The Winding Path of the Theories of Light and the New Paradigm

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Abstract. It seems as though light is fully understood, as there are two recognized, albeit contradictory, theories for light; however, there is no appropriate theory for dark energy. In this article, we briefly discuss the tortuous path in which the theories of light have evolved and demonstrate how their paradox can be resolved by applying a new physical paradigm, in which only one entity is needed to explain dark energy and dark matter together with the phenomena of light. This article discusses the foundations of this new paradigm.

Keywords: wave–particle duality, dark energy, dark matter, gravity, new paradigm, refraction, diffraction, bending of light rays, Planck's equation.

1. Introduction

In the late 17th century, two theories of light were put forth: Newton argued that light consists of tiny particles, now called photons [1], whereas Huygens believed that light is composed of waves [2].

The wave theory of light is based on the Huygens principle, which states that every point in the path of a beam emits secondary waves. If this principle were true, the beam would instantly split in all directions into countless secondary waves (Fig. 1).

On this subject, Newton wrote, "If light consisted of waves, it would "bend and spread every way" into the shadows" [1]. However, this effect is not seen in nature. In contrast, the photon has a vortex mechanism that maintains the integrity of the particle.

More than 100 years later, in 1803, an experiment conducted by Thomas Young on the interference of light confirmed the Huygens wave theory of light [2].

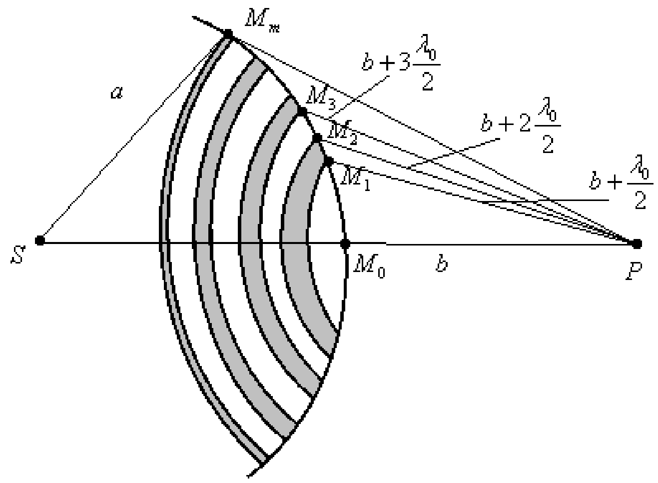

Fig. 1. According to the Huygens principle, a light wave must decay into an infinite number of secondary waves, with a corresponding dissipation of energy.

2. Maxwell’s electromagnetic waves

The wave theory of light was confirmed in 1865, when Maxwell discovered that the mathematical model of a planar electromagnetic wave propagates at the speed of light [3].

However, this model of light was not viable, because Maxwell mistakenly assumed that charges exist in vacuum as in a dielectric. These charges were assumed to create a displacement current [3]. Although there are no charges in vacuum, light still propagates through vacuum, leading to a contradiction.

As stated in a Wikipedia article [4] entitled “Ampère's circuital law”:

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

Subsequently, by studying the photoelectric effect, Einstein [5] showed that light consists of discrete quanta (now called photons) rather than continuous waves. This model contradicts Maxwell’s model of a planar electromagnetic wave, and the latter had to be rejected a second time. However, this problematic situation was frozen by the “wave-particle duality" [6].

Not every mathematical wave that travels at the speed of light is light. By applying Maxwell's equations, N. Kasterin [7] showed that a particle in the form of a closed vortex tube will also move at the speed of light.

As an additional objection, the oscillations of the electric and magnetic fields in a planar electromagnetic wave are synchronous (Fig. 2). Thus, the electric and magnetic fields simultaneously have a value of zero, i.e., the wave disappears, and the fields are then reborn from nothing.

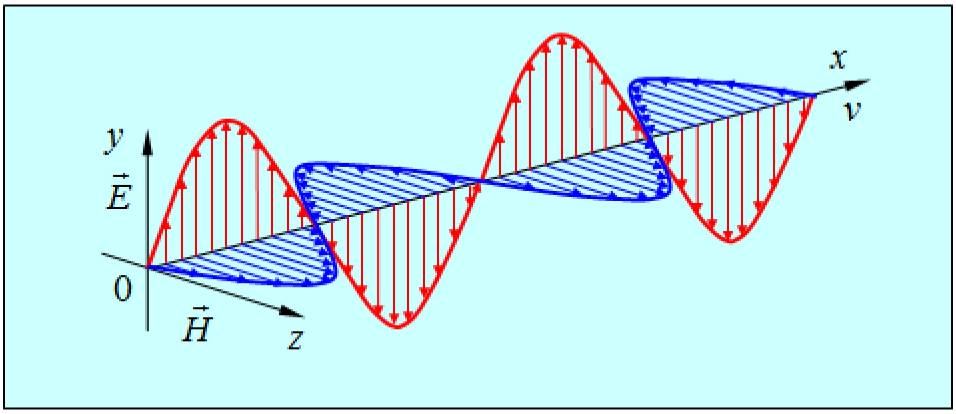

Fig. 2. In a planar Maxwell wave, the electric and magnetic components vanish simultaneously.

