A New Physical Paradigm

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Abstract. The inability to solve the dark energy/matter problem within the current paradigm has prompted many physicists to seek an answer in the nature of a vacuum. It has long been recognized that a vacuum is not empty; rather, according to the quantum hypothesis, a vacuum contains vacuum fluctuations. However, this approach has not resolved the dark energy/matter problem.

The new paradigm presented herein begins with the basics. First, a definition of space is formulated, which leads to the definition of mass. From these definitions, it follows that unorganized mass is present everywhere as the background of all phenomena.

By considering this unorganized mass, the physical mechanism of gravity is clarified, and various phenomena are unified. In particular, dark energy/matter is shown to be a simple special case of the extended concept of gravity.

This new paradigm also provides a unified viewpoint of various phenomena associated with the deflection of light rays: "total internal reflection" (in which reflection does not occur), diffraction at the edge of an opaque obstacle, and the deviation of light rays near the Sun.

On the same basis, we predicted and experimentally confirmed deviation of a laser beam in the empty gap between the Casimir plates.

This new paradigm provides physical explanations for more than 10 phenomena and paradoxes, with potential for further explanations.

Keywords: dark matter, dark energy, gravity, paradigm shift, space–mass relation, black holes, unification, refraction, diffraction, bending of light rays, light slowing, Casimir effect, electron size, Planck's equation, wave–particle duality.

Contents

1. Introduction

All phenomena in the physical world have a cause. When we understand the cause of a phenomenon, the need to impose postulates is eliminated. The truth does not need assumptions.

In modern physics, a very important element is missing; thus, many phenomena remain unexplained. The rupture of causal relationships has compelled scientists to incorporate postulates, unsubstantiated principles, rules, and empirical laws as a substitute for the physical causes of phenomena.

Attempts to join uncoordinated knowledge as fragments of the world picture are difficult and require theoretical complications. To paraphrase Occam's principle, these attempts increase, beyond what is necessary, the number of entities required to explain phenomena. Thus, physics pays the price of highly complex theoretical concepts due to the absence of an important element.

Recently, this complexity has led to problems in explaining the phenomena of dark matter and dark energy. Many physicists have concluded that the underlying hypotheses are incorrect. A deep revision of the current physical paradigm has become urgent. Cosmetic corrections are not effective; rather, a revolutionary change in paradigm is necessary.

In this work, we offer a conception in which only a definition of MATTER together with some of its features, is postulated. Further events causing changes in the state of MATTER, i.e., the appearance of new properties or changes in their inter-relations, are explained by concrete physical reasoning. By revealing the mechanism governing the events induced by these causes, we can build a contradiction-free model of the Universe.

As its primary achievement, this new paradigm reveals the mechanism of gravity, which provides a simple explanation for the phenomena of dark matter and dark energy.

The new paradigm predicts a previously unknown case of deviation of a laser beam passing in the empty gap between the Casimir plates, which has been experimentally confirmed.

Under the new paradigm, many unsolvable physical issues have been resolved. Below is a list of problems and paradoxes that have been resolved by the new paradigm:

- Physical definitions are established for space and mass.
- The direct cause of gravity is identified, and the mechanism of gravity is revealed.
- The phenomena of dark matter and dark energy are shown to have the same direct cause as gravity.
- The postulated limit on the speed of a particle is explained.
- The wave–particle duality problem is solved.
- A black hole is shown to give birth to a galaxy, rather than being a dead end for mass.
- The cause for light refraction at the boundary of two media is identified, without the need for Huygens' principle. Light diffraction is also shown to have the same cause.
- On the same basis, the deviation of a laser beam in the empty gap between the Casimir plates is predicted and experimentally confirmed.
- The experiment by Hau et al. with a light pulse delay of up to 17 m/s is explained.
- The proportionality between a photon's energy and frequency is explained.
- The mechanism by which a counteraction force emerges in Newton's third law is revealed.

Furthermore, we demonstrate why the Michelson–Morley experiment could not detect ether and, therefore, why progress has been hindered in fundamental physics.

This work is intended for all those who are familiar with classical physics, not only professional physicists. Only a willingness to accept new ideas is required from the reader.

2. The need for a universal medium

We employ two well-known facts: 1) the speed of light is finite, and 2) no medium impedes the motion of the planets.

If a pure vacuum is empty, light would not experience any resistance in vacuum, and the speed of light would be unlimited. This expectation contradicts the first fact.

Hence, there is only one possibility: namely, all objects of our world must be structures of a universal medium. That is, this medium is the universal basis for all the masses. Moreover, in order not to impede the motion of the Earth or other celestial bodies, the viscosity of the universal medium must be zero.

The difference between our universal medium and the ether will be clarified later.

By introducing the concept of a universal medium, many phenomena are found to be manifestations of the same essence.

Below, we present a systematic description of our paradigm.

3. MATTER and space.

Modern physics does not define the concept of space, as clearly stated on Wikipedia: "Space is one of the few fundamental quantities in physics, meaning that it cannot be defined via other quantities because nothing more fundamental is known at the present" [1].

Here, we introduce this missing fundamental concept, from which the concepts of space and mass are derived. Following B. Pogorelsky, we will call this concept MATTER in the new expanded sense of the term [2].

> ***Definition 1. MATTER is an energy-spatial, continuous, and reflecting substance, organized in an extremely complicated manner. The various states of MATTER determine all physical features of the Universe.***

An "energy-spatial substance" should be understood as an energy substance possessing the spatial feature and the ability to change its magnitude, which results in the emergence of MATTER's state denoted by most physicists as ***mass***. Thus, spatiality is a feature of MATTER that is highly important for our further consideration.

The above definition necessarily leads to the following principal conclusions:

1. The postulated physical medium differs from the ether in that MATTER does not fill space.

2. There cannot be space without MATTER because there cannot be a feature without a bearer.

3. MATTER cannot be finite or discrete; otherwise, it would either be devoid of its attribute or separated from its own attribute, which is meaningless.

4. Motion is impossible for MATTER; otherwise, MATTER would show movement in its own attribute.

In this work, we will confine ourselves to considering only one attribute of MATTER - spatiality.

4. Mass and vacuum

The basis of the proposed paradigm is the nature of mass. Three main forms of the structural organization of mass (wave, particle, and virtual mass) and their transmutations constitute a common basis for a causal understanding of hitherto unexplained and disjunct phenomena.

In the conventional paradigm, mass is determined by the manner in which it is measured. This approach is understandable because the physical meaning of the mass concept requires the concept of space.

We denote the ***ideal vacuum*** as the equilibrium state of the energy-spatial feature of MATTER. An ideal vacuum does not exist in our world.

The aspiration of MATTER to return to this equilibrium state determines the direction of all physical processes in our world.

A wave in the MATTER medium known as a vacuum does not constitute a transfer of MATTER, but rather the propagation of a density zone, i.e., a zone whose spatial feature is reduced. This spatial deficit is *mass*. Mass and space are two opposites, similar to cold and heat: when there is less heat, we have more cold; when there is less space, we have more mass, and vice versa. Thus, we derived the following definition of mass:

Definition 2. Mass is MATTER in the state of space deficit.

Below, three properties of MATTER in the state of space deficit, i.e., mass, are postulated:

1. Mass tends towards a balanced state. In other words, contracted MATTER strives to expand. Adjacent MATTER sections with different levels of contraction aim to make these contractions equal.

2. Space and mass are related. Mass, as we measure it, is inversely proportional to spatiality: the contraction of mass by a factor of k results in a k-fold increase in the amount of mass.

3. The total mass is constant. “Unpressing” one zone will cause a contraction in a neighboring zone.

It should be noted that there is no pressure force between adjacent MATTER sections. Rather, there exists a tendency for contractions to be equalized. Forces appear only at the level of particles.

While the variability of space has already been accepted due to the general theory of relativity, the concept of mass as the opposite of space requires further explanation.

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The analogy between the pairs of cold–heat and space–mass opposites helps us to understand mass, but this analogy is not perfect because cold is negative heat. However, mass is inversely proportional to space: as mass increases, its size becomes proportionally smaller.

To illustrate this concept, let us consider a muon, a **heavy variant** of an electron (an elementary particle identical to the electron, except for its mass). The mass of a muon is 206.768 times that of the electron [3]. A natural method for achieving a greater mass is to add smaller masses. However, the muon would then be much larger than the electron, and accordingly, its magnetic moment would be greater. However, we observe the opposite: the measured magnetic moment of the muon is less than that of the electron [3].

According to the new paradigm, the linear dimension of the muon is 206.768-fold smaller than that of the electron because the dimensions are inversely proportional to the mass for identical particles.
This trend agrees with the surprising fact that the magnetic moment of the muon is 206.768-fold smaller than that of the electron. Such a coincidence cannot be accidental.

One can obtain the same result by considering that the spins of the electron and the muon are equal – to have two identical spins, the greater mass must have a smaller size.

* * *

A similar relationship exists between the size and energy of a photon. Initially, it would appear that a higher-energy photon should occupy a larger volume; however, the period of revolution of the wave in a large photon would then be longer and its frequency would be lower (see Section 6), which is wrong.

Hence, the high frequency of the x-ray photon is a result of its small size.

Let E_1 and E_2 be the energies of two photons, and let ν_1 and ν_2 be the revolution frequencies of their waves.

If the linear dimensions of the second photon are k-fold smaller than those of the first, then the second photon is contracted by a factor of k with respect to the first, and its energy is k-fold greater, that is, $E_2 = k\ E_1$.

At the same time, as the photon becomes smaller, the revolution frequency of the wave increases, $\nu_2 = k\,\nu_1$. Hence, $\frac{E_2}{\nu_2} = \frac{E_1}{\nu_1}$. In other words, the ratio of the photon energy to its frequency is constant. Denoting this constant ratio by h, we obtain the famous Planck equation $E = h\nu$ [4].

In 1900, a paradox known as the ultraviolet catastrophe arose [4]. Max Planck resolved this paradox by assuming that radiation and absorption occur in discrete portions of energy, $E = h\nu$. Since its introduction, this assumption has been intensely used in physics with no physical explanation.

Here, we have derived the first physical explanation of Planck's equation as a consequence of the second property of mass.
With this explanation, we understand that the energies of other elementary particles cannot be calculated on the basis of Planck's equation because their structures differ from that of a photon.

5. Three main forms of the structural organization of mass

If there is a deficit of space in a vacuum, virtual clots of mass arise, which disappear immediately afterwards because they have no stabilizing structure. Here, we call these short-living clots ***virtual mass***.

In our previous work [5], we called the virtual mass "unorganized mass," which has the same meaning.

Lawrence Krauss wrote a book called "A Universe from Nothing" [6]. Our paradigm clarifies that the "nothing" from which the universe originated is virtual mass and that the Big Bang is a chain reaction in which virtual mass transforms into ordinary mass.

Virtual mass is invisible; nevertheless, we encounter its manifestations in everyday life and, recently, in the cosmos. We will discuss these manifestations in subsequent sections.

A density wave moves without movement of the spatial domains themselves, similar to the manner in which thermal properties are transferred to neighboring domains in a solid.

When two density waves of MATTER intersect, they swirl into a tube. If the tube closes, we obtain a toroidal vortex–photon - the simplest stable structure of organized mass. The ease of photon creation is due not only to the simplicity of the vortex structure, but also to the stability of photons of various sizes and energies.

Stable vortex structures are elementary particles.

Thus, mass exists in the following main forms of structural organization: 1) virtual mass (no structure), 2) wave structure, and 3) vortex structure (elementary particle).

The reverse transformation of a vortex structure into a virtual mass is also possible. A full or partial transition of mass from a vortex structure into a wave or virtual mass is denoted here as **transnihilation**.

The term "transnihilation" was coined by B. Pogorelsky [2] to emphasize a transition to another form, rather than complete annihilation.

Notably, in conventional physics, the conversion of an electron–positron pair into photons during their collision is called annihilation. Actually, in this reaction, there is only a change in the structure of the particles, without a loss of mass. Remark: In the new paradigm, in contrast to the conventional paradigm, photons do possess mass, according to the definition of mass as space deficit.

6. Elementary particles

Definition 3. An elementary particle is an energy-capacious, dynamically stable functioning vortex structure of MATTER.

This definition does not coincide with the definition of an elementary particle in the dominant paradigm.

By "energy-capacious," we indicate a highly compressed free particle; however, no force acts to compress this particle. The contraction results from the dynamic characteristics of the vortex such that the space deficit is significantly larger than in wave structures. The particle functions through an unceasing process of absorption and radiation.

The notion "dynamically stable" requires some explanation. A vortex of MATTER, which is called a particle, transnihilates and loses part of its mass, increasing the density of the surrounding vacuum.

If a clot of virtual mass arises in the capture zone of the vortex, it is absorbed by the vortex, which increases the particle's mass. Thus, we have two processes: 1) the process in which corpuscular mass is transferred into virtual mass (transnihilation) and 2) the process in which corpuscular mass is restored by the absorption of virtual mass.

The dynamic stability of these two processes determines the particle's life span.

Nikola Tesla [7] described the above process in his own words:

> “By being set in movement this fluid, the ether, becomes gross matter. Its movement arrested (halted), the primary substance reverts to its normal state.”

As a structure, a particle has upper and lower limits of stability. If the transnihilation process causes the particle's mass to decrease below the lower mass limit, the particle decays. If the mass reaches the upper mass limit, the particle either radiates or decays as well. There is a third way for a particle to reach its end, namely, when structure defects accumulate and structure degradation occurs.

The above definition of an elementary particle solves the problem of wave–particle duality [8].

Indeed, the basis of the vortex is a circulating wave; therefore, elementary particles exhibit a frequency, i.e., the number of full wave revolutions per unit time. Due to the asymmetry of the wave front, particles also have a phase of rotation.
It follows from the above description that instead of “wave–particle duality”, the term “particle–vortex” without duality is suitable.

