# Expansion of the Concept of the Term "Physical Vacuum" (Philosophy of Physics)

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## 1. Introduction

### 1.1. Limited Speed of Light in Vacuum

The classical physics of Newton is based on the principle of long-range action, which assumes an infinitely high speed of interaction of bodies at any distance [1]. Modern physics is based on the principle of short-range action [2]. The speed of interaction is limited and does not exceed the speed of light in a vacuum. The speed of light in a vacuum is also limited. In electrodynamics, it is determined from the wave equation as $c = (\varepsilon_0 \ \mu_0)^{-1/2}$, where $\varepsilon_0$ is an electrical constant, $\mu_0$ is a magnetic constant. The speed of light (like any electromagnetic wave) in matter, determined from the wave equation, $v = c \ (\varepsilon \ \mu)^{-1/2}$, where $\varepsilon$ is the dielectric constant, $\mu$ is the relative magnetic permeability. Obviously, the speed of light in matter is less than the speed of light in vacuum.

Why is the speed of light in a vacuum finite? It is known that the degenerate cases ($c = 0$ and $c \to \infty$) in nature are realized with the lowest probability. It is obvious that $c \neq 0$. This means that the speed of light in vacuum is finite. This is perhaps the only explanation.

In the theory of relativity, the speed of light (fundamental or invariant speed) is a fundamental constant. It is present in the Lorentz transformations [2] and in the Minkowski metric [3, 4]. The existence of this constant is associated with the pseudo-Euclidean nature of space-time in the special theory of relativity. This is a dimensional constant, i.e. it depends on the choice of the system of units. It can be set equal, for example, to one, or $3 \cdot 10^8$ m / s (in SI). As $c \to \infty$, the Lorentz transformations go over to the Galilean transformations of classical physics.

### 1.2. Postulate

So, the speed of light c in vacuum is finite, i.e. $c < \infty$. In matter, for $\varepsilon > 1$ and (or) $\mu > 1$, the speed of light $v$ slows down, that is, $v < c$.

Suppose there is some hypothetical substance (matter) that slows down the speed of light in a vacuum. In the absence of this substance, $c \to \infty$, in its presence, $c < \infty$ ($3 \cdot 10^8$ m / s). Let's take the postulate as a basis: light is "slowed down" by some material substance. For this reason, and in the presence of this substance, the speed of light is finite.

The term "ether" has long discredited itself. But, in order not to introduce new definitions, we conditionally call this hypothetical substance "ether field", understanding that it is qualitatively different from ether, considered as a physical object before the beginning of the XX century. Physical fields are often introduced formally for the convenience of describing phenomena.

## 2. Materials and Methods

### 2.1. Philosophy of Physics. From a Contemplative to a Heuristic Approach

Physics and philosophy are inextricably linked. For two or even three millennia of its existence, natural science has developed as an indivisible science of nature. Philosophers were engaged in science. The first works on natural philosophy (philosophy of nature) are attributed to S. Aristotle (treatises "Physics", "On the Sky", etc. [5], IV century BC) and L.A. Seneca ("Research on Nature" or "Natural Philosophical Questions" - "Naturales quaestiones" [6], 63 year A.D.). Seneca's "Philosophia naturalis" developed until the 18th century as an integral system of the most general laws of natural science. The development of physics as a science in the modern sense of the word originates in the first half of the 17th century with the mechanistic worldview of G. Galileo (who denies the speculative metaphysics of Aristotle), who believes that the movement of objects must be described mathematically, not limited to simple observation [7]. The traditions were continued by I. Newton in the work "Mathematical Principles of Natural Philosophy" (1687) [1].

Ancient scientists explored the world through contemplation. So, in ancient Greek, the word "θεωρια" ("theory") meant "contemplation", more precisely, "contemplation of God." Philosophers often contrast contemplation ("vita contemplativa") with action ("vita activa"). The "contemplative" approach can be formally classified as semi-phenomenological. It is well grounded, relatively simple and clear. The approach allows you to explore a wide range of phenomena. It is the contemplative approach that the authors use.

In the middle of the 20th century, the heuristic one replaced the ancient contemplative approach to the study of objects and phenomena. (In essence, this is a new name for the contemplative approach, from which God is purely formally excluded.) Heuristic methods are a special group of methods for collecting and processing information, based on the professional judgment of specialists, on creative thinking. Heuristics (from ancient Greek εὑρίσκω - "looking for", "discovering") is a scientific field that studies the specifics of creative activity [8] or the science of discovering something new [9]. In the general case, heuristics is understood as a set of techniques and methods that facilitate and simplify the solution of cognitive, constructive, and practical problems. Heuristic methods are opposed to a routine, formal enumeration of options according to given rules (compare "vita contemplativa" and "vita activa"). This is important in the creative process of creating and researching something fundamentally new, not yet known [8]. The heuristic is based on the maximum use of analogs of the investigated processes. General statements and formulas, inductive methods, analogies, plausible inferences, visual models and images, thought experiments, etc. [8] are used as heuristic means. Heuristics is a collection of techniques, procedures and methods that facilitate and simplify the solution of cognitive, constructive, and practical problems.

