What makes a photon move? A paradigm shift in physics

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Abstract. We are faced with photons and gravity every second, yet the physical mechanism responsible for the two phenomena is not completely understood. Neither relativity theory nor quantum theory provides an answer to the question "What makes a photon move?" Obviously, a paradigm shift is needed in order to answer.

We have therefore conducted such a study. To build a contradiction-free model, we have had to reconsider some postulates of physics and look at things in new ways. Our approach requires some effort on the part of the reader, who is asked to abandon certain notions he/she has acquired through education.To facilitate reading, we present illustrative analogies.

Investigation of the structure of the photon helped to reveal many secrets of nature, such as mysterious dark energy and dark matter, the physical meaning of gravity, and others.

1 Introduction

In 1865 Maxwell discovered that a solution of his equations in the absence of sources propagates at the speed of light [1]. This was a great discovery, which connected light with electromagnetic phenomena.But this model of light was not viable, because Maxwell mistakenly assumed that there are charges in vacuum as in a dielectric.These charges were supposed to create a displacement current [1], but there are no charges in vacuum, nevertheless the light propagates through it. This leads to a contradiction.

Here is a citation from a Wikipedia article [2] "Ampère's circuital law":

> The displacement current is justified today because it serves prediction of wave propagation of electromagnetic fields.

Is an erroneous or false explanation of the phenomenon better than none?

Subsequently, Einstein [3] showed by the photoelectric effect that light consists of discrete quanta (now called photons) rather than continuous waves. This model contradicts the Maxwell electromagnetic plane wave, and the latter had to be rejected a second time.

But the problematic situation was frozen by the “wave-particle duality" [4]. L.Smolin [5] called it a “conceptual paradox”. Of course, with such an approach there was no chance to get an answer to the question posed in the title of this article.

N.Kasterin [6] showed (on the basis of Maxwell's equations) that a particle in the form of a closed vortex tube will also move at the speed of light. Such a particle is not an ordinary wave, but there is a periodicity in it.

To better understand the development of physics in the case of the electromagnetic plane wave; let us consider a more general problem of Model Selection [7]. Let the choice of possible models be limited to a given set; it is required to select the one that most closely matches the simulated process. It is obvious that the optimal model depends not only on the method of its choice, but also on the possible alternatives. If there is only one model in the model set, then the selection method does not matter at all. But with the expansion of the set of models, the situation changes drastically.

We formulate the following warning learned from the discussion of the plane wave:

> *While limiting the set of models, think twice: maybe you have cut off the most fitting model.*

Prediction of the influence of different hypotheses on a set of allowable models will come in handy to us in the future. For example, in general relativity [8], Einstein declared the variability of space, which opened up great possibilities for model selection; however, in postulating the constancy of the light speed, the scientist significantly reduced this achievement.

After all, velocity is the derivative of distance; therefore the variability of distances inevitably entails the velocity change. To avoid contradictions, Einstein had to introduce a changeable time (see [9]).

2 Alternative model of the photon

When choosing a photon model, we will employ two well-known facts: 1) the speed of light is finite, and 2) there is no medium that impedes the motion of the planets.

If pure vacuum means emptiness, light should not experience any resistance in vacuum and the speed of light would be unlimited. This contradicts the first fact, therefore there must be some medium.
On the other hand, if there were a medium (such as the luminiferous aether [10]) then this medium would have some effect on the Earth in contradiction with the second fact.

Hence, there is only one possibility; namely, there must be a medium that does not hamper the motion of the Earth and all other massive bodies, just as water does not resist the movement of waves on its surface. This medium has to be the universal basis for the world of masses. We will call this medium MATTER in the new expanded sense of the term. Space is a variable property of MATTER, and absolute vacuum is MATTER in the equilibrium state.

Any theory that discusses space, but refuses to recognize the bearer of this property cannot propose a physical reason for changing space.

MATTER, in the expanded sense of the word, is similar to the luminiferous aether [10], so it is necessary to recall the Michelson-Morley experiment [11].

An error in the theory of the Michelson-Morley experiment led to the negation of the aether. The error was in ignoring the fact that reflection of light from a moving mirror occurs at a different angle than from a mirror at rest. At least three scientists attempted to correct the error: in 1920 Professor Righi of Bologna formulated his interpretation of Michelson's experiment, but he died suddenly. The following year J. Stein published Righi's theory [12]. In 1927 E.R. Hedrick presented an investigation related to Righi's theory and Stein's report [13]. In 2000 Paul Marmet rediscovered the error in the Michelson-Morley calculations [14]; however the physics community ignored his publications as well.

The null result obtained in the Michelson-Morley experiment does not contradict the assumption of an absolute frame of reference. We will dwell on this issue in more detail in Section 12.

As a basis for the photon model, we use the model of J.J.Thomson [15], the discoverer of the electron. Thomson considered a photon in the form of a closed vortex tube-toroid (Fig.1-2). A density wave runs around the surface of the toroid both over a large radius R, and around a cross section having a smaller radius *a* (Fig.2).

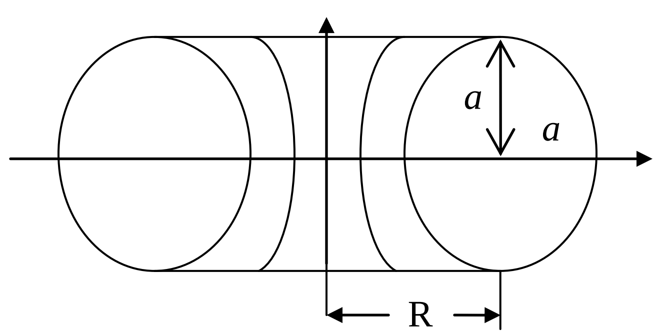

Fig.1. Cross section of the toroid.

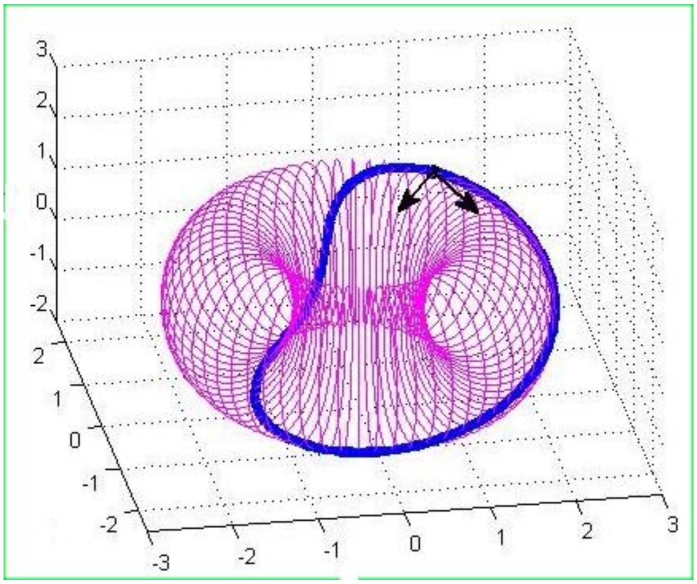

Fig.2. The blue closed line presents the wave front moving in the photon. The arrows show two components of the velocity of a point on the wave front: $v_{\perp}$ is perpendicular to the cross section plane and $v_{\parallel}$ is in the plane.