The theory of relativity postulates an upper limit on the velocity of particles without providing a reason for this limitation. The above definition of an elementary particle also solves this problem. Indeed, because the vortex wave has a return motion, the particle–vortex cannot exceed the wave velocity.

7. Variable speed of light

A light ray can be bent only if there are different speeds of light propagation at different points in space.

However, the theory of relativity is based on the postulate of a constant speed of light. This postulate contradicts the slowing of light in transparent substances.

To resolve this contradiction, a false explanation was dominant over a long period; according to this explanation, the atoms of matter absorb and then re-emit photons, which slows down the light.

An anonymous Wikipedia author wrote:

> “Common explanations for this slowing, based upon the idea of light scattering from or being absorbed and re-emitted by atoms, are both incorrect. Explanations like these would cause a "blurring" effect in the resulting light, as it would no longer be travelling in just one direction” [9] [10].

An experiment [11] with a light pulse delay of up to 17 m/s clearly showed that the true speed of light is variable. Sodium atoms, which are opaque to light, absorb light; however, when they are saturated and cease to absorb light, they become transparent!

In other words, this experiment proved the obvious truth: a substance is TRANSPARENT to visible light if it DOES NOT ABSORB light.

Another false explanation for the slowing of light in matter is based on the electromagnetic nature of light.

In 1865, Maxwell discovered that one solution of his electromagnetic equations in the absence of sources is a wave function propagating at the speed of light [12]. This result has been accepted by the physical community as a great discovery, connecting light with electromagnetic phenomena. However, this model of light was not viable because Maxwell mistakenly assumed that there are charges in a vacuum, as in a dielectric. Although these charges are assumed to create a displacement current [12], there are no charges in a vacuum; nevertheless, the light still propagates, leading to a contradiction.

Here is a citation from a Wikipedia article, "Ampère's circuital law" [13]:

> "The displacement current is justified today because it serves several requirements of an electromagnetic theory: . . . prediction of wave propagation of electromagnetic fields."

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

Subsequently, Einstein [14] used the photoelectric effect to show 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.

This problematic situation was frozen by the "wave–particle duality" [8] containing the two conflicting models. L. Smolin [15] called this duality a "conceptual paradox."

Why have we been haunted by the non-viable plane electromagnetic wave as a model of light for more than 100 years? The fact is that the concept of wave–particle duality took root as a solution to the contradiction: physicists breathed a sigh of relief and moved on, not looking back at the old problem.

Using the new paradigm, the conceptual paradox is solved as follows. Rather than using two conflicting models of a particle and a plane electromagnetic wave, light is represented by one model of a vortex in which a density wave circulates.

The slowing of photons is due to the presence of virtual mass in **the medium**. Its quantity can vary from place to place (and over time as well) and, thus, affects the speed of photons because the distances change.

The density of virtual mass in matter is usually higher than in a vacuum due to the particle transnihilation.

The reverse process of the absorption of virtual mass by vortices also occurs; therefore, an equilibrium density of virtual mass is established. This level is higher in glass than in vacuum such that the speed of photons is decreased by 1.5-fold.

Let us return to the experiment [11] in which a light pulse decelerated to 17 m/s, i.e., by a factor of 20 million compared with the speed of light in vacuum. This deceleration indicates a colossal medium density, for which we have only one explanation: at extremely low temperatures, sodium atoms strongly transnihilate, which increases the medium density.

We will see later that a gravitational effect must also be present under such conditions.
According to our hypothesis, this experiment is the world's first artificial *virtual mass generator*.

For a fundamental discussion of "varying speed of light theories," see [16].

8. Selecting a mathematical description method

In our previous paper [17], we demonstrated that the notion of time in the theory of relativity is non-physical; therefore, here and in our previous works, we use universal time.

Our paradigm is based on the ability of space to contract, which is akin to the curvature of space in the theory of general relativity. However, according to our paradigm, one scalar field is sufficient for describing the MATTER state spatiality.

In the general theory of relativity, Einstein described the stress of space using a metric tensor with 10 independent functions [18]; thus, space was treated as a solid, which requires a stress tensor.

This choice of a solid in the general theory of relativity can be confirmed by the words used to describe changes in space, for example, "curved spacetime" or "energy and momentum <u>distort spacetime</u> in their vicinity."
A question has been posed on the Internet: *Space cannot be touched* so how can mass bend it? [19]

This question contains a correct statement. According to the definition of space in our paradigm, there is no stress inside space and ordinary mass cannot press space; otherwise, the universal medium would "impede the motion of the Earth and other celestial bodies" (see Section 2). Forces are possible only between particles or their composites.

Kip Ingram gave an honest answer to this question [19]:

> "Einstein's theory of general relativity tells us *the manner in which* mass (actually all forms of energy and momentum) bends space, but it doesn't tell us *how* or *why* this happens. Our trust in the theory arises from its ability to make accurate experimental predictions. But we don't have an explanation for why the universe works this way."

Regarding accurate predictions, Sjödin [20] and Broekaert [21] [22] demonstrated that many redundancies of general relativity can be eliminated by introducing a scalar potential instead of the metric tensor to represent a gravitational field.

Their approach predicts the results of all classical general relativity experiments, including the anomalous shift of Mercury's perihelion, without invoking time dilation or curved space.

The redundancies in the mathematical description of space in general relativity arise from the fact that a definition of space is lacking in this theory.

Table 8.1. Comparison of space properties in two theories.

Space properties	General relativity	New paradigm
Parts of space cannot move	Yes	Yes
Ability of space to contract	Yes	Yes
Presence of pressure on space	Yes, implicitly	<u>No</u>
Direction-independent space contraction	No	<u>Yes</u>

Mathematical description of contracted space	Metric tensor	Scalar field

The absence of any stress is a unique property of space; thus, space contraction is direction-independent and is described here by a scalar field (see Table 8.1).

The comparison of the masses and sizes of electrons and muons given in Section 4 confirms these results. Indirect confirmation is also given by Planck's formula for the photon energy, $E = h\nu$. If free photons were compressed differently in different directions, then the frequency ν would be insufficient for calculating the energy of such photons.

Thus, local space contraction occurs equally in all directions. We will denote this model as the "one-parameter model of space."

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The geometry of space plays an important role in general relativity: "Particles move in trajectories determined by the geometry of spacetime."
Assuming that space has some intrinsic basic geometry, Poincaré showed [23] that it would be theoretically impossible to extract this geometry. Thus, the geometry of space is a convention, and physicists may choose **the Euclidean geometry** for describing reality.

This conclusion, together with the contraction of space, produces a remarkably simple mathematical description of the new paradigm in comparison with general relativity.

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In our earlier work [24], we adhered to the approach of Sjödin [20] and Broekaert [21] with the gravitational potential Φ, which is defined by the following equation:

$$c = c_0\Phi^2, \qquad (8.1)$$

where c_0 is the speed of light in a remote vacuum.

However, the new paradigm declares that there are no other entities in our world (including gravitational fields) beyond MATTER states.

Because we choose the spatially variable speed of light as a local scalar characteristic of the MATTER state, there is no need for any additional scalar fields to represent gravitational fields.

Thus, the potential Φ is redundant in this work.

9. Formula for the rotation of photon velocity in an inhomogeneous vacuum

We begin by deriving a formula for the deviation of photon velocity in a gravitational field and then demonstrate the similarity between this process and the refraction of a beam at an interface between two media.

Figure 9.1 shows a photon moving in a non-uniform vacuum, where the velocities of its upper and lower cross-sections differ. This difference can be expressed by the gradient of the light speed in the given region of MATTER.

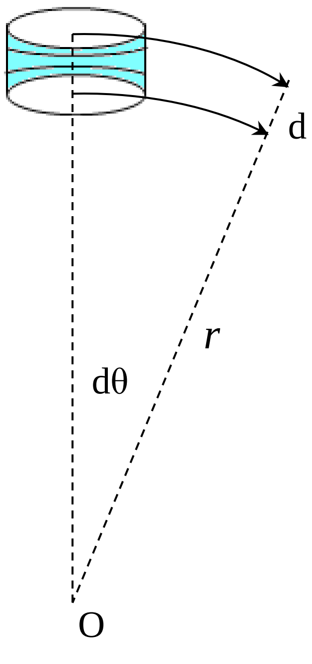

Fig. 9.1. A photon deviates in a gravitational field due to a difference in the velocity of light. (The photon is depicted in the longitudinal cross-section, as calculated in our previous work [5].)

We find the angle of rotation of the photon velocity in an inhomogeneous vacuum $d\theta$ by considering two similar triangles (Fig. 9.1):

$$d\theta = \frac{c\,dt}{r} = \frac{(c+d\,\nabla c \sin\alpha)dt}{r+d} = \nabla c \sin\alpha\,dt, \qquad (9.1)$$

where α is the angle between ∇c and the direction of the photon velocity $\vec{c}$ and d is the distance between the centers of the two cross-sections. The rotation occurs in the plane parallel to ∇c and $\vec{c}$.

In 1915, Einstein obtained the classical expression for the deflection of a light ray passing near the Sun. In our previous work [24], we showed that this expression can be derived from Eq. (9.1). Additionally, an elementary derivation of the Schwarzschild radius has been given in our prior work [5].

Both examples demonstrate the simplicity of a derivation when mathematics follows the physical model, instead of vice versa.

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If the direction ∇c is constant, then a change in the angle α is due only to the rotation of photon velocity, i.e., $d\theta = d\alpha$, and the integration of Eq. (9.1) is simplified.

Another simplification is achieved if the photon moves in a spherically symmetric gravitational field. Then, the direction ∇c can be determined from the coordinates of the photon. This case will be considered in Section 16.

Although the formula for $d\theta$ is simple, deviations of the photon velocity in a general case can occur in different planes, which complicates our calculation of the photon trajectory. Appendix C provides a calculation method for general use.

Equation (9.1) can be written as a vector product:

$$\frac{d\theta}{dt} = \vec{\omega} = \nabla c \times \vec{\imath}_c \ , \qquad (9.2)$$

where $\vec{\imath}_c$ is a unit vector in the direction $\vec{c}$.

10. Transitional boundary layer and light refraction

In optics, the formula for light refraction is derived using the wave theory of light and Huygens' non-physical principle, which states that every point in the path of the beam emits secondary waves.

If this principle were true, then the beam would instantly split in all directions into countless secondary waves.

On this subject, Newton wrote, "If light consisted of waves, it would "bend and spread every way" into the shadows" [25]. However, this effect is not seen in nature.

Nevertheless, this formula has been confirmed for the case of refraction, but it is incorrect for the case of "total internal reflection" [26].

Our derivation of the formula, based on the new paradigm, provides the correct result for all angles of incidence.

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The phenomenon of total internal reflection for a light ray at a glass–vacuum interface has become commonplace and is not considered a paradox; however, the process of reflection remains unclear.

When the angle of incidence is less than the critical angle, reflection does not occur, as if there is no obstacle blocking the passage of the ray into the vacuum. However, when the angle of incidence exceeds the critical angle, an unknown reflector begins to reflect the ray back.
How does this reflector choose whether to reflect the ray? No answer has been given.

We are beginning to solve this paradox within the framework of our paradigm.

In the previous sections, we concluded that virtual mass exists everywhere, including in materials, not just in vacuum. Moreover, the density of virtual mass is usually higher in materials than in vacuum.

Although glass has a sharp boundary, MATTER, as a medium, is continuous. Therefore, it is natural to assume that at the boundary between a substance and vacuum, the density of virtual mass does not change abruptly; rather, the density changes gradually as one approaches the edge of the glass and further in the vacuum.

Therefore, there should be a transition layer in which the speed of light increases from c_0/n in the substance to the speed of light in vacuum c_0.
We call this layer the "**boundary layer**."

* * *

According to the new paradigm, photon rotation at the boundary between two media (Fig. 10.1) occurs in the same manner in which a photon deviates in a gravitational field, as discussed in the previous section.

In Fig. 10.1, the blue strip represents a transparent substance (e.g., glass) with a refraction index n. We choose the h-axis such that the glass surface lies in the plane h = 0. Above this plane, there is a layer of unknown thickness D, in which the virtual mass density of the medium gradually decreases to the vacuum density.

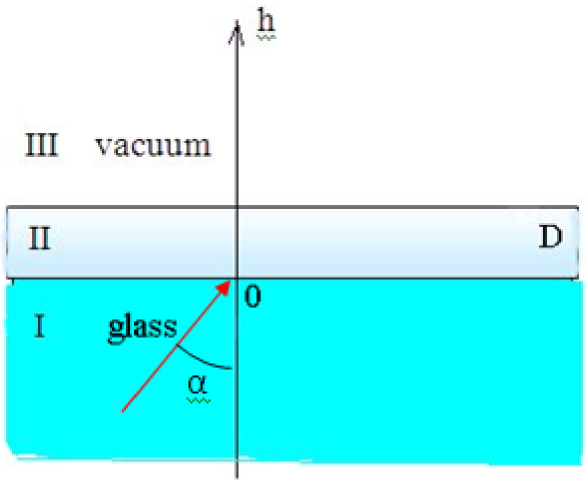


Fig. 10.1. Three regions with different densities of the medium.

We determine the speed of light $c(h)$ in the three regions listed above as follows:

$$c(h) = \begin{cases} \frac{c_0}{n}, & h < 0 \\ g(h), & 0 \le h \le D \\ c_0, & h > D \end{cases} \qquad \nabla c = \frac{\partial c}{\partial h} = \begin{cases} 0, & h \le 0 \\ \frac{dg}{dh}, & 0 < h < D, \\ 0, & h \ge D \end{cases}$$

where g(h) is an unknown function. Without a loss of generality, $g(0) = \frac{c_0}{n}$ and $g(D) = c_0$; moreover, g(h) is continuous, increases monotonically for all h, and is differentiable in region II.