While the Huygens principle leads to the dissipation of wave energy, the energy of the Maxwell wave completely disappears at some points along the trajectory and is then recovered (Fig. 2).

3. Deviation of a light ray when passing near the Sun

In 1919, physicists discovered that the light from a distant star deviated from a straight line as it passed the Sun [8]. However, this phenomenon was not caused by the wave nature of light, but by the gravity of the Sun (Fig. 3).

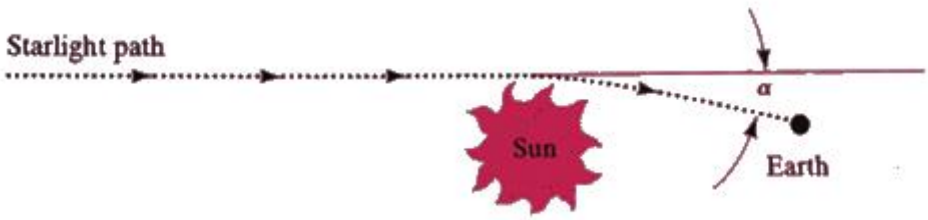

Fig. 3. Deflection of light by the Sun.

Here, it was necessary to revise the wave theory, as proposed in [8], but an appropriate medium was missing to unify diffraction and ray deflection near the Sun. Thus, physicists were left with two conflicting theories - one theory in which light is a stream of particles and another theory in which light consists of waves.

After another 100 years, in 2020, the author published a new physical paradigm [9] that resolves this paradox and additional articles on selected topics [10] [11] [12] that resolve other unsolved problems of modern physics.

This new paradigm is based on the concept of an unorganized mass, which, when in motion, transforms into ordinary mass. Nikola Tesla called this unorganized mass “the primary substance” [13], indicating that our world of mass was created from this substance.

Thus, unorganized mass is not simply a medium similar to the ether, but it is actually "the raw material of the universe."

According to Tesla, subatomic particles are vortices of the primary substance. We denote the primary substance as “unorganized mass” to emphasize its similarity to and difference from ordinary mass and the possibility of their interconversion.

Unorganized mass is present everywhere, and although it is invisible, it manifests itself in the phenomenon of gravity. For this phenomenon to occur, the unorganized mass must be inhomogeneous.

4. Basis of the new paradigm

There exists a universal medium that contains this unorganized mass. By introducing the concept of a universal medium, many phenomena are found to be manifestations of the same essence, and their physical causes are revealed.

The unorganized mass has the following properties:

a) Unorganized mass is present everywhere.
b) Unorganized mass has no stable structures.
c) Ordinary mass is created from unorganized mass.
d) Unorganized mass does not interact with ordinary mass; therefore, it is invisible and does not impede the movement of bodies.

In contrast to unorganized mass, ordinary mass has the following properties:

a) Ordinary mass is organized into stable structures.
b) When a structure of ordinary mass collapses, its mass becomes unorganized.
c) Forces exist between the structures of ordinary mass.

According to the new paradigm, elementary particles, including photons, are stable vortex structures, in which a density wave circulates.

A photon is a stable vortex with the form of an elongated toroid (Fig. 4). The vortex is formed by a rotating density wave of organized mass, which results in a photon moving at the speed of light. This answers the question of what causes a photon to move [14].

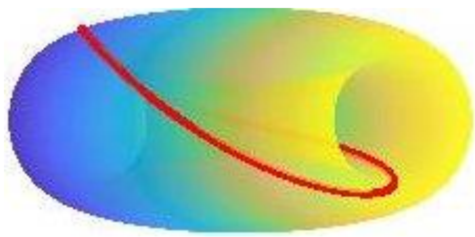

Fig. 4. A photon vortex is formed by a rotating density wave of organized mass. An instantaneous position of this wavefront is shown by the red line. The colors were chosen for clarity. In reality, each photon of visible light is an elementary/indivisible carrier of only one color (see Fig. 5).

Figure 5 illustrates the new paradigm discovery that reveals the physical meaning of Planck's formula for photon energy $E = h\nu$ [15]. In Fig. 5, photons of different colors are shown to have different sizes. Blue photons are smaller than red ones ("compressed") by a factor of 1.5; therefore, their energy is 1.5-fold greater than the energy of red photons. Because of the small size of blue photons, the density wave rotates around a blue photon 1.5-fold faster compared with a red photon. Hence, the frequency (and energy) of the blue photon is 1.5-fold higher than that of the red photon.