The wave front is not axially symmetric. Moreover, part of it is hidden inside the photon; therefore, in the collisions of the photon with other particles, the rotational phase of the density wave plays an important role. If the photon collides by its protruding part of the wave front, then the collision will be much harder than in the antiphase (Fig.2). The phase of rotation imparts to the photon some wave properties, which were erroneously taken as proof of the wave nature of light. The photon-toroid also moves at the speed of light [6], but its intrinsic periodicity allows it to completely replace the mixture of two conflicting models: the wave and the particle.

J. J. Thomson believed that the photon is a vortex of aether; however we are replacing the aether with MATTER, which does not resist the movement of masses.

3 Variable speed of light

We follow Einstein's general relativity on the issue of the space variability, however we use the usual time [9]. As a consequence, contraction of space reduces the speed of light by the same factor, so we abandon the general relativity postulate on the constancy of the light speed.

The density of MATTER could be an indicator of its state, but this is not yet available for measurements. Instead we take the speed of light since it is inversely proportional to the space contraction, and is accessible to measurements. Then it is not necessary to take into account the space curvature.

Thus, instead of ten independent components of Einstein's tensor [16], we confine ourselves to a single scalar quantity which is sufficient to describe various physical phenomena. Indeed, many physicists have derived the four tests of general relativity on the basis of the variable speed of light without considering the space-time curvature (Broekaert [17], Okun [18], Bakman [19]).

From what has been said, it is already possible to write down several equations for the photon. Imagine a narrow strip of the photon surface on its largest circumference, the equator. Its length is 2π (R + *a*). This strip rotates around the cross section and in half a period it will be on the inner surface of the photon of radius R-*a*. The strip contracts in (R + a) / (R-a) times, and therefore the wave velocity inside the photon in (R + a) / (R-a) is smaller than outside. In general, the wave velocity at the photon surface is $\boldsymbol{v_w} = \boldsymbol{v_0}\frac{\boldsymbol{d}}{\boldsymbol{R+a}}$, where $\boldsymbol{v_0}$ is the velocity of the wave on the outer surface of the torus, and *d* is the distance from the point to the torus axis.

We designate the speed of light c as usual. Then the period of revolution of the wave around the photon is $T=2\pi(R+a)/v_\perp = \lambda/c$, where $v_\perp$ is the component of the wave velocity v_w, perpendicular to the cross section (whereas $v_\parallel$ is the component parallel to the cross section). Thus,

$$v_\perp/c = 2\pi(R+a)/\lambda \qquad (1)$$

The following equation is derived in Appendix A:

$$\lambda = \frac{v_\perp}{c}\frac{\pi(2R^2+a^2)}{(R+\boldsymbol{a})}.$$

We plug in the ratio of the velocities from (1):

$$\lambda = \frac{2\pi(R+a)}{\lambda}\frac{\pi(2R^2+a^2)}{(R+a)}.$$

Finally

$$\lambda = a\cdot\pi\sqrt{4k^2+2} \qquad (2)$$

where k=R/*a*.

Below we will show that the photon is stretched in motion, but this does not affect eqs. (1) - (2), since these do not include the longitudinal dimensions of the photon.

4 The meaning of the formula $E=mc^2$

Our statement that the speed of light is variable looks like an encroachment on the most famous Einstein's formula $E = mc^2$. It turns out that the energy of the body depends on the environment. The problem with formulas is that they often seem to be universal, suitable for use in any conditions and in all parts of the Universe. But in fact they also have their own conditions of use.

Energy is the ability to do work, but this ability cannot always be fully realized. This limit on realization is written in the formula $E=mc^2$.

As a simple analogy, let us consider the energy of a compressed gas: the gas is compressed to a pressure p_0 greater than the atmospheric $\boldsymbol{p_0 > p_{atm}}$. In the expansion of the gas, its pressure cannot drop lower than $\boldsymbol{p_{atm}}$.

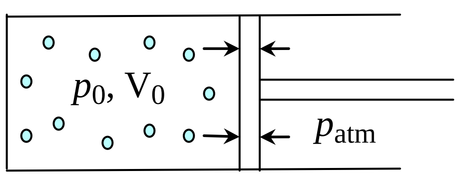

Fig.3. The maximum work done by the compressed gas is limited by the atmospheric pressure.

In the isothermal process $\boldsymbol{pV = p_0 V_0}$, and the work done $\mathbf{A} = \boldsymbol{p_0 V_0 \log \frac{p_0}{p_{atm}}}$. In this formula the factor $\boldsymbol{p_0 V_0}$ depends solely on the gas itself and corresponds to the mass of the body in the Einstein formula. But in the second multiplier there is the external factor p_{atm}, which limits the maximum possible work by the gas.

Similarly, in the formula $E = mc^2$ factor c^2 is a medium-dependent index of the possibility of realizing the energy of the body under specific conditions. At a high density of MATTER, the speed of light is less, as is the realized energy of its carrier. Because we use the light speed as an indicator of the density of MATTER, the influence of the environment becomes obvious.

The former attitude toward the formula $E=mc^2$considered the mass to be separate from the medium. Ignoring MATTER as the medium is the source of many contradictions in the dominant paradigm. Since the effect of atmospheric pressure is not disputed by anyone, the analogy with the compressed gas demonstrates the need to take into account the influence of MATTER on different phenomena.

In conclusion: mc^2 is a part of the total energy possible for realization in specific conditions.

5 A stretched cycloid

Because the front of the density wave in the photon is continuous, the period of the wave revolution around the toroid should equal the period of the wave revolution around its cross section. Otherwise there will be a breakdown of the wave and the photon will collapse. But the cross section radius a is less than the outer radius of the torus a+R. This means that a photon with a circular cross section is unstable.