In regions I and III, $\nabla c = 0$; thus, there is no rotation of the photon velocity, i.e., the photon moves in a straight line.
In region II, ∇c does not change its direction (it is directed vertically upward); therefore, the change $\mathrm{d\alpha}$ in the angle between $\nabla \mathrm{c}$ and $\vec{c}$ depends only on the rotation of $\vec{c}$, that is, $d\theta = d\alpha$.

Hence, the general formula [Eq. (9.1)] for the deviation of the photon velocity can be written in a simpler form:

$$d\alpha = \frac{\partial c}{\partial h} \sin \alpha \, dt. \qquad (10.1)$$

Because α is the angle between the photon speed $\vec{c}$ and the vertical axis, this angle is equal to the incident angle at the first time point.

Considering that $dh = c \, dt \cos \alpha$, we find

$$\frac{cos\alpha}{sin\alpha} \, d\alpha = \frac{dg}{g(h)} \, . \qquad (10.2)$$

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

$$\int_0^h \frac{dg}{g(h)} = \log g(h) - log \; g(0) = \log c(h) - log \left[\frac{c_0}{n}\right].$$

There are two options for the photon trajectory. For the first option, the photon reaches region I with h = D, and then $c(D) = c_0$ and

$$\frac{\sin \beta}{\sin \alpha} = n, \qquad (10.3)$$

which is the known refraction law.

The unknown thickness D of the intermediate layer and the unknown function g(h) both drop out in the end.

For the second option, $\alpha = \pi/2$ is reached before a photon reaches h = D. Then, the photon motion becomes horizontal, and the photon does not rise above h = D. In this case, Eq. (10.2) should be integrated from α to $\beta = \pi/2$ while h < D:

$$log \frac{\sin \pi/2}{sin\alpha} = \log g(h) - log \left[\frac{c_0}{n}\right]. \qquad (10.4)$$

Now, we apply the monotonic property of g(h) and the log:

$$\log g(h) < \log g(D).$$

Substituting $\log g(h)$ by $\log g(D)$ in Eq. (10.4) yields the following inequality:

$$log \frac{1}{sin\alpha} < \log g\,(D) - log \left[\frac{c}{n}\right] = \log n, \text{ or } sin\alpha > \frac{1}{n}. \quad (10.5)$$

This expression corresponds to the condition of "total internal reflection" of the ray, although the ray is not reflected from anything. Not reaching a uniform vacuum, the photon motion turns back toward the glass.

Thus, we derived the law of refraction from the formula for the deviation of a photon in a gravitational field without the Huygens wave theory or reflection!

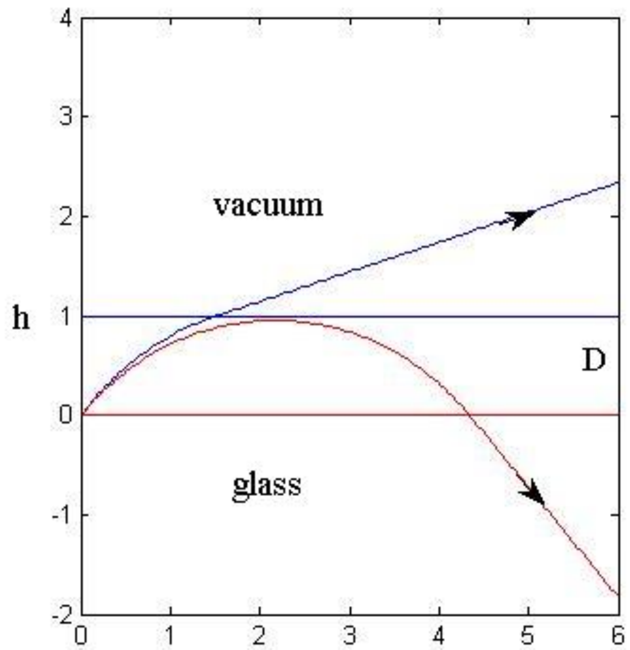


Fig. 10.2. Two possible trajectories of a photon: refracted (blue) and "reflected" (red).

In Fig. 10.2, we see both options: the blue ray reaches h = D and continues to refract, while the red ray does not reach h = D and returns to region I. This process is similar to a ball that is thrown upwards and returns to the ground without being reflected from anything.

* * *

When I searched the Internet for the phrase "intermediate layer," I was surprised to find that the great Newton had already hypothesized an intermediate layer more than 300 years ago in a letter to Robert Boyle [27]. In the third paragraph of this letter, Newton described the 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 diffraction resulted from the refraction of photons in a boundary layer at the edge of an opaque obstacle.

Newton's description can be made fully compatible with our idea of the refraction of photons in the boundary layer if one replaces "the rarer aether" with "the denser aether" and vice versa. This inversion of the aether density in Newton's letter has already been discussed by Eric Baird [28].

11. Physical mechanism of gravity

A paradoxical situation arises with gravity. On the one hand, the general theory of relativity supposedly explains gravity. On the other hand, this theory does not define gravity.

In the famous book "Gravitation" by Misner, Thorne, and Wheeler [29], the authors stated:

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

According to the new paradigm, gravity is directly caused by an inhomogeneous vacuum. Massive bodies create gravity indirectly, i.e., they transnihilate and thereby create a denser virtual mass around them.

We examined the deviation of photon velocity from rectilinear motion in a gravitational field and in a boundary layer using a simple model. Here, we seek to understand why a particle accelerates from a state of rest.

This task requires that we consider the internal mechanism of a particle-vortex. An example of a circulating wave in a torus is shown in Fig. 11.1.

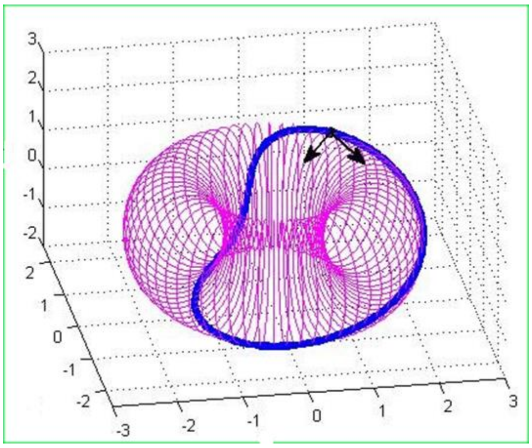


Fig. 11.1 A circulating wave in a torus. The blue closed line represents the wave front moving in a particle. The arrows show two components of the velocity at a point on the wave front: $v_\perp$ is perpendicular to the cross-section plane, and $v_\parallel$ is parallel to the plane.

For these calculations, we use Eq. (9.1), replacing the speed of light with the speed of the wave u:

$$d\alpha = \nabla u \sin\alpha \, dt. \qquad (11.1)$$

For point P at the wave front, the vertical component of the velocity equals (see Fig. 11.2)

$$u_z = u\cos\alpha.$$

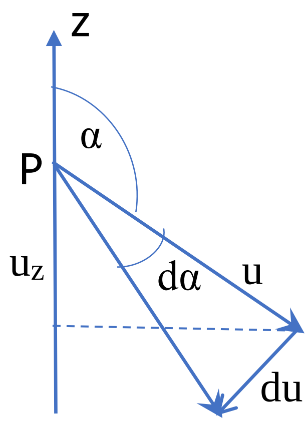


Fig. 11.2. Change in the vertical velocity component for point P at the wave front of a particle-vortex during free fall. The direction of the z-axis is vertical and coincides with the direction of ∇u.

A change in angle α by $d\alpha$ leads to a change in the vertical component u_z of the velocity u by

$$du_z = -u \sin\alpha \, d\alpha + \cos\alpha \, du. \qquad (11.2)$$

Substitution of $d\alpha$ from Eq. (11.1) into Eq. (11.2) yields

$$du_z = -u \, \nabla u \, sin^2\alpha \, dt + \cos\alpha \, (\nabla u \cdot \vec{u} \, dt).$$

Hence, the vertical acceleration of point P is

$$a_z = \frac{du_z}{dt} = -u \, \nabla u \, sin^2\alpha + \cos\alpha \, (\nabla u \cdot \vec{u}) = -u \, \nabla u(sin^2\alpha - cos^2\alpha).$$
(11.3)

Points at the front of the vortex wave are located on either the external or inner surface of the particle as well as transitions between these regions (see Fig. 11.1); therefore, the factor $sin^2\alpha$ varies for different points of the wave front. As a result, some sections have a greater acceleration, alternately stretching parts of the vortex in the vertical direction.

In a uniform vacuum, $\nabla u = 0$; therefore, $a_z = 0$ for any angle α.

We can express the vertical acceleration for point a_z in terms of u_z by considering that $sin^2\alpha = 1 - cos^2\alpha = 1 - (u_z/u)^2$. Then, we find

$$a_z = -u\,\nabla u\,[1 - 2(u_z/u)^2]. \qquad (11.4)$$

Equation (11.4) clearly illustrates how the infinite acceleration of a freely falling body in a gravitational field is prevented: as the vertical component of the wave velocity u_z increases, the acceleration a_z tends to zero and can even become negative. In previous work, we deduced the possibility of such a phenomenon by another method [24].

* * *

In 2001, L. Smolin wrote about the search for quantum gravity [30]:

> "… atoms do fall, so the relationship between gravity and the quantum is not a problem for nature" (p. 6).

In this section, we clarify this phenomenon.

A particle-vortex in free fall reacts to the heterogeneity of the medium and changes its speed **without any external force**, by rotating the velocity of the wave forming the vortex.

In this regard, there is some doubt regarding the legitimacy of the established term "gravitational force." Instead, it is more accurate to talk about the "gravitational acceleration," which is real.

12. Black holes and the origin of galaxies

Modern astrophysicists believe that black holes swallow mass forever. The new paradigm views black holes differently: each galaxy originates from a black hole, which is located in the center of the galaxy [2].

From the viewpoint of the new paradigm, the role of black holes in the origin of galaxies becomes clearer. The transnihilation of a huge amount of mass in a black hole creates a high density of virtual mass, even at distances far from the center of the black hole. These conditions are favorable for the birth and evolution of elementary particles.

Around black holes, a chain reaction of particle creation occurs, which we observe as the birth of a supernova [2].

Such explosions occur in different zones in the vicinity of black holes; however, we do not see these explosions because black holes absorb the explosions along with their radiation. Only explosions of supernovae that occur sufficiently far from the black hole and acquire orbital speed are observed by astronomers.

In the birth of a galaxy, an unorganized virtual mass transforms into particle-vortices, while decreasing the vacuum density. Gigantic zones of reduced vacuum density lead to the phenomenon denoted by astrophysicists as "dark energy."

Thus, a black hole is not a dead end for mass; rather, black holes lead to the birth of galaxies. The mass is dispersed in space in the form of stars and planets. As their distance from the black hole decreases, the stars and planets form a flat formation, with several spirals twisting towards the black hole.

13. On dark energy and dark matter

In recent decades, astrophysicists have discovered that the vast majority of gravity must be caused by an invisible form of matter termed "dark matter." The mysterious dark energy was soon discovered as "an unknown form of energy which is hypothesized to permeate all of space, tending to accelerate the expansion of the universe" [31].

Scientists around the world have sought to explain these mysterious phenomena.

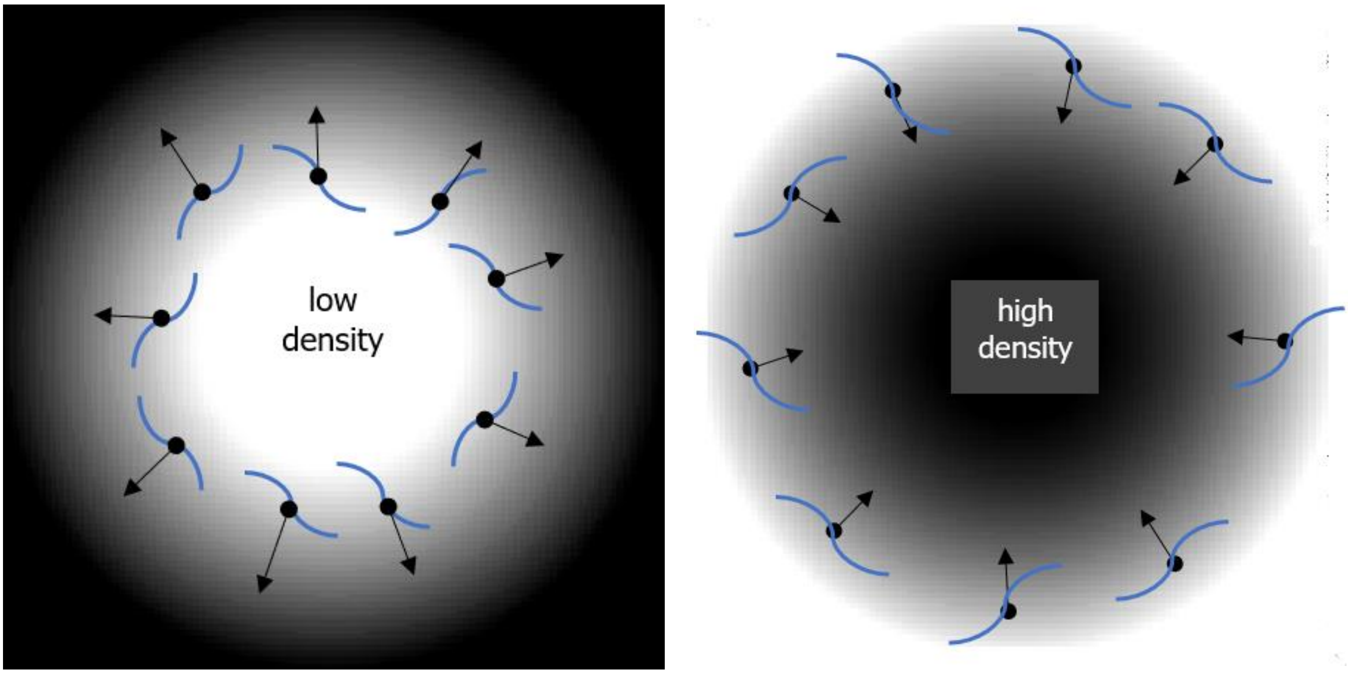
The problem here is the lack of a physical model of gravity, while gravity is the key feature for both phenomena.

