Quantum Level of The Material World, Photon, Mass, Energy, Wave Parameters.

1. Introduction

The work relates to the basics of quantum physics and photonics, in particular to the formation of photons in two states: elementary particles and they're of electromagnetic radiation. The study of these problems is an urgent and important task that has not been fully resolved for their energy and mass indicators. Currently, the photon is considered a massless physical particle, which is the only one in the material world, which is an amazing exception to the general rules of its formation [1]. Therefore, such uniqueness is questioned by many researchers, since the exclusion of the photon from the general rules is not really justified and has not been strictly proven. So far, the validity of its zero mass is explained at the level of contradictions with a number of physical laws and phenomena that arise with its non-zero mass [2].

1.1 Analysis of the State of the Problem, Setting Goals and Objectives of the Work

Eliminating the contradictions of the non-zero photon mass is a difficult task, so it was easier to recognize it as equal to zero and to reject all researchers who doubt this, suppressing them by force of traditional scientific system. Everything that does not fit into traditional science is ruthlessly rejected by it. Exceptions may be made for little-known scientific conferences [3]. However, in science the collapse of many scientific dogmas and their creators is known. An example of this is the dogma of the indivisibility of the atom, destroyed by the revolution in science at the beginning of the 20th century [4].

Currently, there are many scientific works that question a number of provisions of official science. Therefore, there is every reason to believe that in physics a similar revolution is now possible, but at an even deeper level than the atomic level – at the initial quantum level of the material world and the Universe [5].

The **main goal** of this work is to show that such a revolution is a reality. Its scientific novelty lies in the substantiation of the process of the collapse of a number of scientific dogmas on the basis of strict physical laws and experiments. In particular, it's the dogma about the zero mass of the photon.

Solving the problem of experimentally determining the mass of a photon on the basis of reliable physical laws and regularities and developing a method and device for its measurement is the second goal and **scientifically novelty** of the work being performed.

2. Research Methods

The work performed has a level of scientific discovery, for which the techniques have not yet been developed [6]. Therefore, it used the methods of the general principles of scientific research – deduction and induction, based on the application of the laws of dialectics, reliable laws of physics and general ways of developing the theory of knowledge [1, 7, 8]. The method of accessing the initial level of the material world was also used [5, 9, 10].

2.1 New Results and Their Discussion.

One of the scientific works that began to develop new principles for understanding the fundamentals of the material world is article, which substantiated the possibility of creating a mass standard at the quantum mechanical level [11].

18 years later (in 2018), CODATA introduced a quantum mass standard [12]. For it, a Kibble balance is used, in which a bowl with a tested mass standard is balanced by an electromagnetic field and the current required to balance it is determined. However, in this case, the reference to the original mass standard remains and the accuracy of the new weighed standard is coming down to only to its accurate repetition. There is no such drawback in [11]. Moreover, it's led to the formation of a scientific method [5,9-11], based on the transition to the initial quantum mechanical level of the material world, which is associated with the fundamental physical constants c, h, G, the values of which are recommended by CODATA [13]:

Speed of light in vacuum c: $c = 0.299792458 \cdot 10^{9}\,(\text{exactly})\frac{m}{s}$,

Planck constant h:

$$h = 6.62607015 \cdot 10^{-34}\,(\text{exactly})\,J \cdot s = 6.62607015 \cdot 10^{-34}\,(\text{exactly})\frac{kg \cdot m^{2}}{s},$$

Gravitational constant G: $G = 6.67430(15) \cdot 10^{-11}\,\frac{m^{3}}{kgs^{2}}$.

They make it possible to obtain strict physical (rather than abstract mathematical) laws and calculated dependencies with unambiguous final solutions [9, 10]. With the publication of the book [5]. this principle acquired an independent life, independent of journal publishers In define the minimum quantum values of length and time in the Universe [5, 9, 10], It has been proven that the shape of the minimum space quantum of the universe is not a ball (Fig. 1), but a regular hexagonal prism consisting of 3 sectors of real quarks alternating with 3 sectors of virtual quarks [5,9,10].