The stability of the photon can be achieved if it is stretched along its axis. Then, instead of a circular cross section, we obtain an ellipse. Let us denote the length of its greater semiaxis by b. In the parametric form, the equation of the photon stretched along the axis with its cross section center shifted by R is:

$$\begin{cases} X = b\sin\theta \\ Y = R + a\cos\theta \end{cases} \qquad (3)$$

On the other hand, there is a need to track the trajectory of an individual point on the wave front during the photon motion. A cycloid appears to be a suitable model for a point in the torus cross section, since the cycloid is the trajectory of the point on the hoop rolling on the ground. The parametric equation of the cycloid is as follows:

$$\begin{cases} X = r\theta - r\sin\theta \\ Y = r - r\cos\theta \end{cases} \qquad (4)$$

where r is the hoop radius, and θ is a parameter, whose values vary from 0 to 2π. But the cycloid does not have the ellipse elongation; therefore we extend the class of cycloids by combining (3) and (4):

$$\begin{cases} X = q\,\theta - b\sin\theta \\ Y = R - a\cos\theta \end{cases} \qquad (5)$$

We call the generalized model (5) an "elongated cycloid". It has a segment of the backward movement (Fig. 4) and an additional parameter q in (5). Its meaning becomes clear if one takes into account that during one cycle the parameter θ changes from 0 to 2π, and X moves from 0 to X(2π) = 2πq, which corresponds to the wavelength λ. Hence q = λ/2π.

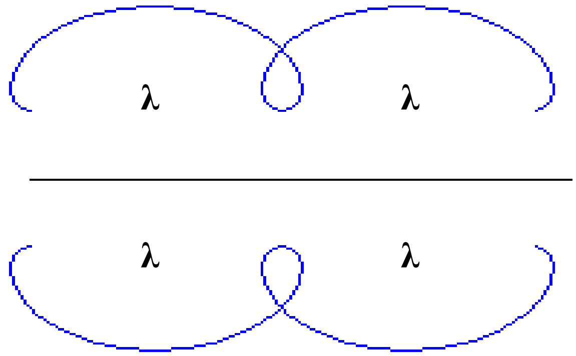

Fig.4. The trajectory of an elongated cycloid (in two cross sections). Since two cycles are depicted, the distance between the initial and final points of the trajectory is 2λ.

Our approach is that the parameters a, b, and R of the photon are proportional to its wavelength λ [15]. Therefore *we are looking not for the values of these parameters, but for their relations.*

6 The photon energy equation

For derivation of the equation from which we can obtain the value of k=R/*a*, we again turn to the works of J. J. Thomson [20]. In this book Thomson suggested the hypothesis that electric field consists of vortex tubes of aether. In support of his theory, Thomson deduced Maxwell's equations from motion of the vortex tubes [20], pp.6-12.

In the Standard Model of particle physics [21], carriers of the electric field are called "virtual photons." If we adhere to this terminology, then as a result of closure of the vortex tube the virtual photon turns into a real one, but it is hardly possible to identify the concept of a virtual photon with Thomson's vortex tube.

J. J. Thomson reasoned as follows: the minimal element of electric field is a single vortex tube, and the minimal source of the electric field is the elementary charge e. Therefore there must be a connection between the two, namely, a single vortex tube must end on an elementary charge! Moreover, since the photon is formed from the closure of the vortex tube, the electric field strength E in the tube corresponds to the charge e.
Kasterin [6] continued Thomson's reasoning: by Gauss's theorem in the cgs system of units $E\sigma = 4\pi e$, where σ is the tube cross section area. The energy density u is given by Maxwell's formula

$$u = \frac{E^2}{8\pi} + \frac{B^2}{8\pi} = \frac{E^2}{4\pi}.$$

Let V = 2πRσ be the volume of a closed vortex tube. Then the photon electromagnetic energy equals $h\nu = Vu = 2\pi R\sigma\, u = 2\pi R\sigma \frac{E^2}{4\pi} = 2\pi R\sigma \frac{1}{4\pi}(4\pi e/\sigma)^2$.

$$h\nu = 2\pi Re^2(4\pi/\sigma) = 8\pi^2 Re^2/\sigma.$$

Next, we take into account the fact that Maxwell did not know about the existence of photons. His equations are true for open vortex tubes; therefore their application is valid at a moment <u>before</u> the birth of a photon from an open vortex tube having a circular cross section. Therefore, when calculating the photon energy we should take $\sigma = \pi \boldsymbol{a}^2$, the cross section of the tube before it detaches from the charges and closes onto itself.
Then

$$h\nu = 8\pi^2 e^2 R/(\pi \boldsymbol{a}^2) = 8\pi e^2 k/\boldsymbol{a}.$$

Hence we find

$$\boldsymbol{a}/\lambda = (8\pi e^2/hc)\, k. \qquad (6)$$

Comparing $\boldsymbol{a}/\lambda$ from (2) with (6), we get the following equation for k:

$$k\sqrt{4k^2 + 2} = hc/(8\,\pi^2 e^2). \qquad (7)$$

In the cgs system $hc = 6.626\ 10^{-27} \cdot 3\ 10^{10}$, $e = 4.8\ 10^{-10}$. The only positive solution of the equation is k=2.284.

7 Completion of the photon structure calculation

It remains to derive the value b/λ. To do this, we formulate two equations, the first of which is for the photon period. Its value from the general formula T = λ/c must coincide with the time for the density wave to travel around the photon cross section

$$T = \int_0^{2\pi} dL/v(Y), \text{ where } dL = \sqrt{\left(\frac{dX}{d\theta}\right)^2 + \left(\frac{dY}{d\theta}\right)^2}\, d\theta.$$

The wave velocity depends on its distance Y to the photon axis in the following way:

$$v(Y) = v_{\parallel} \frac{Y}{R+a} = v_{\parallel} \frac{R - a\cos\theta}{R+a}.$$

Here $v_{\parallel}$ is the longitudinal component of the velocity of the density wave on the outer surface of the photon.

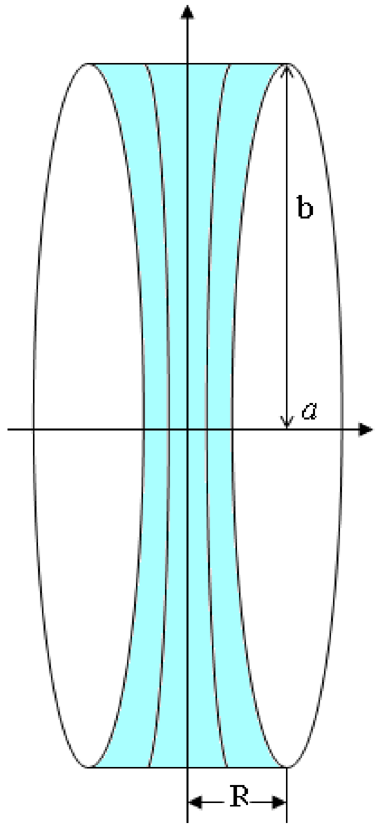

Fig.5. The cross section of the unstressed photon in its free flight.

The calculations appear in Appendix B. The obtained equation yields $\frac{v_{\parallel}}{c}$ in terms of b/λ, which is not enough to calculate b/λ.Therefore, we need to derive another equation, which would give one more expression for the same ratio of velocities $\frac{v_{\parallel}}{c}$. Equating both expressions, we can find b/λ.