As described in the previous sections of this work, according to the new paradigm, the direct cause of gravity is an inhomogeneous vacuum, which can exist without the presence of massive objects. The gravitational field thus created is non-static due to the equalization of vacuum density; however, if an inhomogeneous vacuum has dimensions of millions of light-years, then the equalization will continue for millions of years.

If the vacuum density is lower within one zone, then the gravitational acceleration will be directed outward (see Fig. 13.1a), because it is always directed towards a higher vacuum density. This is the case of "dark energy." During the formation of the universe, the virtual mass was transformed into ordinary mass, and consequently, zones with a low vacuum density were formed. This trend explains the predominance of “dark energy” in the universe.

Let us imagine the opposite situation, in which the vacuum density is higher inside a zone than outside (Fig. 13.1b). Then, the gravitational acceleration will be directed to the center (inward gravity). This case corresponds to "dark matter."

In any case, the acceleration of gravity is directed towards a higher vacuum density, and the apparent difference between dark matter and dark energy is associated with the direction of the convexity of the intermediate zone.



a) b)

Fig. 13.1. Influence of the direction of a vacuum density gradient in the boundary zone on the apparent acceleration of galaxies. a) The vacuum density is lower inside the zone than outside; therefore, it appears as though “dark energy” pushes the galaxies away. b) The vacuum density is higher inside the zone than outside; thus, it appears as though “dark matter” attracts galaxies.

If the boundary between two zones were flat, then the direction of acceleration of objects in the intermediate zone would be parallel. In this case, astrophysicists could call the corresponding phenomenon “dark wind.”

Figure 13.2 demonstrates the unity of all three phenomena: theoretically, these phenomena can all occur in one intermediate zone between two zones with different vacuum densities.

Some physicists have suggested that dark matter and dark energy may not be separate physical phenomena; instead, they may be different facets of the same unknown substance [32] [33]. Scientists have called this unified entity different names, such as quintessence or dark fluid. The use of a scalar field to describe this entity provides an additional similarity to our model.

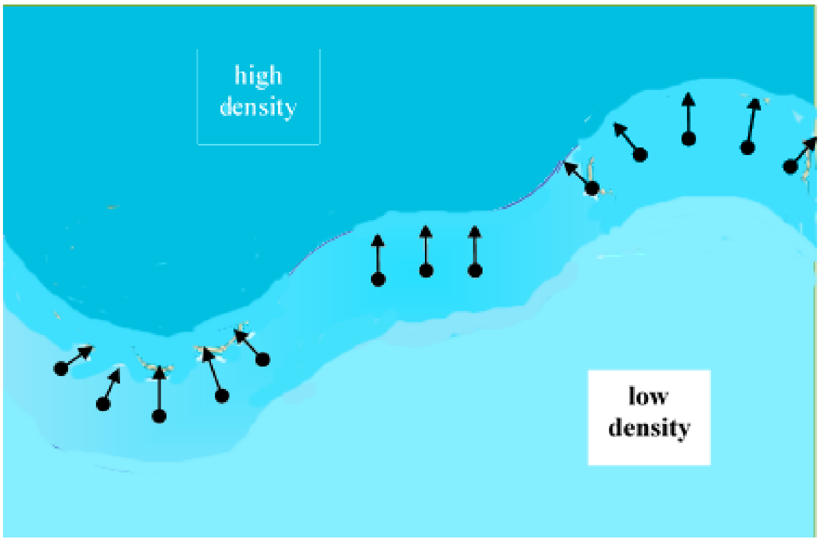


Fig. 13.2. Unity among the three types of "dark phenomena" in the boundary layer between zones with different vacuum densities. The apparent behavior of gravitating objects, i.e., the inward or outward gravity of objects, depends on the convexity/concavity of the boundary between zones.

Our explanation of dark matter and dark energy is advantageous because it does not require the introduction of a new entity; rather, this explanation is based on an inhomogeneous vacuum, which is the direct cause of ordinary gravity.

Based on the same inhomogeneous vacuum, we predicted and experimentally confirmed the bending of a laser beam in the gap between the Casimir plates (see Section 15). The same cause is also responsible for the refraction of light and diffraction at the edge of an opaque obstacle (Sections 10 and 17).

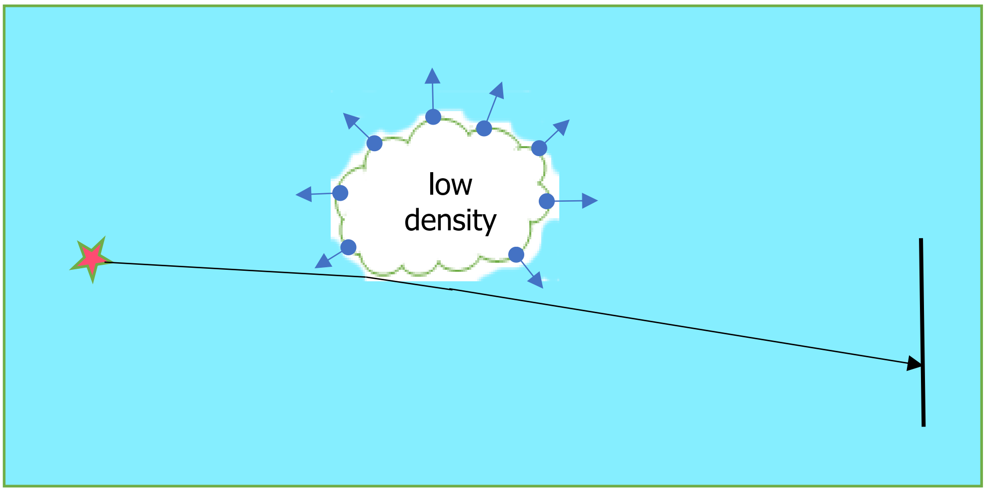


Fig. 13.3. A ray from a star deviates to one side when passing near a zone with a low vacuum density. Such a zone works as a diverging lens.

Figure 13.3 shows that the boundary of a zone with a low vacuum density works as a diverging lens, thus complementing the set of converging gravitational lenses of general relativity [34].

14. Terminology

In accordance with the new paradigm, a number of established physical terms require clarification, as their current names may be misleading. In addition, new entities are introduced in the new paradigm, which have been given their own names.

Of the terms "dark matter" and "dark energy," only the word "dark" is appropriate. These phenomena have the same direct cause as ordinary gravity; however, no massive objects replenish the outflow of virtual mass. According to the first property of MATTER in the state of space deficit (Section 4), the vacuum density is being equalized; consequently, the gravitational effect decreases.

For this reason, we propose that "dark matter" and "dark energy" be combined under the general name "non-static gravity."

The currently used concept of gravity, as a phenomenon by which masses are attracted to each other, is too narrow. Thus, an extension of this term is needed. This approach is supported by the anonymous author of the Wikipedia article "Unsolved problems in physics" [35]:

> "What is the identity of dark matter?. . . do the phenomena attributed to dark matter point not to some form of matter but actually to an extension of gravity?"

A new definition of gravity can be formulated as follows:

> ***Definition 4. In the broad sense, gravity is a universal phenomenon in which the magnitude and direction of particle velocities change under the influence of vacuum/medium inhomogeneity.***

The difference between a vacuum and medium is that ordinary mass is present in the medium, in addition to virtual mass. This fact adds particularities to various phenomena; for example, a higher density of virtual mass is observed in a medium than in a vacuum.

Because a vacuum contains only virtual mass, we use the short unambiguous term "vacuum density" instead of the full "virtual mass density in vacuum."

Applying the usual concept of density to a vacuum is problematic because one would have to divide the mass of space by its volume, similar to dividing heat by cold.

The speed of light is measurable. We may use the ratio c_0/c as an indicator of virtual mass density, where c_0 is the speed of light in vacuum and c is the speed of light at a given point. This ratio indicates the contraction level of space at a given point in any direction (see Section 8).

In addition, c_0/c is also the refractive index.

* * *

In our paradigm, the vacuum energy is the energy of contracted space. This energy may be confused with the term "zero-point energy" used in quantum field theory and meaning the energy of vacuum fluctuations.

The energy of vacuum fluctuations, if it existed, would lead to an infinite force on the Casimir plates, which would break them to pieces (see Appendix A). However, this effect is not observed; therefore, we reject this form of vacuum

energy.
The reader is asked to consider this ambiguity.

15. Experimental investigation of the existence of a boundary layer

If the boundary layer is real, it should be identified in an unusual way in an experiment. In our opinion, the refraction of a light beam passing between two opaque plates is an appropriate experiment.

Indeed, there is no substance between the plates that can refract the beam. However, according to the new paradigm, each of the plates has a boundary layer. As the plates approach each other, their layers merge, and the density of the medium between the plates is higher than that at a distance.

Experiment. The experimental set-up is shown in Fig. 15.1. The laser beam enters the gap between two opaque plates, where the merged boundary layer is present. Because the speed of light in this region differs from the speed of light at a distance, the beam should be refracted.

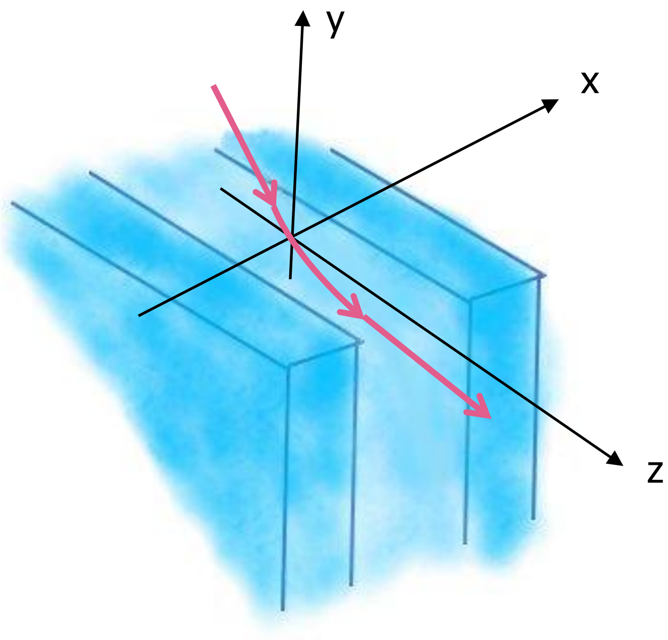


Fig. 15.1. The laser beam enters from above into the gap between the plates and is refracted in their merged boundary layer. This layer is invisible; however, for clarity, it is depicted by a fog in this image, lighter between the plates and darker at the edges of the plates.

A blue laser beam (λ = 0.405 μm) was aimed into the gap between the upper edge of two steel plates at an incidence angle of 80°. The screen was located at a distance of 1550 mm from the plates.

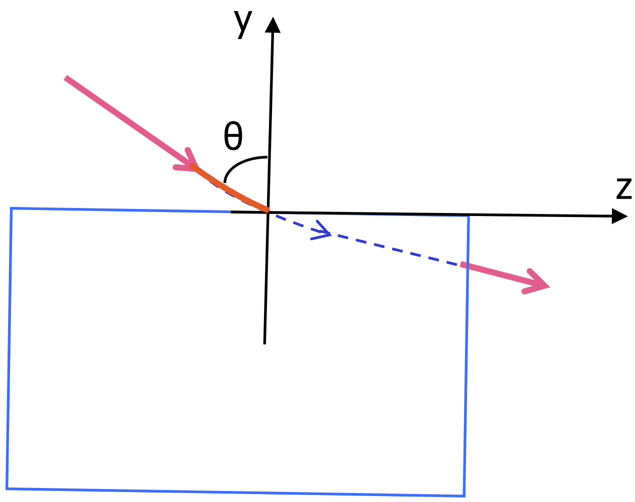


Fig. 15.2. Side view of the plates. The dotted line shows the beam path for the region in which the closer plate blocks our view of the beam.

The following image appeared on the screen:

Fig. 15.3. Screen image. The beam width is greater than the gap width; therefore, one can see the traces of rays that have passed at different distances from the plates.

In this experiment, the beam bent upwards. The fact that the beam is deflected confirms the boundary layer hypothesis. It is possible to see with the naked eye that the beam deflection is greater at the edges than in the middle (Fig. 15.3). If there were no boundary layer, the image on the screen would exhibit the form of a light spot.

Image stretching was performed by diverging the plates towards the beam exit from the gap, in accordance with the boundary layer hypothesis. The slit width was 20 μm at the entrance to the gap and 0.5 mm at the exit.

Part of the beam glides along the surface of the upper plate (see Fig. 15.4), is reflected from the surface, and then returns to same plate again due to "total internal reflection" in the boundary layer. This phenomenon occurs several times and is also observed for the bottom component of the beam.

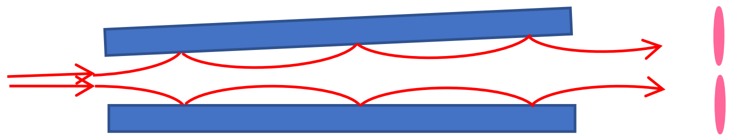


Fig. 15.4. Top view of the plates. Parts of the beam slide along the plates due to the presence of a denser boundary layer near each plate.

In this case, the boundary layer acts as a photon guide. If there were no boundary layer, then reflection would occur only once and the beam would travel to another plate.

In physics, there are three classes of phenomena for light ray deviation: refraction, diffraction, and the phenomenon that occurs when light passes near the Sun. Our experiment does not fall into any of these three classes. Rather, the concept of this experiment is based on a boundary layer that has not been considered in the dominant paradigm.