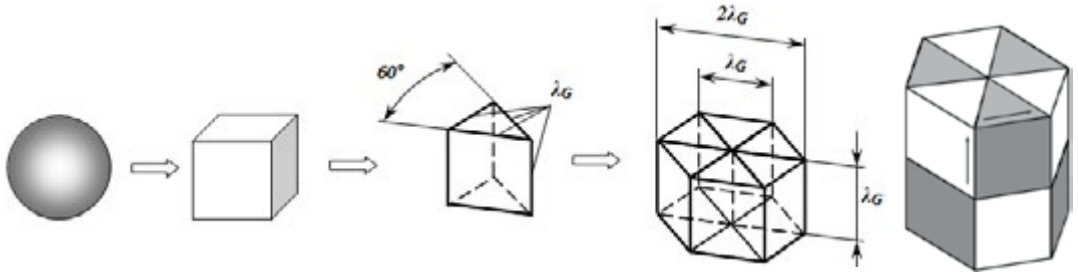

Figure 1: The Concept of The Formation of a Quantum of Space in The Universe.

At the same time, their energy is exchanged without loss, which leads to virtual rotation and ensures high stability and "eternity" of the life of the quanta of the Universe.

The connection of minimal space quanta with gravitons and photons is substantiated, according to which a photon has a hexagonal structure similar to a space quantum, but its energy is real. A photon is a quantum physical value that cannot be divided further. For example, a photon of red light with a wavelength of 760 *ηm* cannot be divided into 2 photons with a wavelength of 380 *ηm*, since this does not reduce its energy, but, on the contrary, requires an increase in its costs by 2x2 = n^2 times. The quantum structure of the photon is very important.

2.2 Structure and Basic Parameters of the Photon

By analogy with the quantum of space of the Universe, a photon can be represented as a hexagonal prism of 3 real and 3 virtual quarks, which flow into each other without loss of energy (the energy expended on a real quark is then fully returned when it turns into a virtual quark). This creates its virtual rotation of the photon without energy consumption and ensures its stability. Light is the front of the movement of photons. The full wavelength of a photon λ is formed in 6 quantum steps of rotation and translational motion of the energy of its quarks, as shown in Fig. 2:

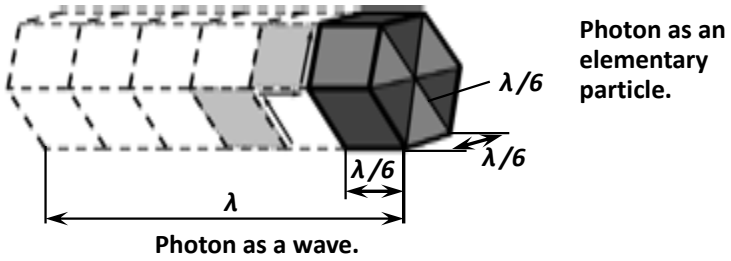

Figure 2: New Photon Formation Concept (Further Research Needed).

In this case, the photon has the form of a wave and an elementary particle, in the form of a regular hexagonal prism, all of whose constituent dimensions are 6 times less than the wavelength. This form allows us to explain the polarization of light, the waves can be turned. Division by 6 is justified not only by the quantum relationship of sizes, but also by the connection with Planck's circular constant, which was obtained by Dirac as a result of dividing Planck's constant h by the number 2π: ħ = *h*/(2π). It is used to describe physical closed objects (for example, elementary particles), to which the photon belongs, but at the quantum mechanical level there is no fractional number π; there are only integer values, for example, the number 6. Modeling of a photon is shown, that its substance part (physical particle) in the direction of its movement is 6 times shorter and 3 times thinner than the photon wavelength. But in the circular direction of motion (along the perimeter of the hexagon), a full wave is formed, which determines the energy state of the photon. In this case, a longitudinal wave is formed in 6 consecutive positions of the substance part of the photon, in each of which there is its total energy $E = hc/\lambda$ and is actually a virtual wave λ.

The substantiation of the finiteness of quantities of the material world, which change by quantum leaps, calls into question all mathematical theories based on the continuity of functions, therefore they need to be reworked, and the book introduces fundamental changes to the modern of science, at the level of General Relativity [5].

Since it was proven in that there are no zero and infinite quantities in the material world (they exist only in abstract mathematics), therefore, it is impossible to compress a physical object to 0 and obtain an infinite mass, when it reaches the speed of light c. This reduces the relativistic laws of long *l* (1) and mass *m* (2) to a new form (3), (4), which represent the dimensional relativistic coefficient – of the gamma-factor in Einstein's GR theory [1,14].