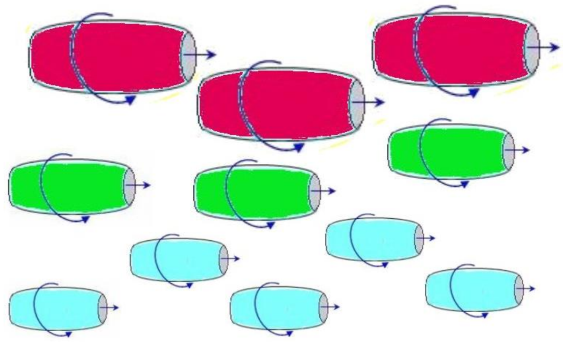

Fig. 5. Relationship between the size of photons and their color, i.e., the frequency of their rotation.

Therefore, there is a proportional relationship between the energy and frequency of photons, which is reflected in Planck's formula.

Planck derived his formula from purely mathematical considerations in order to avoid the ultraviolet catastrophe [15]. So far, no physical explanation for this dependence has been provided. The new paradigm provides such an explanation (for more details see [11]).

5. Boundary layer and 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.

A new definition of gravity can be formulated as follows:

> ***Definition 1. Gravity is a universal phenomenon in which the magnitude and direction of particle velocities change under the influence of vacuum/medium inhomogeneity.***

Vortices of elementary particles, atoms, and molecules are not absolutely stable, and therefore, they lose part of their mass. As a result, there is high density of the medium inside the bodies that gradually decreases as one approaches the boundaries of the bodies and moves further away from the surface (Fig. 6).

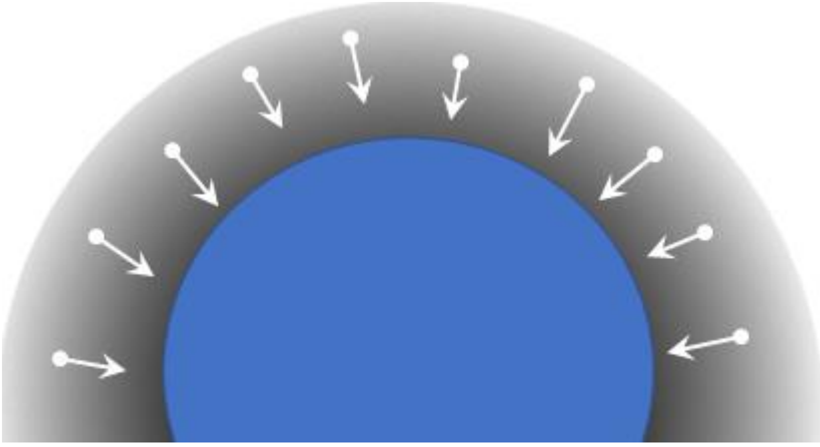

Fig. 6. In the boundary layer around a planet, the medium density (shown in shades of gray) decreases with distance from the surface. This inhomogeneity of the medium causes bodies to accelerate in a "downward" direction, i.e., toward the higher density of the medium. This phenomenon is recognized as gravity.

Thus, the direct cause of gravity is not massive bodies, but an inhomogeneous medium. Massive bodies create gravity indirectly, by creating a denser unorganized mass in the surrounding area.

The mechanism of gravity is based on the fact that particles, atoms, and molecules are vortices of organized mass: their density waves turn toward denser media (see [10] [9]). As a result, all bodies fall toward a higher medium density, i.e., "top down."

Photons are also vortices; thus, similar to other particles, they are deflected toward the Sun when they pass close to it (see Fig. 3). However, a boundary layer is also created around small objects, such as a razor blade, which turns the light beam in diffraction experiments.

6. Role of the boundary layer in light diffraction

Just as a gravitational field forms around massive space objects, 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.

In other words, 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.

Here, it is useful to classify light diffraction as a separate phenomenon. We define light diffraction as follows:

> ***Definition 2. 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 new paradigm states that the deviation of a light ray near the Sun and in the phenomenon of light diffraction occur due to the inhomogeneity of the medium. However, 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.

Figure 7 (left) shows the cross-section of a razor blade. As the beam passes the edge, it enters a tiny boundary layer and is slightly deflected. However, we can apply our understanding of the boundary layer and choose an obstacle shape from which the beam will deviate over a larger section of the boundary layer and deviate by a larger angle.