We derive this second equation based on the known speed of light c, which should be equal to the speed of the center of mass of the photon cross section: c = the averaged projection of the velocities of surface points on the photon axis:

$$c = \frac{1}{2\pi}\int_0^{2\pi} v(\theta)\, cos\alpha\; d\theta$$

where α is the angle between the direction of the point velocity and the axis Ox,

$$\cos\alpha = dX/dL.$$

These calculations also appear in Appendix B. Integration yields the expression $c/v_{\|}$ in terms of b/λ. Comparison of the new expression with the previous one gives b/λ= 0.5058.

It is interesting that the photon length 2b differs from the wavelength λ only by 1%. It is possible that such a coincidence is not accidental. Thomson [15] suggested that 2πR = λ; according to our calculations, the difference in the values is about 4%.

Finally we have a =0.06654 λ; R=0.152 λ; b= 0.5058 λ. The density wave velocity v_w=3.41c. Fig.5 shows the cross section of a photon in accordance with its proportions.

8 Photons and gravity

According to our model, the photon is stretched 7.6 times in the direction of its motion, as a result of acceleration to the light speed, but its energy does not change. When a photon enters a denser medium (e.g. the gravitational field of the Sun), its wavelength and all dimensions decrease in equal measure. So does the velocity, therefore the period and frequency of the photon remain unchanged. After exiting the dense medium, all photon dimensions are restored. This is observed when a light ray passes near the Sun without any change in its spectrum.

The deviation of a photon in the gravitational field is due to the difference in the velocity of light. We discussed this phenomenon in the earlier article [19], but now we know the photon structure.

Fig.6 shows the same photon as in Fig. 5, the velocities of the upper and lower cross sections differ. The difference can be expressed by the gradient of the light speed in a given zone of MATTER.

Let us compute the angle dα by considering two similar triangles (Fig.6):

$$d\alpha = \frac{c(r)dt}{r} = \frac{[c(r)dt + D(\nabla c(r)\cdot\vec{n})dt}{r+D} = (\nabla c(r)\cdot\vec{n})dt \qquad (8)$$

where $\vec{n}$ is a unit vector perpendicular to the photon's velocity and directed away from the point O, D is the distance between the centers of the two cross sections. It is important to note that the angle of the photon rotation does not depend on its diameter D, so the angle is the same for photons of all energies.

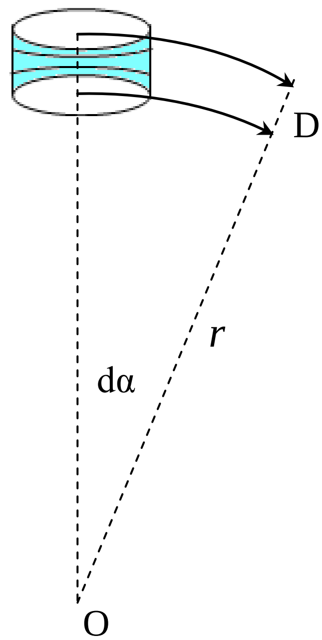

Fig.6. The photon deviates in a gravitational field due to the difference in the velocity of light.

Following Broekaert [17], for the spherically symmetric case of a massive body

$$c(r)=c_0 \exp(-2\kappa/r), \qquad (9)$$

where c_0 is the speed of light at infinity, $\kappa=MG/c^2$, M is the massive body mass.

From eqs.(8) - (9) one can deduce the deviation of the light ray near the sun (see [19]). Instead we will apply them to deduce the Schwarzschild radius. The task is to find the distance r from the center of a black hole to the photon, at which the photon will make circular motions of radius R around the black hole, without being able to leave it.

From (8)-(9)

$$\frac{d\alpha}{dt} = \frac{\partial c(r)}{\partial r} = c(r)\frac{2\kappa}{r^2}. \quad \text{But } \frac{d\alpha}{dt} = \omega = \frac{c(r)}{r}.$$

Consequently

$$\frac{c(r)}{r} = c(r)\frac{2\kappa}{r^2}.$$

After the reductions, we have $r = 2\kappa = \frac{2MG}{c^2}$, and this is the Schwarzschild radius. The space contraction is taken into account by the slowing down of the light speed without the complexities of general relativity.

9 Light refraction

In material substances light propagates at a speed less than c. The common explanation of the delay is that the slowing of the light speed is the result of absorption-reemission of photons by atoms. Obviously, this requires the reemission of the light in the same direction, otherwise the scattering would occur.As a counterexample we propose the dark lines discovered by Fraunhofer in the solar spectrum [22]. These "are the result of photons being absorbed as light passes from the source to the detector". If after the absorption there were reemission in the same direction, then there would be no Fraunhofer lines.
The postulate of GR on the constant speed of light does not allow an alternative interpretation of the slowing of the light speed as it passes through a transparent substance, but we can assume that the phenomenon is due to the high density of the medium inside the substance (see more in Section 11).
According to our paradigm, refraction at the boundary between two media takes place just as the deviation of a photon in the gravitational field discussed in the previous section.

In Fig.7, the blue strip represents a transparent substance (e.g. glass) with a refraction index n. We choose the coordinate axis Oh so that the glass surface lies in the plane h = 0. Above this plane there is a layer of unknown thickness D, in which the density of the medium decreases gradually to the density of vacuum.

We determine the speed of light c(h) in the three regions listed above in the following way:

$$c(h) = \begin{cases} \frac{c}{n}, & if\ h < 0 \\ g(h), & if\ 0 \le h \le D, \\ c, & if\ h > D \end{cases} \qquad \frac{\partial c}{\partial h} = \begin{cases} 0, & if\ h \le 0 \\ \frac{dg}{dh}, & if\ 0 < h < D \\ 0, & if\ h \ge D \end{cases}$$

where g(h) is an unknown function, though without loss of generality g(h) is continuous (g(0)=c/n, g(D)=c), monotonically increases for all h, and is differentiable in region II.

In region II, the gradient of c is directed vertically upward, therefore the general formula (8) for the deviation of the photon velocity can be written in a simpler form:

$\frac{d\alpha}{dt} = \frac{\partial c}{\partial h} \sin\alpha$, where α is the angle between the vertical and the direction of the photon speed $\vec{c}$ (α is measured in the clockwise direction).

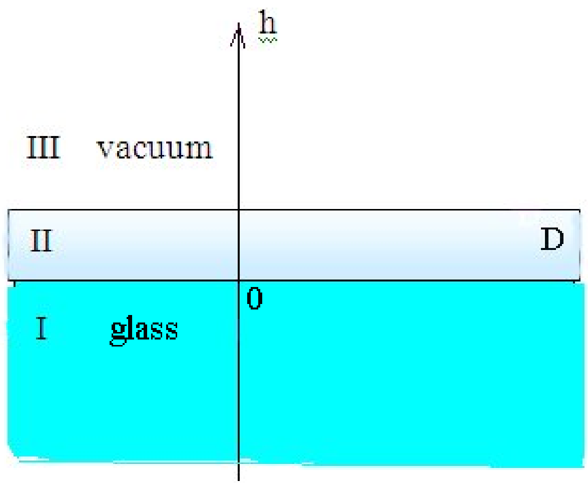

Fig.7. Three regions of the different density of the medium.