A photon, like a wave, does not have a sinusoid. It is virtual, since it is formed during the virtual rotation of quarks in the photon: the starting point of 1 quark occupying the upper position 1', then moves downwards and forward in quantum jumps by the amount of λ/6 to positions 2', 3', 4', and then similarly thus moves up and forward to positions 5', 6', 1" (Fig. 3). There are 6 such sinusoids, shifting relative to each other by λ/6. They form a virtual tube, which can be considered a photon beam.

The formation of virtual sinusoids is an indirect confirmation of the correctness of the proposed model of the photon and its movement. The λ wave should be measured along its crests, and not along the centerline; these points are not present during quantum jumps.

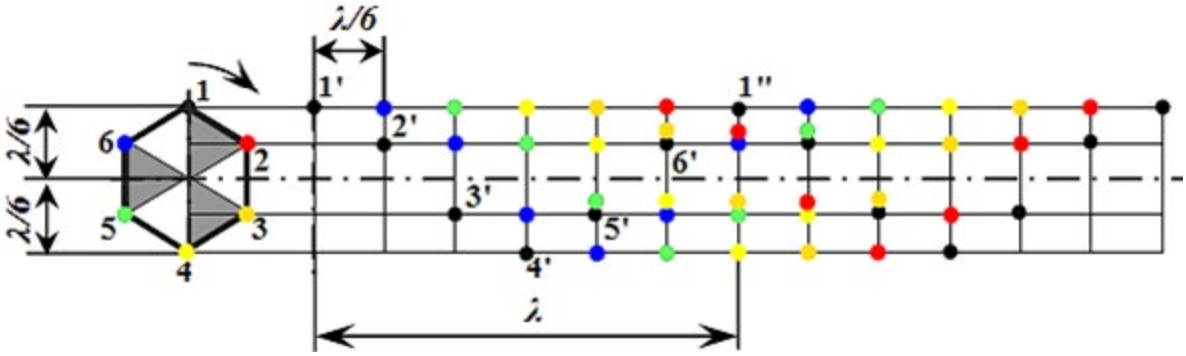

Figure 3: Formation of virtual wave sinusoids during photon movement. (Color is not associated with the spectrum of photons, but is adopted to distinguish sinusoids from each other. The position of the point on top is its conditional covering of another point, which is actually separated in space and time during quantum leaps).

$$l = \frac{l_o}{\sqrt{1-\frac{\upsilon_i^2}{c^2}}}(m). \tag{1}$$

$$m = \frac{m_o}{\sqrt{1-\frac{\upsilon_i^2}{c^2}}}(kg). \tag{2}$$

$$l_R = \frac{l_o}{\sqrt{\left|1-\frac{\upsilon_i^2}{c^2}\right| + \left|l_{\min}^2\right|}}. \tag{3}$$

$$m_R = \frac{m_o}{\sqrt{\left|1-\frac{\upsilon_i^2}{c^2}\right| + \left|m_{\min}^2\right|}}. \tag{4}$$

where l_0, m_0 – initial length and mass of the physical object;

υ_1 – is the real speed of the physical object.

Depending on (3), (4), the minimum values of the parameters of a physical object are introduced: length l_{min} and mass m_{min}, less than which they cannot change. In this case, Planck determined the minimum possible l_{min} as the Planck value l_P according to dependence (5) [15].

$$l_p = \sqrt{\frac{hG}{c^3}} = \sqrt{\frac{6.62607015\cdot 10^{-34}\left(\frac{kg\cdot m^2}{s}\right)\cdot 6.67430\cdot 10^{-11}\left(\frac{m^3}{kg\cdot s^2}\right)}{\left[0.299792458\cdot 10^9\left(\frac{m}{s}\right)\right]^3}} = 4.05135\cdot 10^{-35}\,(m), \tag{5}$$

Smaller sizes do not exist in the material world [5].