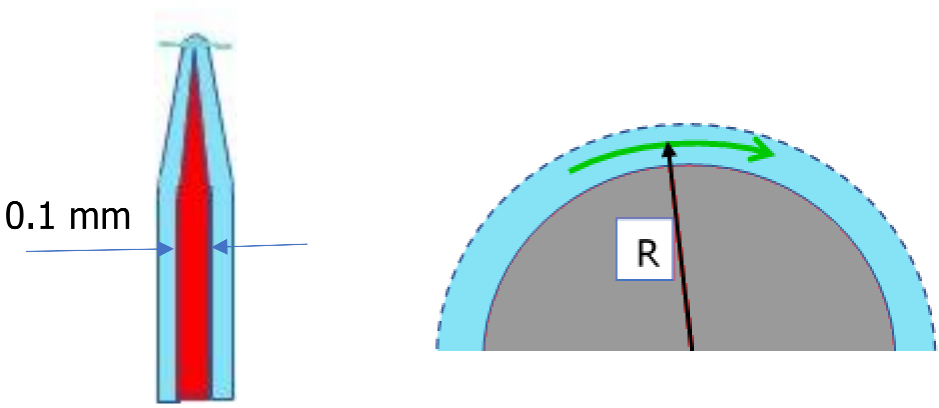

Fig. 7. Cross-sections of a razor blade (left) and a ball (right). The boundary layer, which is actually invisible, is shown in blue.

Figure 7 (right) shows the cross-section of a ball. By applying the boundary layer model, the new paradigm allows us to compare the deflection of the beam near the razor blade and near the surface of the ball.

If the size of the ball is chosen so that its surface bends in accordance with the rotation of photons in the boundary layer, the beam will deflect along an arc parallel to the surface of the ball.

We performed an experiment to test this hypothesis. Figure 8 (left) shows a photograph of a ball on a steel rod. The thickness of a razor is 0.1 mm, while the diameter of the ball is 5 mm, corresponding to 50 times the razor thickness.

A laser beam was directed to the top edge of the ball. The shadow obtained on the screen is shown in Fig. 8 (right), indicating that the beam deviated downward by a distance equal to the ball diameter (5 mm).

The experiment demonstrates that the new paradigm is capable of predicting unexpected experimental results that cannot be explained by the wave theory of light.

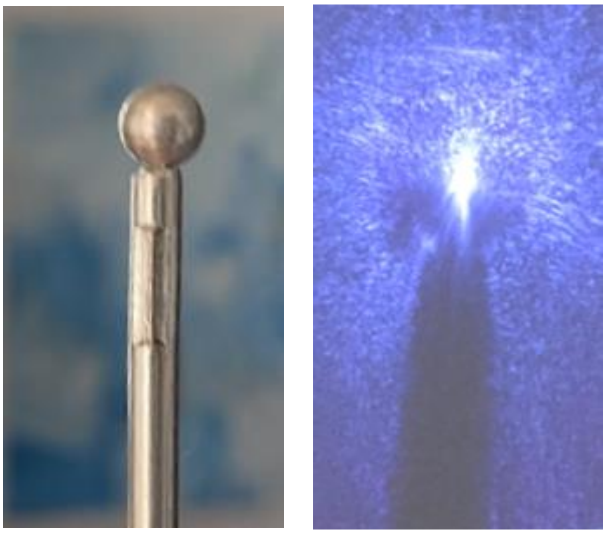

Fig. 8. Image of a steel ball on a rod (left) and its shadow on a screen (right). A blue laser beam goes around the ball and penetrates the shadow area of the ball.

More than 300 years ago in his letter to Robert Boyle [16], the great Isaac Newton had already hypothesized an intermediate layer around bodies as follows:

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

Then, Newton continued:

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

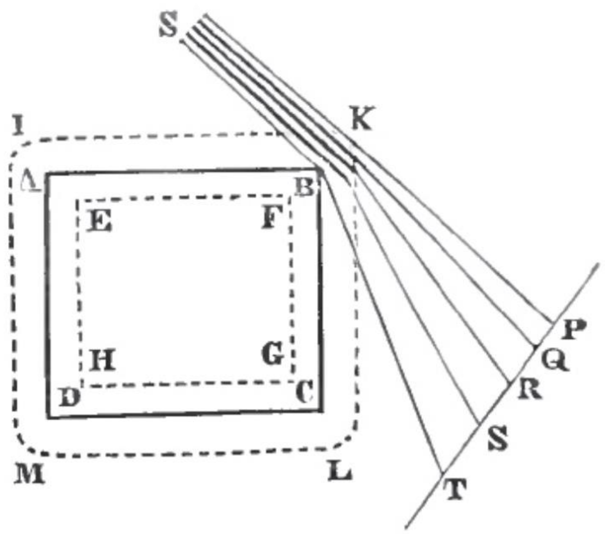

Fig. 9. Drawing by Isaac Newton in his letter to Robert Boyle [16] in 1679.

Thus, Newton believed that diffraction resulted from the refraction of photons in a boundary layer at the edge of an opaque obstacle (Fig. 9).

The corpuscular theory of light was abandoned in 1850 (more than 100 years after Newton's death) in favor of Huygens' wave theory. The reason for this choice was the inability of the corpuscular theory to explain why light corpuscles deviate from a straight line when passing through a narrow slit or small aperture [17].