In regions I and III, ∇c = 0, so there is no rotation of the photon, i.e. it moves in a straight line. In the transition region II, the photon rotation formula takes the form

$$d\alpha = \frac{dg}{dh} sin\alpha\, dt, \;\; dt = \frac{dl}{g(h)} = \frac{dh}{cos\alpha\;\, g(h)}, \;\; d\alpha = dg\frac{sin\alpha}{cos\alpha}/g(h)$$

$$\frac{cos\alpha}{sin\alpha}\, d\alpha = \frac{dg}{g(h)} \qquad (10)$$

The integral of the left side from α to β is equal to $log\,\frac{\sin\beta}{sin\alpha}$. And of the right side

$$\int_0^D \frac{dg}{g(h)} = \log g(D) - log\; g(0) = \log c - log\left[\frac{c}{n}\right] = \log n.$$

Finally

$$log\,\frac{\sin\beta}{sin\alpha} = \log n, \;\; \text{or} \;\; \frac{\sin\,\beta}{sin\alpha} = n,$$

that is the known refraction law.

This is an unbelievable result. The law of refraction has been derived from the formula for the deviation of a photon in the gravitational field without the Huygens wave theory! You probably think this was a trick.
But no, it's quite straightforward. I myself was surprised when I received this result. After all, the intermediate layer of unknown thickness D and an unknown function v = g(h) were introduced into the consideration, but both disappeared.

And what about the “total internal reflection” from vacuum? We integrated over dh from 0 to D, but it is possible that photons won't reach h=D. If the value $\alpha = \pi/2$ is reached, the photon speed becomes horizontal and it does not rise anymore and h does not reach D. So we get Hmax < D.

Let us integrate eq. (10) with respect to α from 0 to π/2, and h from 0 to Hmax:

$$log\frac{\sin \pi/2}{sin\alpha} = \int_0^{Hmax} \frac{dg}{g(h)} = \log g(Hmax) - log\ g(0)$$

Now we use the monotonic property of the function g(h) and the logarithm:

$$\log g(Hmax) < \log g(D),$$

$$log\frac{1}{sin\,\alpha} < \log g\,(D) - log\left[\frac{c}{n}\right] = \log n,\ \text{ or }\ sin\alpha > \frac{1}{n}.$$

This is the condition of the "total internal reflection" of the ray, although the ray is not reflected from anything.

In Fig. 8 we see both options: the blue ray reaches h = D and continues with the refraction, while the red ray does not reach D and returns to the region I. A ball thrown upwards also does not reflect on anything when it returns to the ground.

Thus, we have described the phenomenon without waves and without reflection.

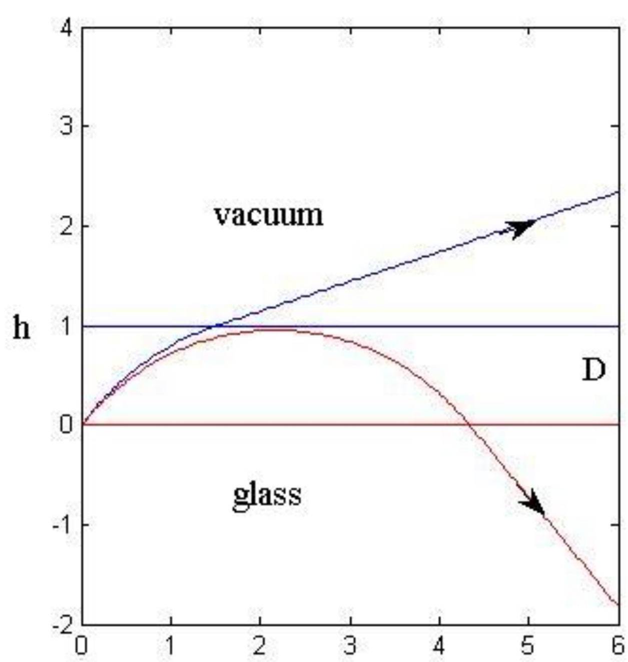

Fig.8. Two trajectories of a photon shown: in blue when refracted and in red when “reflected”.

10 Interference and diffraction of light

In modern physics interference is explained by the addition and subtraction of the electric fields. However, the human eye does not perceive the electric field. What the eye perceives is the photons reaching the eye from the screen.
Hence the conclusion: more photons come to the eye from the bright interference fringes than from the dark ones. With the help of our photon model, one can explain the reason for this behavior of photons.
A density wave runs around the photon. Part of this wave is inside the photon and is inaccessible when the photons touch each other weakly. But the outer part of the shockwave manifests itself even in weak collisions.
Two types of collisions are shown in Fig. 9, where the photons are shown from the point on the path of the ray. In the upper row, two photons are in anti-phase, the protruding fronts of their waves collide while rotating. As a result both photons deviate from the direct path and do not fall into the place on the screen, wherever they would be if in the same phase.

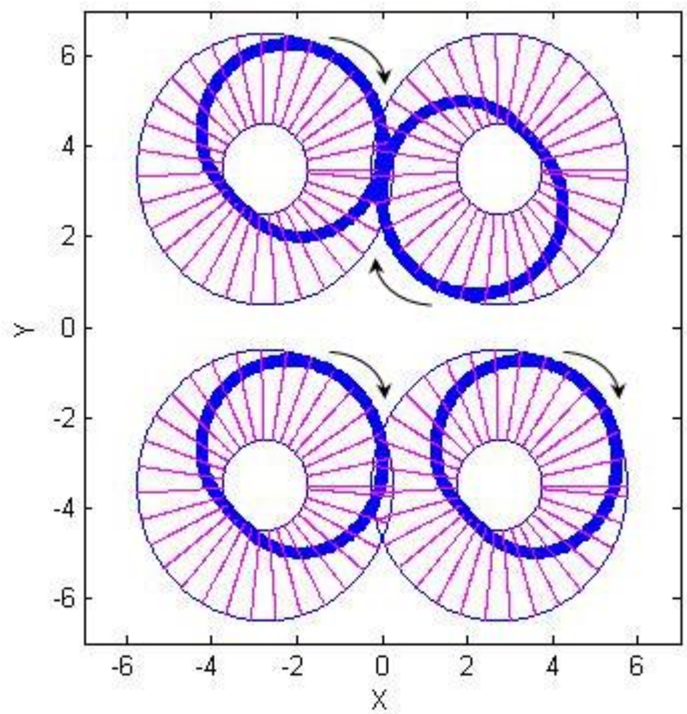

Fig.9.View of a pair of close photons from the point on their path. In the upper row, the wave fronts of the two photons being in anti-phase repel each other. Such photons are

scattered, not reaching the screen, and a dark fringe appears on the screen. In the lower row, in-phase photons do not repel each other, so they produce a bright fringe.