It is generally accepted that the gravitational radius of physical particles is smaller than size l_P (5), but in it is shown that the gravitational conditions in them change, which excludes sizes smaller than l_P [1, 16]. The shorter wavelengths obtained in from distant X-ray sources are also erroneous data, which is explained by the quantum magnitude of these wavelengths and is further substantiated in this work [17,18]. However, Planck did not determine the minimum possible mass m_{min}, since from dependence (6), which is similar to dependence (5), he obtained the maximum quantum of mass m_P [15].

$$m_p = \sqrt{\frac{hc}{G}} = \sqrt{\frac{6.62607015 \cdot 10^{-34}\left(\frac{kg \cdot m^2}{s}\right) \cdot 0.299792458 \cdot 10^{9}\left(\frac{m}{s}\right)}{6.67430 \cdot 10^{-11}\left(\frac{m^3}{kg \cdot s^2}\right)}} = 5.45551 \cdot 10^{-8}\left(kg\right). \quad (6)$$

This drawback was eliminated in [19], which defined the minimum energy quantum E_{min} within the framework of dependence (7), where T is the period of natural oscillations of the waves of a physical object, which cannot be more than 1 s (otherwise the waves will exceed the speed of light c, which is impossible within the framework of Einstein's STR and GTR).

$$E_{\min} = \frac{h}{T_{\max}} = \frac{6.62607015 \cdot 10^{-34}(Js)}{1(s)} = 6.62607015 \cdot 10^{-34}(J). \quad (7)$$

Based on the minimum energy value (7), within the framework of the physical law (8), which is strictly satisfied for objects of the quantum level of the material world [1], the minimum quantum of mass (9) can be determined:

$$E = mc^2 = \frac{h}{T}(J).. \quad (8)$$

$$m_{\min} = \frac{E_{\min}}{c^2} = \frac{6.62607015 \cdot 10^{-34}(\frac{kgm^2}{s})}{\left[0.299792458 \cdot 10^{9}\left(\frac{m}{s}\right)\right]^2} = 7.372497328 \cdot 10^{-51}(kg). \quad (9)$$

A smaller mass does not exist in the material world.
In this case, when substituting l min and m min into dependences (3), (4), we obtain a new law – the relationship between the original and relativistic quantum values (10), (11) which at the υ_i = c = const degenerates into an identity and the γ-factor equal to 1, which is a new scientific result:

$$\gamma_{lc} = \frac{l_{\min}}{\sqrt{\left(1 - \frac{\upsilon_i^2}{c^2}\right) + l_{\min}^2}} = 1. \quad (10)$$

$$\gamma_{mc} = \frac{m_{\min}}{\sqrt{\left(1 - \frac{\upsilon_i^2}{c^2}\right) + m_{\min}^2}} = 1. \quad (11)$$

Thus, the laws of relativism do not apply to physical objects of the quantum level, the parameters of which cannot change (otherwise they will not be quanta).

For physical objects of the quantum level, which cannot decrease further, the laws of relativism are very different from infinite value with the object's own velocities approaching the speed of light c by < 0.1% within the framework of dependence (12).

$$\left|1 - \frac{\upsilon_i^2}{c^2}\right| \to \left|l_{\min}\right| \quad (12)$$

Then for the sizes the general picture of changes looks like (Fig. 3):

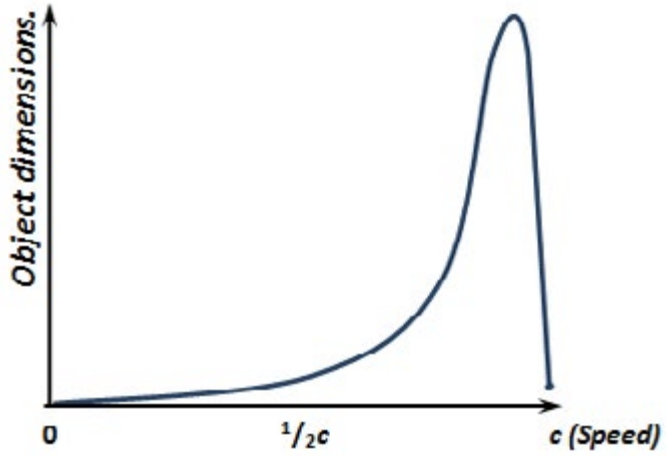

Figure 4: Change in Relativistic Dimensions for Physical Values at The Quantum Level.