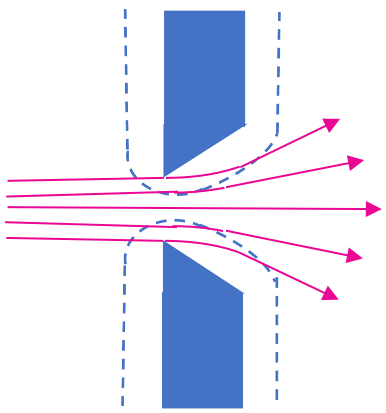

Fig. 10. Passage of a light ray (photons) through a slit. The boundary layer, shown by a dotted line, deflects the photons passing through it toward the near edge of the obstacle.

The new paradigm provides the missing explanation: the cause of the deviation is the boundary layer (Fig. 10).

If Newton were alive, he would be surprised that no one could solve such a simple problem. Maybe they did not want to.

7. New understanding of the phenomenon of light refraction

In [9], a formula for ray refraction was derived based on the integration of deviations along the ray path. It turns out that the formula does not depend on the path of the ray. It depends only on the density of the medium at the initial and final points of the trajectory. For this reason, even the piecewise linear path of the beam in the wave theory of light gives the same deviation.

A problem arises in the wave theory when one considers the phenomenon of "total internal reflection," because it is obvious that there is nothing to be reflected at the boundary of glass and vacuum when the wave leaves the glass. This paradox is no less paradoxical than the wave–particle duality.

When seeking to explain "total internal reflection", scientists usually talk about the conditions under which "total internal reflection" occurs. However, a Wikipedia article provides Newton's explanation of "internal reflection" [18].

Newton attributed this phenomenon to the attraction of a denser medium. In what follows, we will show that his explanation is accurate.

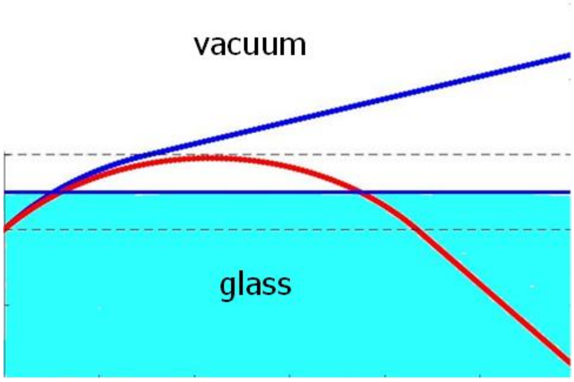

Fig. 11. Two possible trajectories of a photon: refracted (blue) and "reflected" (red). The boundary layer between the glass and vacuum is marked by a dotted line.

According to the new paradigm, a smooth rotation of a photon occurs in an inhomogeneous medium (red line in Fig. 11), and a deviation occurs toward the denser medium. Photon rotation at the boundary between the two media occurs in the same manner in which a photon deviates in a gravitational field.

Now, it is clear that the word "reflection" is just as inappropriate in the phenomenon of "total internal reflection" as the statement that a thrown ball returns to the ground as a result of reflection. Now we can, without blushing, explain to our children, grandchildren, and students the reason for "total internal reflection."

8. Suggested experiment

In Fig. 12, rays A and B fall on the face of a glass prism at the same angle. According to the wave theory of light, no boundary layer exists, and both rays are refracted in the prism in the same way and exit the prism at the same angle, regardless of whether refraction occurs in the wide or narrow region of the prism.

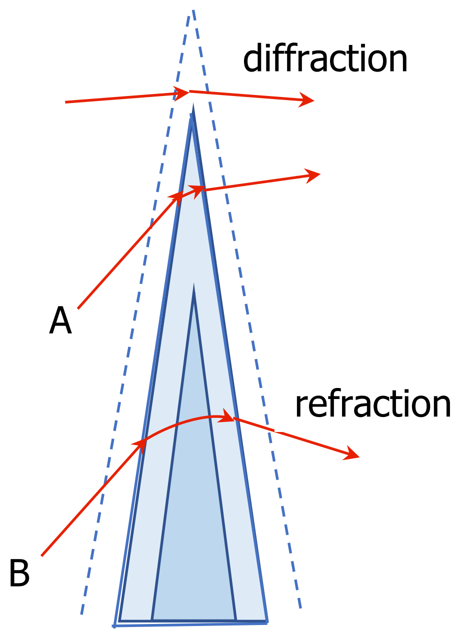

Fig. 12. According to the new paradigm, beam refraction at the tip of the prism is intermediate between full refraction in a wide region and diffraction outside the prism near its edge.

In the new paradigm, the boundary layer model unifies diffraction and refraction and even demonstrates a smooth transition between these phenomena. The refraction of a beam passing through glass near the tip of a prism is intermediate between the two phenomena (Fig. 12).

The purpose of the proposed experiment is to detect a difference in the deflection of a beam when it passes through a wide or narrow region due to the presence of the boundary layer and the unattainability of the full refractive index n=1.5 in a narrow region. The wave theory cannot explain such a result.

When the beam passes deep into the glass, the refractive index gradually increases, but in a narrow region, the beam can begin to approach the opposite face of the prism before reaching the index of n=1.5.