Diffraction of light is a deviation from the rectilinear propagation of light as it passes near the edge of an object or through a narrow slit.

Modern physics explains diffraction using the Huygens-Fresnel principle of secondary waves. This theory describes the behavior of sound and water waves but experiences problems when applied to the propagation of light. Typical interference patterns produced by light differ from typical samples created on the surface of water [23].

Within the framework of our paradigm, another explanation of the diffraction of light is possible. It is contained in Newton's letter to Boyle [24]. In paragraph 3 of the letter, Newton described an intermediate layer around bodies as follows:

> “I suppose the rarer aether within bodies, and the denser without them, not to be terminated in mathematical surfaces, but to grow gradually into one another.”

Then Newton continued:

> “…this may be the cause why light, in Grimaldi's experiment, passing by the edge of a knife, or other opaque body, is turned aside, and as it were refracted...”

That is, Newton believed that the cause of diffraction, discovered by Grimaldi in 1660, is the refraction of photons in the intermediate layer at the edge of the opaque obstacle.

Newton’s description can be made fully compatible with our idea of the refraction of photons in the transition region (see Section 9), if we replace “the denser aether” with “the rarer aether” and vice versa. This inversion of the aether density in the Newton’s letter has already been discussed by Eric Baird [25].

Thus, the great Newton presented the explanation of the diffraction of light, which does not use the secondary Huygens-Fresnel waves and corresponds to our paradigm.

11 The nature of dark matter and dark energy

Scientists around the world are racking their brains in an attempt to explain such mysterious phenomena as dark matter and dark energy. The problem is the lack of a physical model of gravity, while gravity is the key word for both phenomena.

Here is a quote from the famous book “Gravitation” by Misner, Thorne and Wheeler [26]:

> «… nowhere has a precise definition of the term "gravitational field" been given» (p.399).

For a visual depiction of the gravitational field, a globe is often drawn, which presses on space-time, shown as a trampoline.

In our paradigm, space is a property of MATTER. A property cannot be pressed, but it can be changed by affecting the property carrier. You can raise the body temperature by heating it, but you cannot press the temperature.

It is natural to assume that massive bodies lose small part of their mass which turns into unorganized mass filling the neighborhood of the massive bodies. This increases the density of surrounding MATTER. The properties of this type of mass are different from the properties of the organized mass that are familiar to us.

First, the unorganized mass does not hamper the movement of bodies, just as water molecules do not impede the movement of the water waves. Secondly, the space contraction is directly related to the density of the unorganized mass. Thirdly, the unorganized mass tends to equalize its density.

(The density of MATTER means the density of the unorganized mass.)

Both dark matter and the unorganized mass cause gravity, which suggests that these are one entity. The question is whether the unorganized mass detached from its source is possible. The answer is positive because gravitational waves break away from the black holes that created the waves [27], and thus prove that such a detachment of the unorganized mass from its source is possible.

Now about <u>dark energy</u>. According to our paradigm, another phenomenon takes place inside regions with high density of the unorganized mass: aligning their density with less dense neighboring regions (3rd property of the unorganized mass). The result is an increase in distances (2nd property). This phenomenon looks like runaway of visible objects.

The name "dark energy" presupposes the action of pressure forces acting repulsively, however in reality, the increase in the distances occurs without participation of any forces because the velocities of bodies due to the density of the unorganized mass are only apparent.

Thus, we have two opposite phenomena: dark matter causes gravity, and dark energy causes anti-gravity. Can both be combined into one? Consider an analogy: a heated body raises the temperature of the neighboring bodies, but its own temperature decreases. That is two opposite phenomena can happen simultaneously.

Smolin [5] wrote that what science needs is unification: “to bring together two things previously understood as different and recognize them as aspects of a single entity”. Here is a classic example of such unification: *The Sun is just another star*.

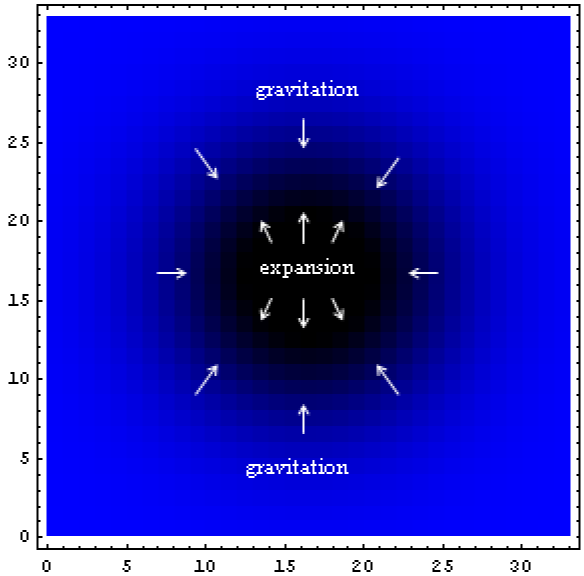

Fig.10. Illustration for the two opposite phenomena: dark matter and dark energy. Zones with high density of the unorganized mass (shown in black) expand. Where there is a nonzero density gradient of the unorganized mass, a gravitational process is observed.

In a static gravitational field, the density of MATTER is not equalized because of the constant replenishment of the unorganized mass from the source. This accounts for the excess gravity inside the galaxies and clusters. On the other hand, away from galaxies and clusters where there is little or no inflow of the unorganized mass, the alignment process that looks like anti-gravity predominates.

So, there is only one MATTER with which two opposite processes occur (Fig.10). In order to explain the fact that the universe is expanding at an accelerating rate, we will find the apparent rate of expansion.

Let us denote by ρ_{uom} the density of the unorganized mass and by s the distance between two bodies <u>at rest</u>. According to the second property of the unorganized mass $s\sim 1/\rho_{uom}$. Then the apparent velocity of the expansion $\tilde{v} = \frac{ds}{dt} \sim -\frac{d\rho_{uom}}{dt}/\rho_{uom}^2$, which shows that as the density of the unorganized mass decreases, a tendency of accelerating the universe expansion is expected.

Thus, within the new paradigm the phenomena receive physical explanations.

It was said in Section 9 that the slowing down of light in a transparent substance is due to the increased density of the medium inside the substance. This density is created as a result of mass loss by the substance molecules, i.e. the unorganized mass. The molecules compensate for the mass loss from the same medium.

Some physicists also consider that dark matter and dark energy are not separate physical phenomena but rather different facets of the same unknown substance [28] [29]. They call this unified entity different names: quintessence, dark fluid, etc. The use of a scalar field for the description has additional similarity to our model, but these theories do not specify the origin of the dark fluid or quintessence.