A similar picture occurs for the masses of quantum objects. It should be taken into account that photons, at any wavelength, remain quantum value. Therefore, this nature of changes in mass and size also applies to them. It's allows us to put forward a hypothesis about the non-zero mass of the photon, which cannot be infinite under relativism. In this case, the mass, which for a photon, within the framework of the law (8), could be identified with the rest mass, is in fact -its relativistic mass. For a photon of red color with a wavelength of 760 *ηm*, yellow color with a wavelength of 590 *ηm* and blue color with a wavelength of 480 ηm, their masses will be:

$$m_{760} = \frac{hc}{\lambda_{760}c^2} = \frac{h}{\lambda_{760}c} = \frac{6.626070040\cdot 10^{-34}\left(\frac{kg\cdot m^2}{s}\right)}{760\cdot 10^{-9}\left(m\right)\cdot 0,299792458\cdot 10^{9}\left(\frac{m}{s}\right)} = 2.90818297\cdot 10^{-36}\left(kg\right). \quad (13)$$

$$m_{610} = \frac{hc}{\lambda_{610}c^2} = \frac{h}{\lambda_{610}c} = \frac{6.626070040\cdot 10^{-34}\left(\frac{kg\cdot m^2}{s}\right)}{590\cdot 10^{-9}\left(m\right)\cdot 0,299792458\cdot 10^{9}\left(\frac{m}{s}\right)} = 3.746133995\cdot 10^{-36}\left(kg\right). \quad (14)$$

$$m_{480} = \frac{hc}{\lambda_{480}c^2} = \frac{h}{\lambda_{480}c} = \frac{6.626070040\cdot 10^{-34}\left(\frac{kg\cdot m^2}{s}\right)}{480\cdot 10^{-9}\left(m\right)\cdot 0,299792458\cdot 10^{9}\left(\frac{m}{s}\right)} = 4.604623036\cdot 10^{-36}\left(kg\right). \quad (15)$$

Mass parameters (13), (14), (15) can be used in further studies. Non-zero photon mass does not create problems of gauge invariance in modern physics, since their wavelength = *constant*, therefore there is no dispersion on the way from the stars. This is confirmed by astronomical observations of near and distant stars.

It is believed that the zero mass of a photon has been proven within the framework of general relativity due to the curvature of space, which was recognized during the solar eclipse of May 29, 1919 [20]. when the curvature of light rays was determined when passing by massive objects, in particular the Sun (Fig. 4).

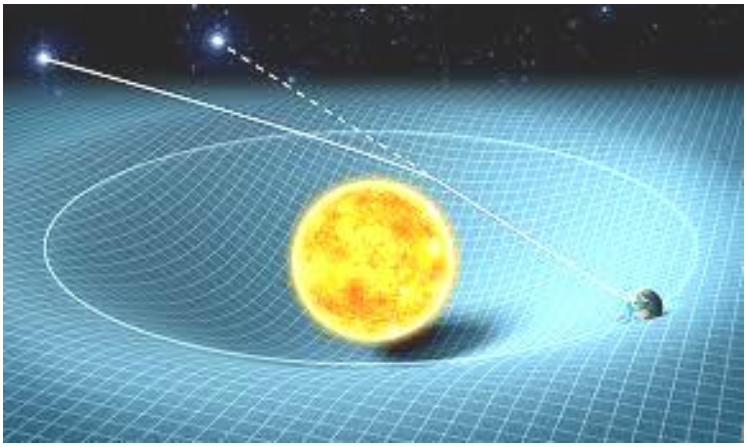

Figure 5: The Scheme of Passing of Light Rays from A Distant Star Near the Sun [21].

However, the same curvature of the path of light rays is possible within the framework of Newton's law of Universal gravitation (16), with a non-zero photon mass [1, 22, 23].

$$F = G\frac{m_1 m_2}{r^2}(N). \qquad (16)$$

The results of the solar eclipse of May 29, 1919 showed that Einstein in 1915 predicted the deflection of a light ray when passing near the Sun by an angle of 1.75″. Actual astronomical measurements made on the island of Principe off the western coast of Africa and in the area of the town of Sobral in Brazil were 1.61″ and 1.98″. The trajectory curvature, found using classical Newtonian mechanics, was 0.87″. However, it was obtained for red photons with a wavelength $\lambda = 0.76 \cdot 10^{-6}$ m, although most stars in the Universe are yellow with a wavelength $\lambda = 0.59 \cdot 10^{-6}$ *m*. At the same time, its energy $E = hc/\lambda$ increases by 0.76/0.59 = 1.29 times and the pulse frequency also increases by 1.29 times relative to red pulses.