As a result, when the beams exit the prism, the deviations of beams A and B will be different (beam B deviates more than A), which will be recorded in the experiment.

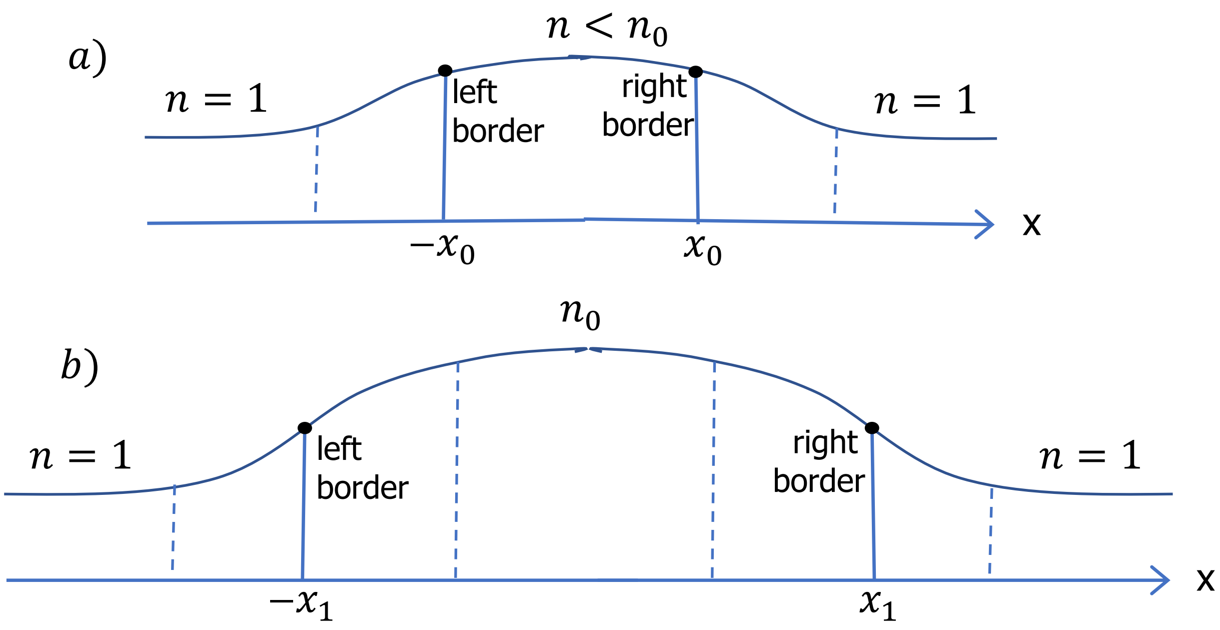

Fig. 13. Approximate plot of the relative density of the medium n depending on the distance to the edge of the glass: a) at the narrow part of the prism, b) at the wide part. n_0 denotes the refractive index of the glass; in our model, it is the maximum relative density of the medium deep in the glass.

As an indicator of the relative density of unorganized mass, we use the refractive index n. A graph of the relative medium density as a function of the distance to the edge of a thin glass prism is shown in Fig. 13a.

If the cross-section of the prism is taken in the wide region, the density of the medium reaches $n_0 = 1.5$ in the interior region of the glass. If the width of the prism in a narrow region is less than the width of the boundary layer, then the density of the medium does not reach 1.5, and the beam deflection in this region is smaller.

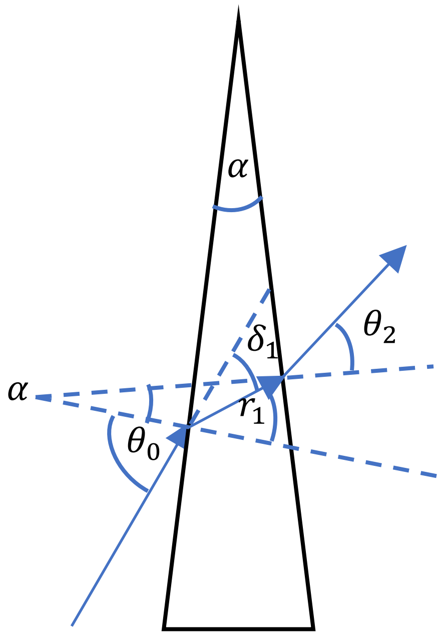

Fig. 14. Figure for deriving the formula for beam deflection in a thin prism depending on θ_0, the angle of incidence on the first face, and α, the angle at the top of the prism.

The formula for the final beam deflection in a thin prism is

$$\delta(\theta_0, n, \alpha) = \theta_0 - \arcsin(n \sin(\arcsin(\sin\theta_0 / n) - \alpha)) - \alpha ,$$

where n is the maximum refractive index of the glass along the entire path of the beam. This formula is essentially the same as the formula for a wide prism.