A clear classification and unification of these phenomena will be presented in Section 17. For the time being, we use term "refraction" to describe the beam deflection in our experiment because for diffraction to occur, the beam must go around an opaque obstacle, which is absent is this experiment.

16. Equations of motion of a free photon in a static, spherically symmetric gravitational field

In the experiment described in the previous section, the speed of a photon can change direction without any restrictions. In this section, our investigation is simplified by the fact that the trajectory of a photon does not extend beyond the limits of one plane.

We choose a coordinate system whose center is the center of gravity, and the direction of the x-axis is parallel to the initial speed of the photon. (If we denote the angle formed by the velocity of the photon with the x-axis by θ, then the initial value $\theta_0 = 0$.)

In addition, we choose the direction of the y-axis such that the photon lies in the xy plane at the initial time point. Furthermore, the photon will remain in this plane because the photon velocity is parallel to it. Thus, to describe the photon location, two coordinates (x, y) are sufficient.

Due to the spherical symmetry of the gravitational field, the direction of ∇c coincides with the direction of the polar radius vector $\vec{r}$.

Let φ be the polar angle of the current location of the photon and α be the angle between the photon velocity $\vec{c}$ and ∇c. We then have $\alpha = \varphi - \theta$ (see Fig. 16.1).

* * *

The photon velocity vector rotates according to Eq. (9.1)

$$d\theta = -\left|\nabla c\right| \sin\alpha \, dt.$$

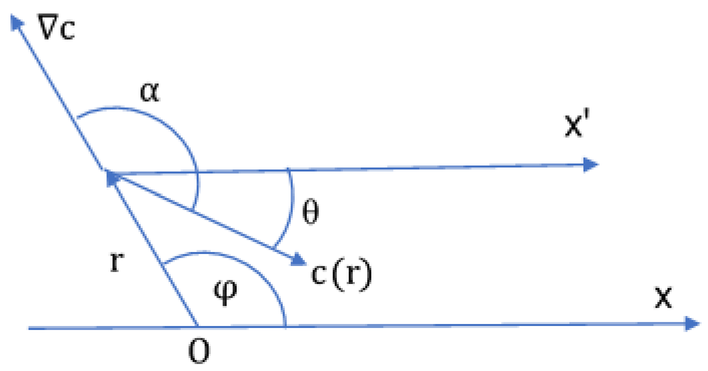


Fig. 16.1. Angles used in this model. The angle θ is negative in the figure.

In a spherically symmetric gravitational field, the following system of differential equations is valid:

$$\begin{cases} \frac{dx}{dt} = c(r)\cos\theta \\ \frac{dy}{dt} = c(r)\sin\theta \\ \frac{d\theta}{dt} = -\nabla c \sin(\varphi - \theta) \end{cases} , \qquad (16.1)$$

where $r = \sqrt{x^2 + y^2}$ and $c(r)$ is the magnitude of the speed of light.

The system of differential equations [Eq. (16.1)] is sufficiently general to be applied to three different cases in this work.

This equation will be used to calculate the diffraction of light by a spherical obstacle in Section 17 and to interpret the experiment in which the speed of light is reduced [11] in Section 18. The third case is presented below.

* * *

Here, we consider the well-known deviation of a light ray passing near the Sun.

Because the starlight deflection angle θ near the Sun is very small, it can be neglected in trigonometric formulas.
From Eq. (16.1), we obtain a simplified system of equations:

$$\begin{cases} dx \approx c(r)\, dt\, ; \quad dy \approx 0 \\ d\theta \approx -\nabla c \sin\varphi\, dt = -\nabla c\, \frac{y}{r}\, dt \end{cases} . \qquad (16.2)$$

Let us apply the Sjödin [20] and Broekaert [21] formula for the speed of light in a static spherically symmetric gravitational field:

$$c(r) = c_0 \exp(-r_s/r), \qquad (16.3)$$

where r_s is the parameter of the virtual mass source, analogous to the gravitational radius for massive bodies.

Using Eq. (16.3) and substituting dt by dx/c in Eq. (16.2), we find

$$d\theta \approx -\nabla c\, \frac{y}{r}\, \frac{dx}{c} = -c\, \frac{r_s}{r^2}\, \frac{y}{r}\, \frac{dx}{c} = -\frac{r_s}{(x^2+y^2)^{3/2}}\, y\, dx, \qquad (16.4)$$

where y ≈ b is the constant impact parameter.

Now, we integrate the right-hand side of Eq. (16.4) over x from -∞ to ∞:

$$\theta \approx -\int_{-\infty}^{\infty} \frac{r_s}{\left(x^2+b^2\right)^{\frac{3}{2}}}\, b\, dx = -\frac{2r_s}{b},$$

which coincides with the classical expression obtained by Einstein in 1915.

* * *

From $\frac{d\theta}{dt} = -\nabla c \sin(\varphi - \theta)$, one can obtain a simple formula to expand $\sin(\varphi - \theta)$ into $\sin\varphi\cos\theta - \cos\varphi\sin\theta$ and substitute

$$\cos\theta = \frac{\dot{x}}{c(r)},\ \ \sin\theta = \frac{\dot{y}}{c(r)},$$

which yields $$\sin(\varphi - \theta) = \sin\varphi\frac{\dot{x}}{c(r)} - \cos\varphi\frac{\dot{y}}{c(r)}.$$

Time derivatives $\dot{x}$ and $\dot{y}$ can be expressed in terms of the angle φ:

$$x = r\cos\varphi,\ \dot{x} = \dot{r}\cos\varphi - r\sin\varphi\,\dot{\varphi}$$

$$y = r\sin\varphi,\ \dot{y} = \dot{r}\sin\varphi + r\cos\varphi\,\dot{\varphi}.$$

We obtain $\sin(\varphi - \theta) = \frac{r\,\dot{\varphi}}{c(r)}[-\sin^2\varphi - \cos^2\varphi] = -\frac{r\,\dot{\varphi}}{c(r)}$.

Thus, we find that $$\frac{d\theta}{dt} = \nabla c\frac{r\,\dot{\varphi}}{c(r)}.$$

If we again use Eq. (16.3) for the speed of light in a spherically symmetric gravitational field, then

$$\nabla c = \frac{r_s}{r^2}\,c(r) \qquad (16.5)$$

$$\frac{d\theta}{dt} = \frac{r_s}{r^2}\,c(r)\frac{r\,\dot{\varphi}}{c(r)} = \frac{r_s}{r}\dot{\varphi}\ . \qquad (16.6)$$

This simple formula, $\dot{\theta} = \frac{r_s}{r}\dot{\varphi}$, may be useful for some situations.

* * *

When a photon collides with other particles, it deforms; however, a free photon may be considered rigid. This viewpoint follows from the fact that in free flight, the photon structure is stretched to the limit and is therefore stable [5]. Hence, the equations of motion for a free photon, as described by geometric optics, are simple.

In Section 11, we considered the behavior of other particles in a gravitational field whose velocities in free fall are not fixed, in contrast to photon velocities. Thus, the description of their motion is not as simple. Consideration of all factors leads to the correct expression of the precession of the perihelion of Mercury, which ceased to be anomalous [20] [21] [24].

17. Role of the boundary layer in light diffraction

17.1 Definition of light diffraction

Just as a gravitational field forms around massive space objects due to the transnihilation of their particles, a boundary layer forms around small material objects. In such a layer, the density of the virtual mass decreases with increasing distance from the object.

That is, the boundary layer is an inhomogeneous medium with all of the ensuing consequences. In particular, this layer explains and unifies various cases of light ray deviation (see Sections 10 and 15).

More than 300 years ago, Newton wrote that light is refracted in diffraction [27]. More recently, E. Bagge called the deflection of a ray near the Sun "refraction" [36]. With the introduction of the boundary layer, this unification becomes obvious.

Nevertheless, classifying light diffraction as a separate phenomenon may be useful as well. We define the diffraction of light as follows:

> ***Definition 5. Light diffraction is the bending of a light ray around an opaque obstacle due to passage of the ray through the boundary layer of the obstacle.***

The deviation that occurs when a light ray passes near the Sun resembles diffraction in the sense that it also occurs in an inhomogeneous medium; although called a gravitational field instead of a boundary layer.

The second difference, which prevents the unification of these two phenomena, is the sphericity of the Sun. In contrast, light diffraction is stereotypically thought to occur exclusively at the sharp edge of an obstacle.

We will overcome the obstacle stereotype in this section. The boundary layer paradigm predicts that diffraction around a spherical obstacle is even more effective than that for the sharp edge of a blade. Our experiment confirmed this prediction.
Below, we present simulation and experimental results for beam deflection around a ball.

17.2 Simulation of light diffraction for a spherical obstacle

In this work, we conducted a diffraction study. We aimed to apply an obstacle shape in which the boundary layer would serve as a photon guide and deflect the light beam as a whole by a significant angle, rather than scattering into many secondary waves, as follows from Huygens' wave theory.
A spherical or cylindrical surface is suitable for such verification.

Let us assume that the photon moves along the boundary layer of a spherical/cylindrical obstacle, as shown in Fig. 17.1. Due to symmetry, ∇c is directed radially; thus, the photon moves perpendicular to ∇c. In accordance with Eq. (9.1), during the time dt, the photon velocity vector will rotate through an angle

$$d\theta = -\nabla c \sin\alpha \, dt = -\nabla c \, dt.$$

At the same time, the photon will advance a distance ds = c dt, which corresponds to a rotation of the radius of the photon vector by an angle
c dt/R, where R is the distance of the photon to the center of the spherical (or to the axis of the cylindrical) surface of the obstacle (see Fig. 17.1).

If the rotation radius of the photon and its radius vector coincide, the photon will follow the curvature of the surface and can remain near the surface for a long period of time.

For this behavior to occur, the following equality should hold:

$$d\theta = \nabla c \, dt = \mathrm{c\,dt/R}, \text{ hence } \mathrm{R} = \mathrm{c}\,/\nabla c.$$

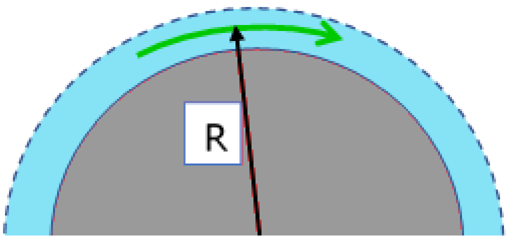


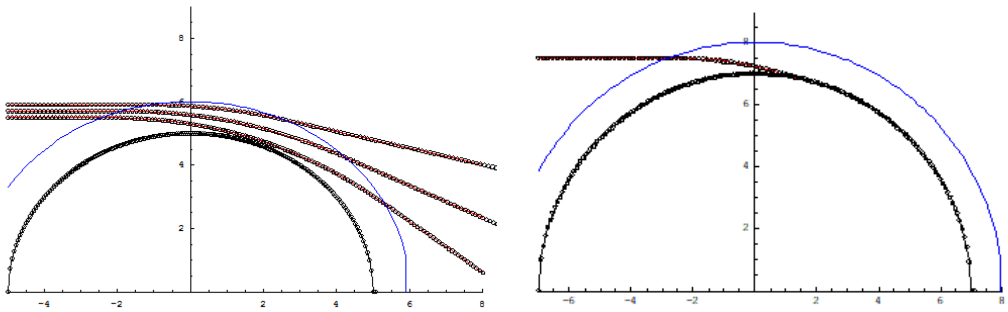
Fig. 17.1. The trajectory of a photon inside the boundary layer of a spherical obstacle can theoretically be circular.

If the thickness of the boundary layer is small compared with R, then the optimal radius of the obstacle surface approximately coincides with R = c /∇c.

To study the effect of R on the beam deflection angle, we used Eq. (16.1) for the photon motion in a spherically symmetric gravitational field. That is, we consider the gravitational field and the boundary layer to be manifestations of the same entity.

In the simulation of the photon trajectory bending around a spherical obstacle, the boundary layer works as a photon guide (Fig. 17.2a).

The simulation shows that as R increases, the angular deviation of the beam also increases. However, there is a limit at which the beam hits the obstacle (Fig. 17.2b).



a) b)

Fig. 17.2. Options for deflecting a beam by a spherical obstacle. a) The beam is deflected, passing along the boundary layer, which acts as a photon guide. b) If the radius of the obstacle is too large, the beam hits the surface.

17.3 Experimental results

These results were further verified through an experiment. In conventional physics, diffraction is usually demonstrated at the edge of a blade, which corresponds to a cylindrical obstacle with a radius of approximately R = 0.05 mm. With such a small R, the beam leaves the boundary layer without having sufficient time for significant deviation. Therefore, we conducted our experiment with R = 2.5 mm, which is approximately 50 times larger than that of a blade edge.

For this experiment, we studied diffraction around a magnetic ball with a diameter of 5 mm, held at the end of a steel rod with a diameter of 3 mm. A blue laser (λ = 405 nm) was used in the experiment.

As shown by the screen image (Fig. 17.3), the beam penetrates the shadow area of the ball, going around the ball from above.

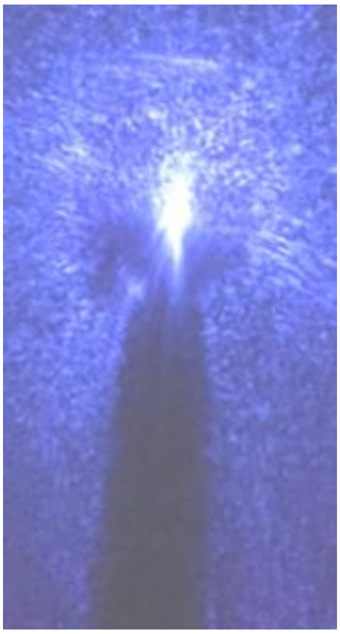


Fig. 17.3. Image of a shadow from a magnetic ball when a blue laser beam passes around the ball from above. The beam is diffracted in the boundary layer of the ball and extends far into its shadow area.