Considering that the gravitational force of the Sun, which has a radius of $6.96 \cdot 10^8$ m, at the extreme point of approach of the photon is a constant value F and acts normal to the path of its flight, then for energy *E=Fl,* as the ability of force F, to do work on path l, this path will also increase by 1.29 times. Then, with an increase in the pulse frequency, the total transverse displacement of a photon of yellow light, compared to a photon of red light, will increase by at least 1.292 = 1.66 times (there are more accurate calculations, taking into account the deviations of the photon during the approach to the Sun). In this case, the minimum angle of photon rotation will be 1.66•0.87″ = 1.45″, which significantly corrects the assessment of the 1919 experiments.

Since there is information that in the experiments of 1919 there was a scattering of the results and the values of 1.61″ and 1.98″ constitute the extremum in this scattering, there is a need to repeat the experiments taking into account the real radiation spectrum of the stars being studied.

2.3 Experimental Confirmation of The Presence of Mass in Photons

Since for the curvature of space by the Sun, it does not matter what the mass of the light rays is, then when experimentally identifying the difference in the deviations of light rays from blue, yellow and red stars (Figure 5), his will be the same. If it is not the same, then this will confirm that photons have different masses.

However, carrying out such experiments is difficult due to the coincidence conditions in the location of stars during a solar eclipse. Therefore, it is necessary to search for other options for experiments to determine the photon mass.

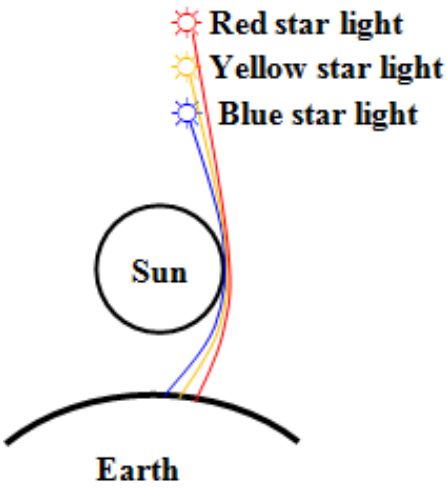

Figure 6: Light Rays with Of Different Wavelengths of His Deflection.

A number of experiments are known in which there are signs of the presence of mass in photons. In particular, this is the experiment of Professor Lebedev on determining the pressure of light [24]. However, in it, the mass m_γ of the photon was replaced by the momentum of motion p_γ, although within the framework of dependence (17) its appearance without the presence of mass mγ is not a physically correct conclusion:

$$p_\gamma = m_\gamma c. \qquad (17)$$

In this experiment, a vacuum was created in a hermetic container, which excludes external influences, and 2 plates (petals), which are the same in size, mass and shape, were symmetrically suspended on the vertical axis. One of them had a coating that absorbed light (ab-solute black body), and the second one had a shiny coating that reflected light, which created different conditions for the light rays to act on them. As a result, the system of 2 plates felt different pressure of light rays and they turned around the axis of suspension by light rays.

In work, the direction of orientation of the axis of the plates (petals) was changed to horizontal with a corresponding change in the direction of irradiation - the light source was placed on the ceiling, which irradiated the black plate from above, and their symmetrical plate was covered by a screen. The development of this scheme was proposed due to similar irradiation of the black plate from below, which balances the light pressure on it (Fig. 6) [22, 25].