If we choose a prism with an angle of α=0.1 rad (~ 6°) and an incidence angle of θ_0=1.3 rad (~74°) for the beam, the beam deflection at the wide part of the prism is calculated as 11.2°. If the maximum density of the medium reaches n=1.4 in a narrow region, the beam deviates by 9.7°. Thus, the difference between the beam deflection in the wide and narrow regions of such a prism can reach 1.5° (Fig. 15), which can be distinguished.

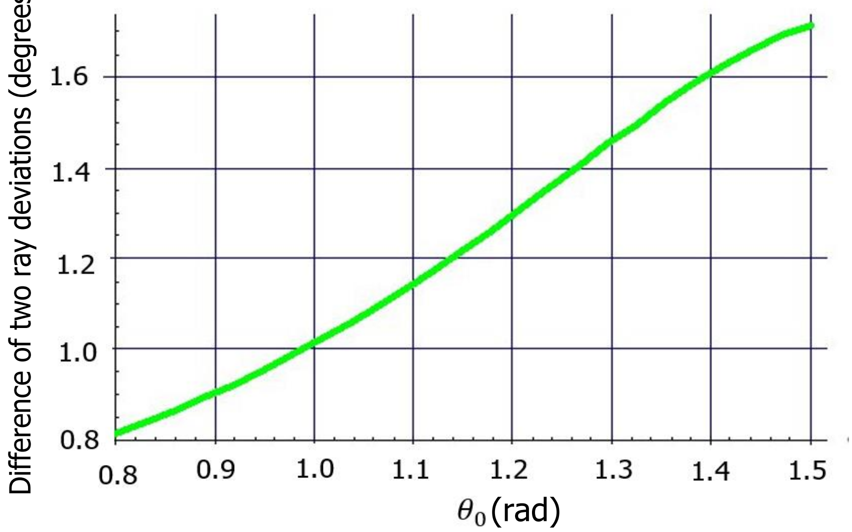

Fig. 15. Difference between ray deviations in a thin prism for n=1.5 and n=1.4, depending on θ_0, the incidence angle of the ray on the first face (α=0.1 rad).

Warning: The edge of a thin glass prism is very sharp and dangerous to work with; thus, we recommend using a transparent plastic prism instead of a glass prism.

9. Dark energy and dark matter

From the above discussions, the reader can easily solve the problem of dark energy and matter, which physicists have unsuccessfully sought to elucidate for several decades [19]. According to the new paradigm, the direct cause of gravity is an inhomogeneous vacuum, which **can exist without the presence of massive objects**. And the direction of gravitational acceleration is always towards a denser medium (Fig. 16).

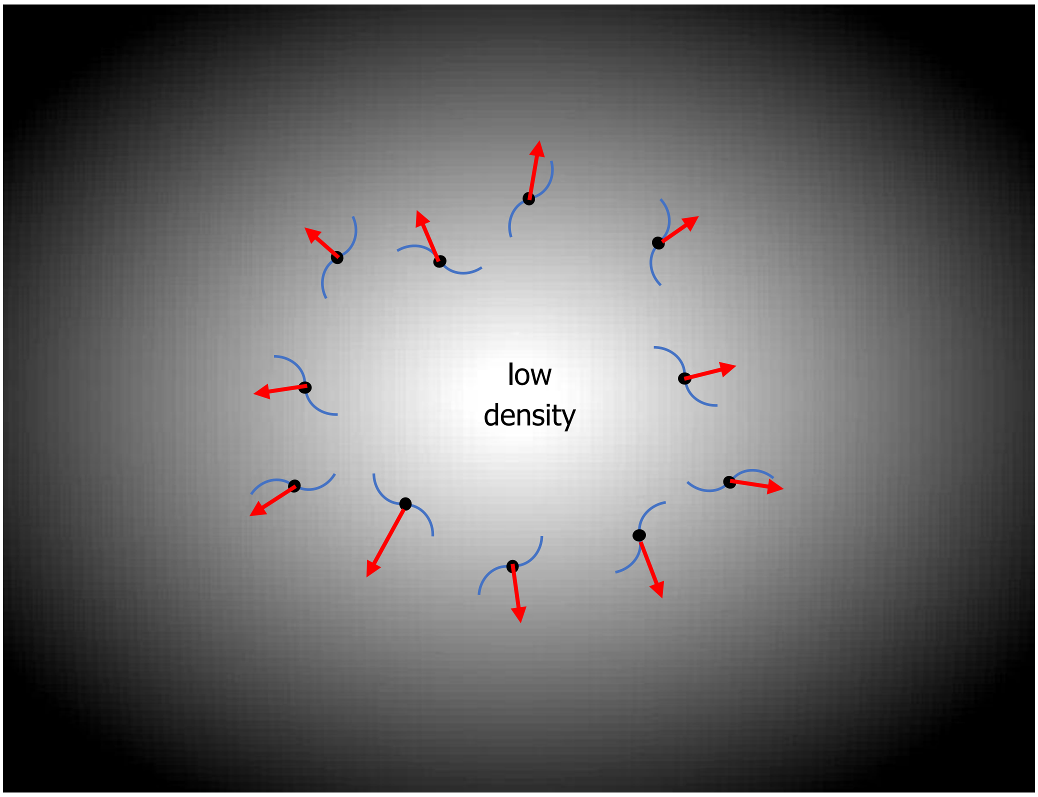

Fig. 16. A large zone with a low density of unorganized mass. Entire galaxies are accelerated away from this type of zone. Astrophysicists have termed this phenomenon as "dark energy."