Because the ball surface was mirrored, some photons reflected from the surface and created a halo around the shadow of the ball on the screen.

In contrast to our diffraction theory, Huygens' wave principle predicts that the beam will lose its direction, scattering into many secondary waves. Einstein objected to the wave theory because of its predicted energy dissipation.

According to our theory, which was confirmed by experiment, the beam preserves the general direction: the boundary layer of the spherical opaque obstacle works as a photon guide.

17.4 Debates on the corpuscular and wave theories of light

Debates between these two theories have arisen over several centuries. Initially, Newton's corpuscular theory of light was predominant for more than 100 years.

The historical introduction to the popular optics textbook by Born and Wolf [37] states that the corpuscular theory of light was abandoned in 1850 in favor of Huygens' wave theory. One reason for this change was the inability to explain why light corpuscles deviate from a straight line when passing through a narrow slit or a small aperture [38].
To explain the scattering of light through a slit/aperture, a model of the propagation of sound waves in air in all directions was adopted.

It was not until the 20th century, after Einstein's experiment on the photoelectric effect [39], that Newton's corpuscular theory of light was partially revived in the "wave–particle duality" [8].

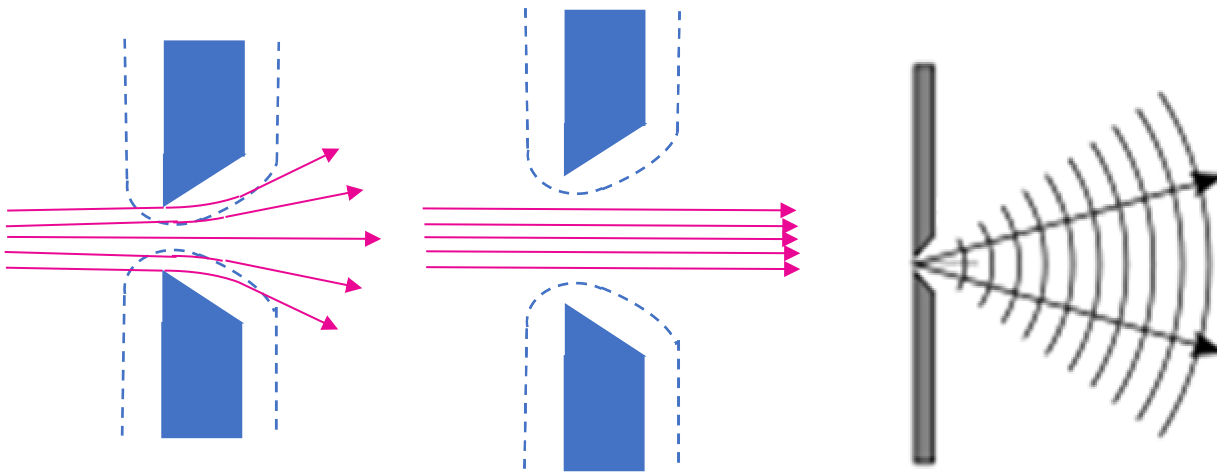
* * *

With the publication of this new paradigm, the situation is changing: the boundary layer explains the scattering of photons passing by the edge of an opaque obstacle.

The boundary layers of small apertures, narrow slits, and edges of opaque objects deflect and scatter light rays; thus, these phenomena fall under Definition 5 and are classified as light diffraction phenomena in our paradigm.

In Fig. 17.4a, the boundary layer of the slit is shown by a dotted line. As photons pass through this layer, they deviate at different angles depending on the distance from the center of the slit.

Why is a wide slit not suitable for light diffraction? If the slit width exceeds two thicknesses of the boundary layer, then the beam will pass between the two layers and will not deviate (Fig. 17.4b).



a) b) c)

Fig. 17.4. Interpretation of the passage of a light ray through a slit. a) The boundary layer (shown by a dotted line) deflects the photons passing through it towards the near edge of the obstacle. b) A ray passes through a wide slit without deflection. c) According to Huygens' wave theory of light, light scattering occurs at any point in the path of the ray.

As noted in Section 6, according to the new paradigm, a density wave is circulating inside a particle vortex, providing elementary particles with two wave parameters: the frequency of the wave circulation and the phase of rotation.

However, these photon wave properties are not needed to explain the deviation of photons from a straight line when they pass through a narrow slit. Thus, light diffraction is a purely corpuscular phenomenon.

In Sections 17.2 and 17.3, we simulated and experimentally verified the behavior of photons at spherical obstacles, whose boundary layers act as a photon guide.

In Section 10, our paradigm also revealed the physical mechanism governing the phenomenon of light refraction. It became clear that the word "reflection" is just as inappropriate in the phenomenon of "total internal reflection" as in the statement that a thrown ball returns to the ground as a result of reflection.

Thus, the new paradigm demonstrates the superiority of the corpuscular theory of light over the wave theory in relation to refraction.

* * *

The scientific nature of any theory is verified by its ability to predict natural phenomena.

The new paradigm predicted that a laser beam would deviate in the gap between the Casimir plates (Section 15).
This prediction was based on the boundary layer and was confirmed in our experiment.

18. Interpretation of experimental light speed reduction results

In Section 7, we referred to the unique experiment from 1999 in which the speed of light was reduced [11]. The authors cooled a cloud of sodium atoms to almost absolute zero and demonstrated that, under certain conditions, the speed of the light pulse passing through the condensate decreased to 17 m/s.

Here, we focus not on the great technological achievement in controlling light, but rather on an important physical discovery.
The experiment contradicted the century-old myth of a constant speed of light; thus, the fundamentals of physics must be revised to explain why light slows down. The old explanation that atoms absorb and then re-emit light in the same direction was excluded by the experimenters – their atoms ceased to absorb light.

The solution to this puzzle is no less important than the solution to dark matter/energy. The new paradigm has already demonstrated its ability to explain mysterious phenomena; here, we will apply this paradigm to interpret the results of this experiment [11].

In accordance with the new paradigm, the reduced speed of light is a sign of medium inhomogeneity, which clarifies the connection with the explanation of dark matter/energy. The cause of the medium inhomogeneity is the decay of sodium atoms.

Indeed, because the cloud of sodium atoms was cooled to almost absolute zero, the atoms began to lose more virtual mass than they received from the medium. As stated in Section 6, under such conditions, the mass of a particle-vortex drops below the lower mass limit.

Therefore, in the experiment [11], some of the atoms decayed, which increased the density of the virtual mass in the cloud region. As a result, the light pulse slowed down.

In addition to slowing down light, an inhomogeneous vacuum can bend light rays; however, such phenomena were not observed in the experiment because the laser beam was directed perpendicular to the boundary of the cloud. In this case, the beam does not deviate. For deflection to occur, the beam must enter the region obliquely.

* * *

Below, we describe a model of the experiment [11]. The model is based on the new paradigm and predicts that the laser beam will deflect at an oblique entry into the cloud of cooled sodium atoms.

Because the cloud of sodium atoms has a size of 0.2 mm, we assume that the atoms decay into virtual mass in a sphere of radius $r_1 = 0.1$ mm. We also assume that the medium is homogeneous inside the sphere, with the same speed of light c_1= 17 m/s, while $c_0 = 3 \times 10^8$ m/s far from the sphere.

As a pilot model, we assume that the artificial gravitational field is spherically symmetric and static. Then, we can apply the Sjödin [20] and Broekaert [21] formula, which gives the speed of light at a distance r from the center of the sphere:

$$c(r) = c_0 \exp(-r_s/r) \ , \qquad (18.1)$$

where r_s is a parameter for the virtual mass source, analogous to the gravitational radius for massive bodies. Substituting r_1 = 0.0001 m into Eq. (18.1) instead of r and the velocity c_1= 17 m/s instead of c(r), we obtain

$$r_s = r_1 \ \log\left(\frac{c_0}{c_1}\right) = 1.7 \ mm.$$

Knowing r_s, we can use Eq. (16.1) to calculate trajectories of photons around the cloud of sodium atoms.

* * *

Using this model, we wrote a simulation program, following the same equations [Eq. (16.1)] and angles employed for Fig. 16.1.

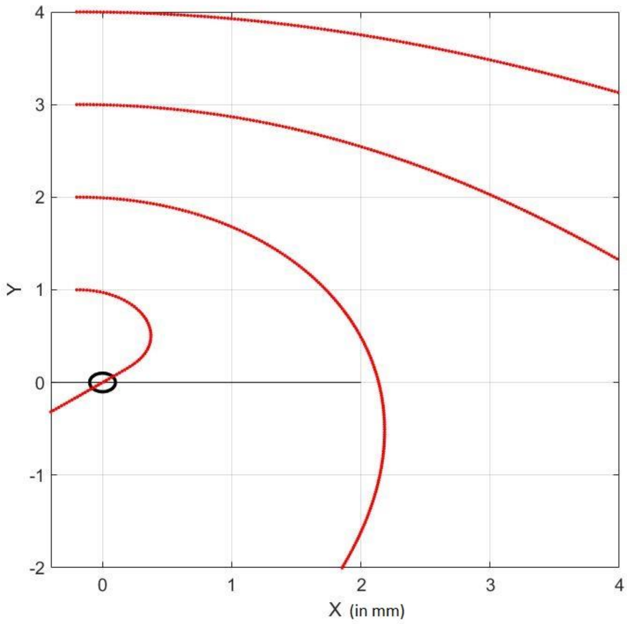


Fig. 18.1. Trajectories of simulated laser beams with different impact parameters. The cloud of sodium atoms is at the center of the coordinates.

The simulation results shown in red correspond to the trajectories of four beams (see Fig. 18.1). At t = 0, the beams are directed parallel to the x-axis but at different distances. All beams deviate towards the sphere of artificial gravity, but to a different degree.

As no material can shield gravity, the beam may pass outside the chamber, in which there is a cloud of highly cooled sodium atoms, but not far from it.

If the prediction of this simulation is confirmed, then it is possible that the zone will not release light that has entered it.

The results of Hau et al. [11] have opened a new era in physics: the era of artificial gravity.

19. Manifestations of an inhomogeneous vacuum/medium in the Universe and in terrestrial conditions

The table below lists the cases in which an inhomogeneous vacuum/medium manifests itself by bending a light ray or extending gravity. In the future, electrical phenomena will join this list as manifestations of local inhomogeneities in the medium caused by electric charges.

Table 19.1. Phenomena in which an inhomogeneous vacuum/medium is manifested.

Situations involving an inhomogeneous vacuum/medium	Manifestation of the inhomogeneous vacuum/medium	
	Bending of light rays	Extension of gravity
Between zones with different vacuum densities; in a gravitational field	Deviation of a light ray passing near the Sun; gravitational lensing	Phenomena of dark energy/matter; ordinary gravity
In a boundary layer at the interface between two media	Refraction of a light ray; diffraction	Concave water surface near vessel walls
Between the Casimir plates	Laser beam deviation in the gap between two opaque plates (Bakman's experiment)	Attraction of two parallel plates (Casimir effect)
Stimulated transnihilation (experiment by Hau et al.)	Our prediction: beam deflection at an oblique entry into the region (Section 18)	Our prediction: gravity effect near the chamber

Within the framework of the new paradigm, the refraction and diffraction of light are united based on the boundary layer common to both phenomena.

* * *

The third row of the table shows the phenomena associated with the Casimir effect: two parallel metal plates are attracted to each other when separated by a distance of several microns.

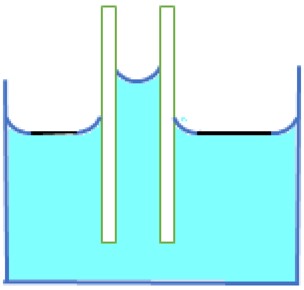
In theoretical physics, the Casimir force is explained by "vacuum fluctuations." For example, we read in Ref. [40]: "Vacuum fluctuations, although seem fictional, may cause observational effects." In contrast to their own statement, the authors of Ref. [40] named their article "Gravitational Casimir–Polder effect."

Hrvoje Nikolić has refuted this claim by presenting a simple general proof that the Casimir force cannot originate from vacuum energy [41].

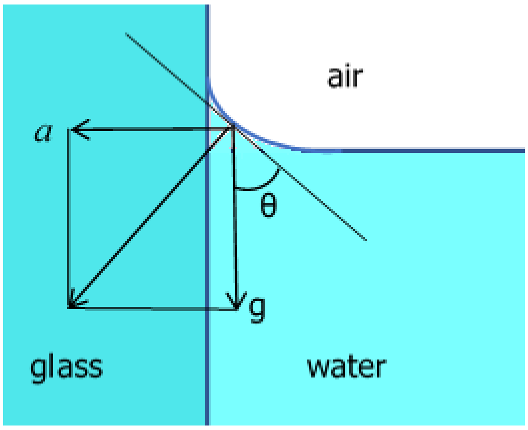
According to our paradigm, the Casimir effect arises from the inhomogeneous medium formed by the boundary layers of two plates (see Appendix A). For the same reason, the laser beam is deflected in the gap between the plates, where there is no opaque obstacle for diffraction. This prediction was confirmed in our experiment (Section 15).

* * *

Water is mobile; therefore, it can aid in detecting the presence of gravity at the boundary of two media (see second row of Table 19.1).



a)



b)

Fig. 19.1. a) In a vessel, the water surface is concave at the glass–water interface. b) Enlarged schematic of the left side of figure (a).

This phenomenon has long been described as "surface tension" [42]. Figure 19.1a shows that the water surface is concave at the water–glass interface. In our paradigm, this phenomenon is attributed to the gravitational effect of the boundary layer (Fig. 19.1b).