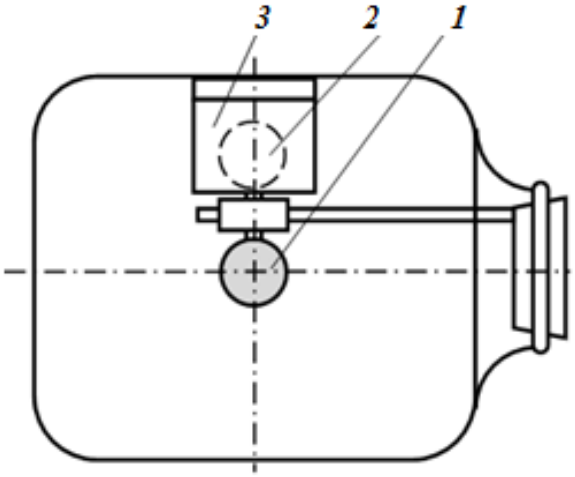

Figure 7: Diagram of a Device for Determining the Mass of a Photon. 1 Working Petal, 2 – Non-Working Petal, 3 Screens

As a result of this irradiation, it is possible to accumulate photons on the upper and lower surfaces of the plate during the period of its irradiation. Therefore, any change in the mass of the previously balanced irradiated plate, due to the accumulation of photons on it, will lead to its rotation on the axis of suspension and will clearly show the presence of mass in the photons. Since

in Professor Lebedev's experiments, the direct effect of photons was greater than thermal transformations, there is hope that with the correct selection of the irradiation mode, they will prevail in this experiment as well.

Further calculations show that for a formation of a mass m = 10^{-8} kg, which is guaranteed to be able to bring the plate out of equilibrium, energy is required (18):

$$E = mc^2 = 1 \cdot 10^{-8} (kg) \left[0,299792458 \cdot 10^9 \left(\frac{m}{s} \right) \right]^2 = 8.98755179 \cdot 10^8 (J). \quad (18)$$

The tilt of the plate will indicate the presence of mass in the photons.

At a specific irradiation energy of 1 *J/s* per 1 sm^2, or its power of 1 W/sm^2, a total power of 2x10 W is required for each side of a plate with an area of 10 sm^2, which can be provided by 2 beams of a red laser of constant action. Therefore, the time period for the creation of a mass of 10^{-8} kg is ≈ 520 days, or 1.425 years. When the power of the laser is increased by n times, the period of irradiation decreases. But the share of irradiation energy, which is converted into heat, increases, which will affect the final results of the process and its speed. Conducting this experiment is offered to everyone who has the conditions for it and is able to perform it.

It should be taken into account that if a photon has mass, it will lose energy along the path l when passing near physical bodies having a Ntewton's gravitational force Fi, within the framework of the law E = Fil. For stars, this loss leads to a shift in their radiation to the red zone. Given the average density of matter in the Universe, the deflection of photons will be proportional to the length of its path from the stars to the observer (on Earth). Therefore, a revision of Hubble's laws and others related to redshift and expansions of the Universe is necessary.

It should also be taken into account that the "speed of light" actually comes down to the speed of movement of real photons. Its change in different media can be evidence of the mass of photons.

3. Conclusions

- Within the framework of the justified indivisibility, immutability and finitude of quantum values in the material world, the minimum dimensions of any physical objects in the Universe are $4.05125 \cdot 10^{-35}$ m, and the minimum mass is $7.372497 \cdot 10^{-51}$ kg.
- Smaller sizes and masses do not exist in the material world.
- Minimum quantum values are not compressible and are not subject to the laws of relativism.
- Photons of any wavelength are immutable quantum values, and therefore do not comply with the principles of relativism and dispersion along any path of their movement from the stars.
- A reasonable finite mass of photons and a theoretical basis for its determination are substantiated.
- Proposed method and devices for determining the mass of photons.
- Experimental verification of the results of the proposed work is necessary.
- The set of calculated and experimental data of the proposed work will allow to rule out the axiom about the zero mass of the photon, and direct the development of science in this field along a new path, which corresponds to the level of scientific discovery.
- Modeling of a photon is showed, that his substance part (physical particle) in the direction of its movement is 6 times shorter and 3 times thinner than the photon wavelength, but in the circular direction of motion (along the perimeter of the hexagon), a full wave is formed, which determines the energy state of the photon.
- In the presence of a photon mass and loss of its energy along the path l when passing near physical bodies having a gravitational force Fi, within the framework of the law E = Fil, a shift in stellar radiation to the red zone occurs, therefore a revision of Hubble's laws and others related to red shift is necessary and expansions of the Universe.

Conflict of Interest

This work was carried out by the author alone, on his own initiative, on the basis of personal scientific works: [3, 5, 6, 9, 10, 11, 16, 18, 19, 22, 23, 25]. It uses literature sources from open databases, so permission for their publication is not required.

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