During the formation of the universe, the unorganized mass was transformed into ordinary mass; therefore, zones with a low vacuum density were formed [20].

10. Global unification

The universal medium declared by the new paradigm has resulted in a global unification. Gravitational fields, dark energy, and dark matter are all manifestations of the same essence - an inhomogeneous universal medium. This medium is also the cause of all types of light deflection: near the Sun, in diffraction, and in refraction. A simple physical explanation has been provided for the phenomenon of "total internal reflection."

Many of these results were anticipated by Newton. He also believed that light deflection by the Sun is a consequence of gravity. However, calculations based on the acceleration of free-falling bodies led to a deflection angle corresponding to the ½ of the measured deflection.

The weak equivalence principle (WEP) of general relativity requires that all test masses experience equal acceleration in a gravitational field [21]. Based on the vortex structure of particles, the new paradigm shows that different particles can have different accelerations in the same gravitational field.

For example, let us explain why a photon moving horizontally in a gravitational field is deflected with an acceleration of 2g.

A derivation of the acceleration of gravity is given in [9] and [10], which show that this acceleration results from the deviation of the density wave in particle and atom vortices in the direction of a higher medium density. The peculiarity of a free photon is that it is extended in the direction of motion (Fig. 17).

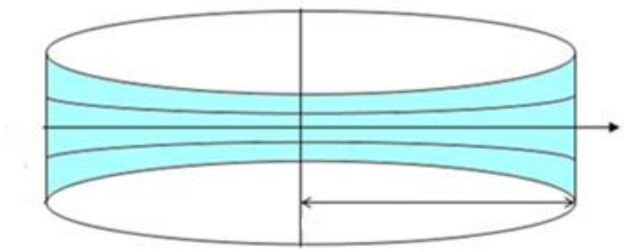

Fig. 17. Longitudinal cross-section of a photon in free flight according to its proportions (from Ref. [14]). For most of the rotational period of the vortex wave, the velocity is horizontal.

The vortex wave deflection follows [9]

$$d\alpha = \nabla u \sin \alpha \, dt$$

where u is the speed of the wave, α is the angle between $\vec{u}$ and ∇u, and $d\alpha$ is the deviation of $\vec{u}$ during dt.

For a horizontally moving photon, the wave speed $\vec{u}$ is horizontal for most of the period, i.e., perpendicular to ∇u. As a result, $\sin \alpha$ is at a maximum. Therefore, a horizontally moving photon reaches the maximum acceleration in the gravitational field.

In contrast, a vertically moving photon experiences zero acceleration because $\alpha = 0$. Thus, a photon can experience any acceleration ranging from 0 to 2g.

The vortex wave of a stationary electron does not have a predominant direction (Fig. 18). In the different phases of wave rotation, the angle α varies over the period of revolution, and thus, its acceleration in the gravitational field has an average of g.

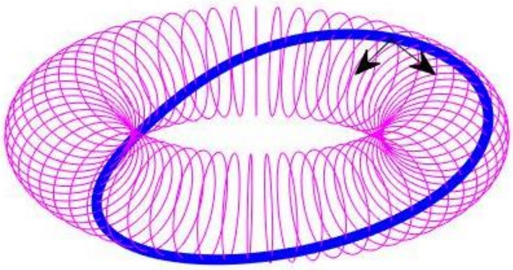

Fig. 18. Vortex wave of a stationary electron. The blue line presents the wavefront circulating in an electron. The arrows show two components of the velocity of a point on the wavefront: $v_\perp$ is perpendicular to the cross-section plane, and $v_\parallel$ is in the plane (from Ref. [12]).

By knowing the physical cause of free-fall acceleration, it becomes clear that the WEP is an unjustified postulate.

Conclusions

The new paradigm confirms the following concepts proposed by Newton:

1) Light consists of particles, not waves.
2) Refraction and diffraction of light have a single cause – medium inhomogeneity in the boundary layer.
3) "Total internal reflection" and gravity have the same cause.
4) The deflection of a light ray near the Sun can be determined from gravity by considering that the acceleration of a photon is twice that of bodies.

Additionally, this article has demonstrated that gravitational fields, dark energy, and dark matter are manifestations of the same entity.

Acknowledgment

I dedicate this article to Aya Bakman, who inspired me.

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