A stable position on the surface of any liquid is established perpendicular to the direction of the vector sum of forces acting on the surface molecules (including fictitious forces, e.g., the centrifugal force).
Let vector $\vec{F}$ denote the direction and magnitude of the vector sum.

The water–air boundary layer produces an acceleration perpendicular to the water surface. This acceleration does not affect the direction of $\vec{F}$ and can be excluded from our consideration.

It follows that the vector sum of the two remaining accelerations, i.e., the acceleration terms due to gravity $\vec{g}$ and the glass–air boundary layer $\vec{a}_{g/a}$, should have the same direction as $\vec{F}$ (see Fig. 19.1b).

Thus, we have the known gravitational acceleration $\vec{g}$, an unknown horizontal acceleration $\vec{a}_{g/a}$, and the known direction of the vector sum of these two accelerations.

Let θ denote the angle between the tangent to the water surface at a given point and the vertical glass wall. The acceleration modulus $a_{g/a}$ resulting from the glass–air boundary layer on the concave surface of the water is then equal to

$$a_{g/a} = g \cot \theta .$$

This acceleration is directed towards a higher medium density and, in this case, towards the glass.

Thus, the dependence of the angle θ on the distance to the glass carries information about the glass–air boundary layer. In particular, when θ reaches 90°, the acceleration $a_{g/a} = g \cot \theta = 0$. This point is outside the boundary layer. Hence, we can measure the width of the outer region of the glass–air boundary layer.

If a vertical plate of another material (for example, steel) is lowered into a vessel with water, one can compare the parameters of the boundary layers of steel and glass by observing the curvature of the water surface near the steel plate.

* * *

The experiment of Hau et al. [11] presented in the fourth row of the table was discussed in Section 18.

20. Discrepancies between the new and old paradigm

The discrepancies between the two paradigms are numerous. Some of the consequences of the new paradigm, which differ from the viewpoints of conventional physics, have already been considered in previous sections. Below, we present some additional differences, although this list is not yet complete.

20.1 On relationship between the speed and mass of a body

In the special theory of relativity, the mass m of a body increases with its velocity v according to the following formula:

$$m = \frac{m_0}{\sqrt{1 - v^2/c^2}}, \qquad (20.1)$$

where m_0 denotes the body rest mass and c denotes the constant speed of light.

Many physicists believe that the relativistic mass is a problematic concept, making it difficult to study the special theory of relativity. Max Jammer wrote, "It is objectionable that the mass of a particle decreases or increases for no physical reasons, merely by being observed from different perspectives" [43].

Our previous work [44] showed that when an electron moves parallel to the plates of a capacitor, it experiences an electrical force whose direction is not strictly perpendicular to the electron velocity. This phenomenon is similar to the aberration of light.

Considering this overlooked phenomenon, the projection of the force on the transverse direction is

$$F_{\perp} = F \cos \delta, \qquad (20.2)$$

where δ is the aberration angle, whose sine is $\sin \delta = v/c$. Hence, $F_{\perp} = F\sqrt{1 - v^2/c^2}$ and the equation of motion of an electron takes the form

$$F\sqrt{1 - v^2/c^2} = m\, a_{\perp}. \qquad (20.3)$$

For $v < c$, this equation is identical to the equation in the special theory of relativity:

$$F = \frac{m_0}{\sqrt{1-v^2/c^2}}\, a_{\perp}. \qquad (20.3')$$

Ref. [44] showed that in other situations (except for $v = c$), Eqs. (20.3) and (20.3′) remain identical, although their physical interpretations are different.

Formulas without a physical model are problematic because the boundaries of their permissible application are difficult to determine. For example, Ptolemy's geocentric formulas correctly predict the movement of planets in the celestial sphere, but the formulas cannot predict whether these results are valid when observations are made from Mars.

In the case of a photon, the variable mass formula [Eq. (20.1)] leads to a singularity, $m_{ph} = \frac{m_0}{0}$. To resolve this issue, physicists set $m_0 = 0$ for a photon. Then, based on Eq. (20.1), the mass of a photon in motion equals $m_{ph} = \frac{0}{0}$; however, this is simply mathematical acrobatics.

The abolition of the mass–velocity dependence [Eq. (20.1)] is especially important for restoring the photon mass.

In 2009, L. Okun [45] revived Planck's previous approach of "relativistic momentum" [46] in order to hide the paradox of increasing mass, but Einstein stated that Planck's equations of motion "do not have a physical meaning" [47].

Here, we consider another problematic application of Eq. (20.1). Let us consider electrons entering water at a speed greater than the velocity of light in water. Because v > c, according to Eq. (20.1), the mass of such electrons should be imaginary.

This experiment was performed by P. Cherenkov in 1934 [48]. The electrons emitted "Cherenkov radiation" and remained real.

In the new paradigm, the constancy of mass is further confirmed. Indeed, if a body falls freely, no force acts on it; the mass remains unchanged although its speed grows, which contradicts the theory of special relativity.

20.2 Newton's third law and gravity

Physics does not provide an explanation of how the reaction force arises in Newton's third law. Our paradigm reveals its physical origin.

Let body A push a stationary body B. As a result of pressure, an increased density of the medium is formed inside the contacting particles of both bodies.

Consequently, the waves of particle-vortices are slowed down and concentrated at the point of contact, which is perceived as the reaction force of body B. Because the contact region and the increased density of the medium within this region are common for the two bodies, the reaction force and the applied force are equal.

After a short time, the waves of the particle-vortices move away from the contact point, and thus, body B appears to give in to pressure.

Unlike a contact force, ordinary gravity is caused by a general inhomogeneous background; thus, particles in this background experience the same acceleration. Therefore, the atoms are not compressed, and there is no reaction force. There is not even a body A that could be counteracted.

Consequently,

***Newton's 3rd law is not valid for gravitational forces*.**

Now, we consider the situation from the viewpoint of inertia.

We read in a Wikipedia article “Inertia”: “Inertia is the resistance of any physical object to any change in its velocity . . . which is quantified by its mass.” When a contact force acts on a body, the body resists any change in its velocity, indicating that inertia exists for such forces.

However, physical objects do not resist a change in their velocity when subjected to gravity. Without resistance, there is no inertia. Therefore, for gravity, a body’s mass is not a measure of its inertia.

Thus, inertia exists for some forces and must be overcome; however, for other forces, there is no inertia. Therefore, for accelerating heavy vehicles, it is better to use non-inertial forces, for example, those produced by a virtual mass generator, as the acceleration will not depend on the vehicle weight.

20.3 On Newton's law of universal gravitation

According to Newton's law of universal gravitation, we have

$$F = G\frac{mM}{r^2}, \qquad (20.4)$$

where G is the gravitational constant.

The mass of the gravitating body M was included in the formula on the basis of the equality of action and reaction forces in Newton's third law. However, in the previous section, we demonstrated that Newton’s third law does not hold for gravity.

Nevertheless, let us consider the physical background of Eq. (20.4) from the viewpoint of the new paradigm.

First, Eq. (20.4) is not applicable to cases of dark matter and dark energy with M = 0. Instead, this equation is used for cases of ordinary static gravity.

According to the new paradigm, all massive bodies transnihilate, releasing virtual mass. If a steady outflow of virtual mass is maintained, the situation appears to exhibit static gravity because the underlying process is not visible.

Taking into account the above description, the value of the virtual mass flow created by the massive body should be included in Eq. (20.4). In fact, this value is present, given as the product of the mass M and the gravitational constant G: $\mu = GM$, called the standard gravitational parameter [49]. Thus, Eq. (20.4) changes to

$$F = \frac{\mu m}{r^2}, \qquad (20.4')$$

This version of the formula is suitable for calculating the product GM based on satellite trajectories and vice versa. To calculate M, one must know how the virtual mass outflow depends on M.

The universality of the constant G implies that each kilogram of a massive body produces the same stream of virtual mass, regardless of how it is created. However, for the Sun and stars, mass transnihilation is more intense due to nuclear fusion processes and very high temperatures.

By assuming the gravitational constant G to be the same for the Earth and the Sun, astronomers exaggerate the Sun's mass; however, this exaggeration does not influence trajectory calculations for planets and their satellites because only the product GM is applied in the formula.

* * *

Einstein included the gravitational constant G in his equation of general relativity:

$$\mathbf{G} = \frac{8\pi G}{c^4}\mathbf{T}.$$

See, for example, the Wikipedia article "Introduction to General Relativity."

21. Size of an electron and a model of the hydrogen atom

In Section 4, we used the identity of the electron and muon structures to derive the ratio of particle sizes as inversely proportional to their masses. We found that the muon is 207 times smaller than the electron. The mass of a proton is 1840 times greater than the mass of an electron; however, due to difference in their structures, it is impossible to deduce the exact ratio of their sizes.

Nevertheless, it is clear that according to the new paradigm, the size of an electron should greatly exceed the size of a proton (Consa [50] came to a similar conclusion based on the Compton wavelength). This expectation is supported by the fact that the magnetic moment of the electron, $\mu_e = -9.285 \times 10^{-24}\, J\, T^{-1}$, is 658-fold greater than the magnetic moment of the proton, $\mu_p = 1.411 \times 10^{-26}\, J\, T^{-1}$ [51].

Such a large electron cannot orbit the nucleus of a hydrogen atom as described in the Bohr atom model [52]; however, this result is a consequence of the new paradigm and cannot be ignored. A large electron should surround the nucleus of the atom and should not be very mobile.

In order to surround the nucleus, the electron must be hollow. To visualize a three-dimensional electron, we consider the well-known fact that an electron and a positron arise from the collision of two photons. Correspondingly, during the "annihilation" of an electron–positron pair, photons are born.

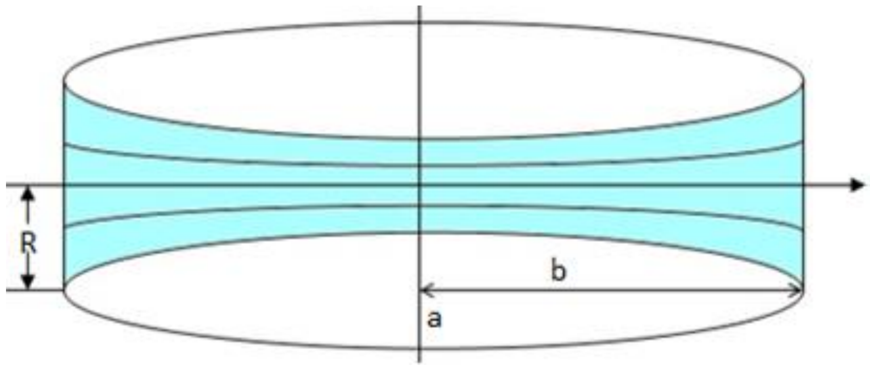


Fig. 21.1. Cross-section of a photon in free flight according to its proportions (from Ref. [5]).

These interconversions suggest that the photon and electron have topologically equivalent structures. In our previous work [5], the proportions of the photon toroid were calculated (Fig. 21.1). This topological similarity indicates that the electron, like the photon, has the shape of a toroid, but with different proportions (see Fig. 21.2).

Fig. 21.2. According to the new paradigm, a large electron in the shape of a toroid encompasses the nucleus of a hydrogen atom. Ring waves — future photons — can run along the electron's body, similar to a waveguide.

This large electron simultaneously resolves several problems of the Bohr atom model [52]. First, in the Bohr model, electrons orbiting the nucleus would constantly lose energy in form of electromagnetic radiation. However, such radiation is not observed [52].

In our paradigm, the bound electron is static; therefore, there is no contradiction.

Second, in conventional physics, a point-like electron must have zero spin, which contradicts the known value of electron spin; in contrast, in the new paradigm, the electron may have a nonzero spin.

Third, in the Bohr atom model, electrons move along intangible orbits, rendering them vulnerable to collisions with other atoms. According to the new paradigm, the material ring of an electron replaces a non-material orbit.

Fourth, according to quantum theory, an electron in a hydrogen atom has a nonzero probability of being inside the nucleus [53].
In our paradigm, such a paradox is impossible.

Finally, regarding the radiation of an atom in the old model, we only know that the electron energy decreases by the energy of the emitted photon. It is paradoxical that the electron should start emitting a photon without knowing what the photon energy will be (to which orbit the electron will jump). Moreover, no information is given regarding what comprises the emitted photon.

In our model, the processes of absorption/radiation occur as follows. A photon is selected for absorption on the basis of the resonant frequency of the bound electron. The absorbed photon is embedded in the body of the electron in the form of a ring wave (Fig. 21.2), which changes the resonant frequency of the electron.
The ring wave (the former photon) runs along the electron like along a waveguide and is ready to be radiated at any moment.

22. Conclusions

In modern physics, a very important element is missing. We call this element unorganized mass or virtual mass. Without virtual mass, it is impossible to explain the phenomena of dark matter and dark energy.

By considering virtual mass, we can clarify the physical mechanism of gravity and resolve the problem of dark matter/energy as a type of non-static gravity.

Knowing the direct cause of gravity allows for its elimination. According to our paradigm, it is necessary to generate an increased density of virtual mass above an object in order for that object to fly or move upward.

One method for generating virtual mass is to bring atoms of matter below the lower limit of their stability.

Such an approach has already been implemented in the experiment by Hau et al., although the method was not explained, as the primary objective of the experiment was to reduce the speed of light to 17 m/s.
According to our paradigm, a reduced speed of light is a sign of a high density of virtual mass. Another sign is the deviation of light rays from rectilinear motion, which was considered from a unified viewpoint in this work.

On this basis, we predicted and experimentally confirmed the deviation of a laser beam in the empty gap between the Casimir plates.

A logical consequence of the new paradigm is a revision of particle sizes, which led to a physical explanation of the unexplained Planck formula, $E = h\nu$. Another consequence led to an alternative model of a hydrogen atom.

Our understanding of these phenomena can lead to the discovery of new technologies.