The main difference in our approach is that we introduce the missing link in the chain of causes and effects of the gravitation processes. This link is not a mathematical concept, but the physical unorganized mass. Without it, it is impossible to understand the nature of dark matter and dark energy.

12 Michelson-Morley experiment revised

While refining the photon structure (see Section 2), we came to the conclusion that the wave nature of light does not apply to it. To be consistent, we have revised some theories related to the wave nature of light and grounded them in accordance with our model of the photon.

On the other hand, MATTER plays a very important role in the photon model. The justification of <u>her</u> existence was based on the criticism of Michelson's theory. Both Righi (see [12]) and Marmet [14] used the wave theory of light in their works, which obliges us to provide the same arguments, but on the basis of the photon-particle. It is not difficult if we use the law of light aberration in the case of a moving mirror. This law specifies the angle of reflection of a photon from a moving mirror without applying the Huygens principle.

The light aberration formulas are also applicable to particles, especially since James Bradley himself, the aberration discoverer, considered light to be a stream of particles.

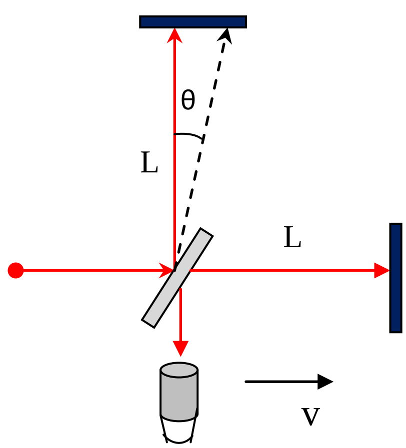

Fig.11. The Michelson interferometer moves along with the Earth in its motion around the Sun.

Fig. 11 shows the Michelson interferometer moving to the right with the velocity v along with the Earth in its motion around the Sun [11]. In all the subsequent arguments we proceed from the hypothesis of fixed aether and the classical laws of physics. According to these laws, the travel time of the horizontal beam to the mirror and vice versa is

$$t_1 = \frac{L}{c-v} + \frac{L}{c+v} \cong \frac{2L}{c}(1+\beta^2), \qquad (11)$$

where β=v/c.

Formula (11) is the same for Michelson's and Marmet's theories.

Now let us look at the transverse beam (which is vertical in Fig.11). If we assume that it is perpendicular to the velocity v in the reference frame S' moving with the Earth, then again the calculation of the time interval is the same for the two theories and is equal to

$$t_2 \cong \frac{2L}{c}(1+\beta^2/2). \qquad (12)$$

The theoretical time difference $t_1 - t_2 \cong \frac{L}{c}\beta^2$ would be sufficient to detect it in the experiment, but in practice there was no noticeable shift in the interference fringes, therefore it was decided to reject the aether hypothesis.

However, Righi and Marmet indicated (based on the Huygens principle) that the reflection from the moving semi-transparent mirror occurs at a different angle. We now obtain the same value of the angle correction by applying the formula for the aberration angle θ ≈ v/c sinα', which is valid for $v \ll c$. α' is the angle at which the light source in the system S' is visible, and θ is the correction of the direction to the light source and the continuation of the beam.

In our case α'= 270° because in Fig.11 the beam goes from below (from the image of the light source). Therefore, θ ≈ -β where the minus sign means that the angle θ must be counted clockwise. This deviation of the beam from the vertical is shown in Fig.11 by the dashed line. The distance to the mirror is equal to

$$L' = L/\cos\theta \cong L/(1-\beta^2/2) \cong L(1+\beta^2/2) \qquad (13)$$

Substituting L' instead of L in (12), we obtain the corrected travel time of beam 2:

$$t_2' \cong \frac{2L'}{c}\left(1+\frac{\beta^2}{2}\right) = \frac{2L}{c}\left(1+\frac{\beta^2}{2}\right)^2 \cong \frac{2L}{c}(1+\beta^2), \qquad (12')$$

which coincides with the time interval of the horizontal beam (11) to within terms of order β^2.

It turns out that for photons-particles, the null result of the Michelson experiment is consistent with the hypothesis of the absolute frame of reference.

In this article we further developed the aether hypothesis: MATTER is the basis of the world of masses, and not only a medium that provides oscillations of light waves.

Conclusion

This article is a proposal for a paradigm shift in physics. The main requirement for the new paradigm is consistency and simplicity. The basis of our world of masses is MATTER, and space is its property. Vacuum is MATTER in the equilibrium state. We retain the GR idea about the variability of space, but the MATTER state is described by one scalar field instead of the space-time tensor. The consequence of the variability of space is the rejection of the light speed constancy. Because the light speed is measurable, it is chosen as an indicator of the MATTER density.

Gravity is explained by the density gradient of the unorganized mass. Dark matter is a huge zone of increased density, detached from its source. Its presence is revealed by the manifestation of gravity. The natural process of leveling out the MATTER density in such a zone increases distances and is perceived by astronomers as anti-gravity. This phenomenon is called "dark energy", but actually it is the same dark matter that produces gravity, just as a heated body raises the temperature of the neighboring bodies, but its own temperature decreases.

A photon is not a wave, but a particle. Because the photon rotates and is asymmetric, it possesses a phase of rotation, which was erroneously taken for the proof of the wave nature of the photon. In this regard, we reject the Huygens principle that every point in the path of light becomes a source of secondary waves. Thus, we demonstrated the ability of the classical concept of "particle" to fully describe the behavior of light.

We calculated the photon structure in the unstressed state. The photon model allows deriving the general formula for the photon deviation and applying it to three seemingly different phenomena: the deflection of a light ray near the Sun, the refraction of light at the boundary of two media, and the diffraction of light when passing near the edge of an opaque object. The Schwarzschild radius is a simple consequence of the general formula.

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Appendix A.

It is known that the spin of a photon is equal to ħ. But having the photon model, we can calculate its spin also according to the general formula

$$\int_0^{2\pi} \vec{r} \times \vec{v}_w \, dm \qquad \text{(A.1)}$$

and equate both values. In (A1), the integration is carried out along the front of the shock wave of the photon.

The fuction θ = θ(φ) describes a line on the photon surface, where φ is the azimuth θ from 0 to 2π. If θ(0) = 0 and θ(2π) = 2π, then the line is closed, which is necessary for the wave front line. Thus, we can define the wave front line θ = φ.

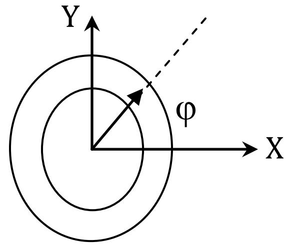

Fig.12. The view of a photon from a point on its axis. The angle φ is the azimuth of a point on the surface of the photon.