Appendix A. Boundary layer as the cause of the Casimir effect

According to the hypothesis of quantum mechanics, **zero-point fluctuations** are present everywhere in space in the vacuum ground state. Many physicists believe that the Casimir effect [55] is an experimental confirmation of the reality of these fluctuations. The energy of zero-point fluctuations is also the leading candidate for explaining dark energy.

On the other hand attempts to explain dark energy in terms of vacuum energy of the standard model lead to a mismatch of 120 orders of magnitude [57].

The theory of quantum fluctuations predicts that the Casimir force F_C between two parallel plates separated by a distance a should have the form [55]:

$$\frac{F_C}{S} = \frac{K}{a^4}, \qquad \text{(A1)}$$

where the coefficient K is a constant and S is the plate area.

According to Eq. (A1), as the gap between the plates decreases ($a \to 0$), the Casimir force grows infinitely, which is not observed when the plates are brought into contact with each other.

Robert Jaffe stated that the standard interpretation of the Casimir experiment is completely unjustified: "Certainly there is no experimental evidence for the "reality" of zero point energies in quantum field theory (without gravity)" [56].

The conclusion is that zero-point fluctuations cannot explain the Casimir effect or dark energy. However, there has been no competing alternative for this theory.

The new paradigm offers an alternative explanation of dark energy and the Casimir effect. According to this paradigm, the Casimir effect is a consequence of gravity created by the boundary layer of a plate. The explanation is given below.

* * *

First, we present a preliminary mathematical model for the boundary layer of a plate. For this model, we make two natural assumptions.

Assumption 1: The plate is sufficiently large to neglect edge effects. Thus, the density of the medium depends only on the distance x to the surface of the plate.

Assumption 2: Because we describe the density of the medium inside the plate using the speed of light, we assume that the plate is transparent. Later on, we will demonstrate that this assumption does not limit the generality of our results.

Let c_1 denote the speed of light at the plate depth, which is less than the speed of light in vacuum, c_0.

If we choose the x-axis to be perpendicular to the two plates, the speed of light c(x) has two horizontal asymptotes $y = c_1$ and $y = c_0$. In the asymptotic ranges, the first derivative of c(x) is close to zero; meanwhile, between these limits, c(x) monotonically increases, that is, $\frac{dc}{dx} = c'(x) > 0$ (see Fig. A1). Hence, there must be an inflection point x_0 at which $c'(x)$ has maximum.

Finally, the graph of function c(x) is given as follows:

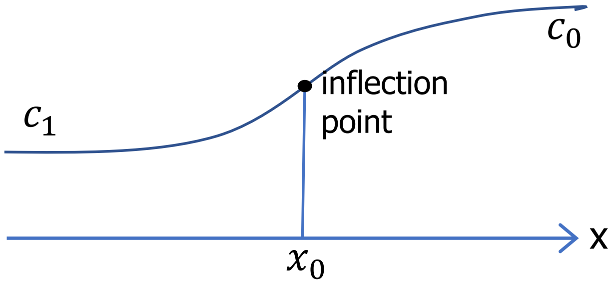


Fig. A1. An approximate plot of the dependence of the speed of light on x. The function c(x) has two horizontal asymptotes and one inflection point.

The following family of inverse tangent functions can serve as a mathematical model for the boundary layer of the left plate because it satisfies the above stated requirements for the speed of light c(x):

$$c(x) = \frac{1}{\pi}(c_0 - c_1)\, arctan(k\,(x - \delta + d)) + (c_0 + c_1)/2\ , \qquad \text{(A2)}$$

where k > 0 is a scale parameter and d is the plate position parameter. The inner surface of the left plate is located at x = -d, and that of the right plate is located at x = d; thus, the width of the gap between the plates is 2d. If d = 0, the plates touch.

Because the boundary layer created by the plate moves with the plates, d shifts the graph of c(x) along with any shifting of the plate.

The meaning of parameter δ becomes clear if we consider that the inflection point for the arctan function occurs when the argument is zero, i.e., at $x = \delta - d$. Thus, an increase in δ shifts the inflection point and the entire curve to the right.
If $\delta = 0$, then the inflection point is directly on the inner surface of the left plate.

$* * *$

Now, we consider that the gravitational acceleration is proportional to $-u\, du/dx$ for an inhomogeneous medium (see Section 11) and that the velocity of the density wave u is proportional to the speed of light c(x) [5].

It is clear that this acceleration, and therefore the Casimir force on the right plate, will vary for different depths from the surface. For example, we calculate the acceleration for x = d, i.e., on the surface of the right plate.

At the point x = d, the derivative dc/dx equals

$$c'(d) = \frac{1}{\pi}\,(c_0 - c_1)k/(1 + k^2(2d - \delta)^2). \qquad \text{(A3)}$$

Thus, the Casimir acceleration on the surface of the right plate is proportional to

$$a(d) \sim u\frac{du}{dx} \sim\ -\frac{k}{1+k^2(2d-\delta)^2} \times \left[\frac{1}{\pi}\,(c_0 - c_1)\,arctan(k\,(2d - \delta)) + (c_0 + c_1)/2\right].$$

(A4)

A negative value indicates that the Casimir effect accelerates the right plate to the left.

The acceleration from the boundary layer does not approach infinity when d = 0, as the quantum fluctuations do, but the acceleration is not equal to zero (Fig. A2). This result implies that the Casimir force is present in all solids and is a bonding force.

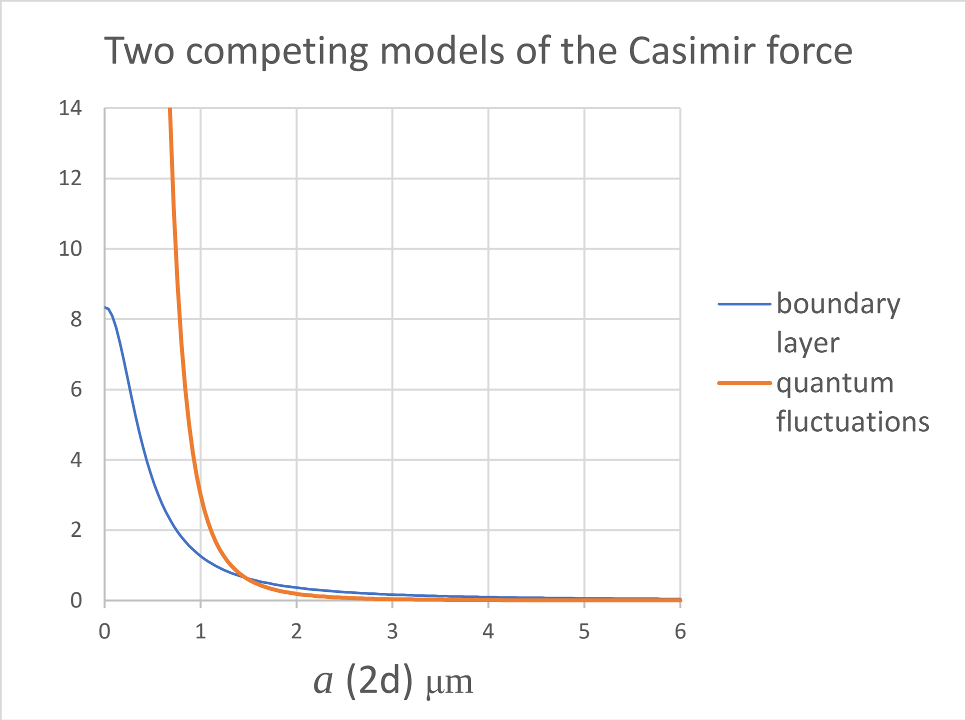


Fig. A2. Both models of the Casimir force predict an increased force as the plates approach each other; however, according to the theory of quantum fluctuations (red), the Casimir force grows infinitely. In contrast, the boundary layer theory (blue) predicts a finite value at d = 0. (The following values of the parameters were used to plot the graph: $\delta = 0,\ c_1 = \frac{2}{3}\,c_0$, k = 2.5.)

* * *

Here, we discuss Assumption 2 regarding the transparency of the plate.

In an opaque plate, a ray of light is rapidly absorbed, making it impossible to directly measure the speed of light. However, the speed of light can be indirectly determined by measuring the critical angle of total internal "reflection" θ_c of the ray at the boundary of a transparent medium with a known high refractive index n_1 and an opaque medium with an unknown refractive index n_2.

Based on the modified condition of total internal "reflection" [Eq. (10.5)] $\sin\alpha > n_2/n_1$, the critical angle θ_c is equal to the minimum angle of incidence α, at which the "reflected" ray is observed. Hence,

$$\sin\theta_c = n_2/n_1. \qquad \text{(A4)}$$

By applying $n_2 = c_0/c_2$, we find that c_2 is the speed of light in an opaque medium.

Appendix B. Michelson–Morley experiment revised

An error in the analysis of the Michelson–Morley experiment [58] led to a negation of the ether. The error arose because the following fact was overlooked: light reflection from a moving mirror occurs at a different angle than that for a mirror at rest.

At least three scientists have corrected this error. In 1920, Professor Righi of Bologna formulated his interpretation of Michelson's experiment, but he died suddenly. In the following year, J. Stein published Righi's theory [59].

In 1927, E. R. Hedrick presented an investigation related to Righi's theory and Stein's report to a conference on the Michelson–Morley experiment [60].

In 2000, Paul Marmet rediscovered the error in the Michelson–Morley calculations [61]; however, the physics community ignored his publications.

While refining the photon structure [5], we concluded that Huygens' wave theory of light does not apply to photons.
However, Righi (see [59]) and Marmet [61] used the wave theory of light in their works.

For consistency, we derived the same results on the basis of the photon particle (see Ref. [5]). James Bradley, who discovered light aberration, derived his aberration formulas by considering light as a stream of particles.

Here, we provide only the primary idea for revising the results of the Michelson–Morley analysis. A detailed derivation of the expected result has been presented in [5].

Figure B1 shows the Michelson interferometer moving to the right with velocity v along with the Earth in its motion around the Sun [58].

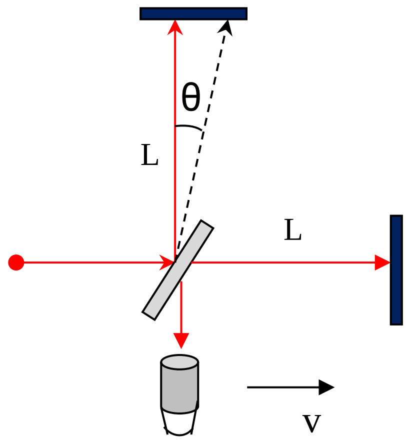


Fig. B1. The Michelson interferometer moves along with the Earth in its motion around the Sun.

According to Michelson's analysis, in the absolute frame of reference, there should be a measurable difference between the transit time t_2 of the transverse ray and t_1 of the ray parallel to the frame velocity v.

Because this difference was not found, the hypothesis of the absolute frame of reference was considered to be disproven.

However, when we consider the light aberration effect in the absolute frame of reference, the travel times t_1 and t_2 of photons in two rays coincide up to terms of the order above v^2/c^2.
Hence, the Michelson–Morley experiment could not determine which of the two hypotheses is true (there was no point in conducting the experiment).

Thus, for photons, the null result of the Michelson–Morley experiment is consistent with the hypothesis of the absolute frame of reference.

Appendix C. Formulas for calculating the photon trajectory in a general case

Here, we present the most general application of Eq. (9.1).
Two vectors are given, ∇c and $\vec{c}$. Rotation of the photon velocity vector $\vec{c}$ by the angle $d\theta = \nabla c \times \vec{i}_c \, dt$ occurs in the plane parallel to these vectors.

Here, we aim to determine the photon velocity vector $\vec{c}'$ after the rotation.

1. First, we find the normal vector for the desired plane. Let

$$\vec{l} = \nabla c \times \vec{c}.$$

Based on the definition of the vector product, the vector $\vec{l}$ is perpendicular to both vectors ∇c and $\vec{c}$. If we normalize this vector, then we will obtain the normal vector of the plane of rotation:

$$\vec{l}'(l_x', l_y', l_z') = \vec{l}/\| \vec{l} \|.$$

2. Next, we calculate the angle of rotation of the speed of the photon

$$d\theta = \nabla c \times \vec{i}_c \, dt.$$

3. We multiply the rotation matrix $R(l', d\theta)$ by the vector $\vec{c}$ to obtain a new velocity vector $\vec{c}'=R(l', d\theta)\vec{c}$, where

$R(l', d\theta)=$

$$\begin{bmatrix} l_x'^2(1-\cos d\theta)+\cos d\theta & l_x' l_y'(1-\cos d\theta)+l_z'\sin d\theta & l_x' l_z'(1-\cos d\theta)-l_y'\sin d\theta \\ l_x' l_y'(1-\cos d\theta)-l_z'\sin d\theta & l_y'^2(1-\cos d\theta)+\cos d\theta & l_y' l_z'(1-\cos d\theta)+l_x'\sin d\theta \\ l_x' l_z'(1-\cos d\theta)+l_y'\sin d\theta & l_y' l_z'(1-\cos d\theta)-l_x'\sin d\theta & l_z'^2(1-\cos d\theta)+\cos d\theta \end{bmatrix}.$$

Example for verification

Let $\vec{l}' = (0, 0.6, 0.8)$. After rotating through an angle $d\theta = \pi/12$, vector $\vec{c}(1, 2, 0)$ must become $\vec{c}'(1, 1.93, 0.52)$.

The reverse operation can also serve as a verification.
Rotation of the vector $(1, 1.93, 0.52)$ through the angle $d\theta = -\pi/12$ in the same plane must give $(1, 2, 0)$.

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Internet searches have shown that open-minded people have obtained similar results for certain issues. Therefore, I often write “we” and “our paradigm,”

referring to everyone who contributed to the new paradigm. I have strived to give credit to them in this work.

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