The mass density per unit length depends on the distance d of a point on the wave front to the photon axis d = R + a cosθ and is equal to

$$\sigma = \frac{dm}{dl} = \frac{m}{2\pi(\mathrm{R} + \mathrm{a}\cos\theta)}.$$

But dl=$(\mathrm{R} + \mathrm{a}\cos\varphi)\mathrm{d}\varphi$, therefore $dm = \frac{m\,\mathrm{d}\varphi}{2\pi} = \frac{\hbar\omega}{2\pi\,\mathrm{c}^2}\mathrm{d}\varphi = \frac{\hbar}{\lambda\,\mathrm{c}}\mathrm{d}\varphi.$

In Section 3 we derived the formula for the speed of the wave of photon

$v_w(\theta) = \vec{v}_0\,(\mathrm{R} + \mathrm{a}\cos\theta)/(\mathrm{R} + \boldsymbol{a})$, where $\vec{v}_0$ is the speed at the outer surface of the photon. We decompose the velocity of a point on the wave front $\vec{v}_0$ into two components: one in the cross section plane, and the other $v_\perp$ is perperdicular to it. The velocity component in the cross section plane has a zero arm relative to the axis of the photon and therefore does not contribute to the cross product $\vec{r} \times \vec{v}_w$.

It remains $v_\perp(\mathrm{R} + \mathrm{a}\cos\theta)/(\mathrm{R}+\mathrm{a})$, and then the cross product is simplified to $\vec{r} \times \vec{v}_w = (\mathrm{R} + \mathrm{a}\cos\theta)\, v_\perp(\mathrm{R} + \mathrm{a}\cos\theta)/(\mathrm{R} + \boldsymbol{a})$, because $v_\perp$ and $\vec{r}$ are mutually perpendicular.

We substitute the expressions found in (A.1). So, we have

$$\hbar = \int_0^{2\pi} \vec{r} \times \vec{v}_w\, dm = \int_0^{2\pi} (\mathrm{R} + \mathrm{a}\cos\theta)^2/(\mathrm{R} + \boldsymbol{a})\, \frac{\hbar\, v_\perp}{\lambda\, \mathrm{c}}\, d\varphi. \qquad \text{(A.2)}$$

After the reductions in (A.2) and the integration, we obtain

$$\frac{\mathrm{c}(\mathrm{R} + \boldsymbol{a})}{v_\perp}\,\lambda = \pi(2\mathrm{R}^2 + a^2).$$

Finally

$$\lambda = \frac{v_\perp}{\mathrm{c}}\,\frac{\pi(2\mathrm{R}^2 + a^2)}{(\mathrm{R} + \boldsymbol{a})} \qquad \text{(A.3)}$$

Appendix B.

The photon period can be calculated from the general formula T = λ/c, and also by the time of traversing the density wave point around the photon cross section, and equating these two values. The second method uses the integration of time intervals $dt = dL/v(Y)$ along the elongated cycloid (5) in one cycle.

$$\mathrm{T} = \int_0^{2\pi} dL/v(Y),$$

where $dL = \sqrt{\left(\frac{dX}{d\theta}\right)^2 + \left(\frac{dY}{d\theta}\right)^2}\, d\theta$, and the velocity of a point depends on its distance Y to the axis of the photon in the following way:

$$v(Y) = v_\parallel \frac{Y}{R+a} = v_\parallel \frac{R - a\cos\theta}{R+a}.$$

Here $v_{\|}$ is the longitudinal component of the velocity of the shock wave on the outer surface of the photon.

Y=R- a cosθ = a(k- cosθ), $v(Y) = v_{\|} \frac{k-\cos\theta}{k+1}$,

$$dL = \sqrt{\left(\frac{dX}{d\theta}\right)^2 + \left(\frac{dY}{d\theta}\right)^2}\, d\theta = \sqrt{(q - b\cos\theta)^2 + (a\sin\theta)^2}\, d\theta;$$

$$dL = \sqrt{\left(\frac{\lambda}{2\pi} - \lambda\left(\frac{b}{\lambda}\right)\cos\theta\right)^2 + \left(\frac{\lambda}{\sqrt{2}\,\pi\sqrt{2k^2+1}} * \sin\theta\right)\hat{}2}\, d\theta;$$

Let P=$\sqrt{\left(\frac{1}{2\pi} - b/\lambda * \cos\theta\right)^2 + \left(\frac{1}{\sqrt{2}\,\pi\sqrt{2k^2+1}} * \sin\theta\right)\hat{}2}$

Then

$$dL/\lambda = P\, d\theta \qquad \text{(B.1)}$$

$$T = \frac{\lambda}{c} = \int_0^{2\pi} dL/v(\rho) = \lambda \int_0^{2\pi} P/\left(v_{\|}\frac{k-\cos\theta}{k+1}\right) d\theta$$

$$\frac{v_{\|}}{c} = \int_0^{2\pi} P/\left(\frac{k-\cos\theta}{k+1}\right) d\theta \qquad \text{(B.2)}$$

The obtained equation yields $\frac{v_{\|}}{c}$ in terms of b/λ, which is not enough to calculate b/λ.Therefore, we need to derive another equation, which would give one more expression for the same ratio of velocities $\frac{v_{\|}}{c}$. Equating both expressions, we can find b/λ.

We derive this second equation based on the known speed of light c, which should be equal to the speed of the center of mass of the photon cross section: c = the averaged projection of the velocities of surface points on the photon axis:

$$c = \frac{1}{2\pi}\int_0^{2\pi} v(\theta)\cos\alpha\, d\theta$$

where α is the angle between the direction of the point velocity and the axis Ox,

$$\cos\alpha = dX/dL.$$

$$c = \frac{1}{2\pi}\int_0^{2\pi} v_{\|}\frac{R - a\cos\theta}{R+a}\frac{dZ(\theta)}{dL(\theta)}\, d\theta$$

$$\frac{c}{v_{\parallel}} = \frac{1}{2\pi}\int_0^{2\pi} \frac{k - \cos\theta}{k+1} \frac{(q - b\, cos\theta)}{\sqrt{(q - b\, cos\theta)^2 + (a \sin\theta)^2}}\, d\theta$$

Now from (B.1) we have $dL = \lambda\, P\, d\theta$

$$dZ = \lambda\left(\frac{1}{2\pi} - \left(\frac{b}{\lambda}\right)\, cos\theta\right) d\theta;$$

$$\cos\alpha = dZ/dL = (1/2\pi - b/\lambda * cos\theta)/P$$

$$c/v_{\parallel} = \frac{1}{2\pi}\int_0^{2\pi} \frac{k - \cos\theta}{k+1}\left(\frac{1}{2\pi} - b/\lambda * \ cos\theta\right)/P\ d\theta$$

The integration yields the expression $c/v_{\parallel}$ in terms of b/λ. Comparison of the new expression with the previous one allowed to find b/λ= 0. 5058.