## 2.2. Wave Equation

The wave equation is used to describe wave processes. The wave equation in physics is a linear hyperbolic partial differential equation that sets small transverse vibrations (mechanical, acoustic, electromagnetic, gravitational). It has the form [10]:

$$\Delta u = \frac{1}{v^2}\frac{\partial^2 u}{\partial t^2} . \qquad (1)$$

Here $\Delta$ is the Laplace operator, $u$ is the function characterizing the displacement from the equilibrium position during mechanical oscillations; the vector of the electric field and the vector of the magnetic field in electromagnetic oscillations; the vector of the gravitational field in the gravitational interaction; $v$ is the wave propagation velocity, $t$ is the time.

## 2.3. Wave Speed

Mechanical wave speed is defined as $v = (E/\rho)^{1/2}$, where the parameter $E$ has different meanings. When a longitudinal elastic wave propagates in a solid thin long rod, $E$ is Young's modulus; with the propagation of transverse elastic waves in an infinitely isotropic solid medium, $E$ is the shear modulus of the medium; when longitudinal elastic waves propagate in homogeneous gases or liquids, $E$ is the bulk modulus of the substance; when a longitudinal wave propagates in gases, $E = \gamma p$, where $\gamma$ is the adiabatic exponent, $p$ is the pressure. In all cases, $\rho$ is the density of the material ($\rho = \text{const}$).

Wave speed $v \to \infty$ as $\rho \to 0$ and finite positive values of $E$, i.e., $0 < E < \infty$. As noted, the speed of the electromagnetic wave is $v = c\,(\varepsilon\,\mu)^{-1/2}$. The speed of light in vacuum $c = (\varepsilon_0\,\mu_0)^{-1/2}$.

In what cases is the wave speed $v$ infinite? Obviously, for mechanical waves: $\rho \to 0$. For electromagnetic waves: $c \to \infty$ or $\varepsilon\mu \to 0$. By definition: $\varepsilon \geq 1$, $\mu \geq 1$. Hence, only $c \to \infty$ remains. This is possible when $\varepsilon_0\,\mu_0 \to 0$.

## 2.3. Wave Equation Analysis

Let's analyze equation (1). The left side of the equation characterizes the spatial variation of the function $u$, the right - temporal one.

Let $v \to \infty$, which, in connection with our postulate, formally corresponds to the absence of a substance that slows down light in a vacuum. In this case, the right-hand side of expression (1)

tends to zero, i.e., $\Delta u \to 0$. The Laplacian is the second derivative with respect to coordinates. For example, in Cartesian coordinates $(x, y, z)$, the Laplace operator has the form: $\Delta = \frac{\partial^2}{\partial x^2} \frac{\partial^2}{\partial y^2} \frac{\partial^2}{\partial z^2}$. Thus, $\Delta u = 0$. This means that there are no oscillations of space.

Let us rewrite equation (1) in the form: $v^2 \Delta u = \frac{\partial^2 u}{\partial t^2}$. As $v \to \infty$ and $\Delta u \neq 0$ ($0 < \Delta u < \infty$), we obtain $\frac{\partial^2 u}{\partial t^2} \to \infty$ or, by the definition of the derivative, $\partial t \to 0$ or, in the limit, $\partial t = 0$. It means immutability, immobility, time, absence of fluctuations in time.

This means that the hypothetical substance under consideration is material and is responsible for the possibility of vibrations and waves.

## 3. Results

### 3.1. Properties of the Etheric Field
So, we assumed that light is "slowed down" by some material substance (called etheric field), in its absence $c \to \infty$ or $\varepsilon_0 \mu_0 \to 0$. Moreover: $\rho \to 0$ and $0 < E < \infty$. In the case $\rho \neq 0$, the absolute vacuum would be characterized by a nonzero density. (Vacuum has some of the properties of ordinary matter.)

Hence, the following conclusions can be drawn.

Ether is characterized by electrical and magnetic constants. Since $\mu_0$ and $\varepsilon_0$ are nonzero, it is formally possible to introduce the wave impedance of the ether field (by analogy with the wave impedance of vacuum or free space) as the ratio of the amplitude values of the electric and magnetic field strengths: $\frac{E}{H} = \sqrt{\frac{\mu_0}{\varepsilon_0}}$. The etheric field can be characterized by the properties of elasticity and pressure. Zero density means zero mass of the etheric field on average. Thus, this field can contain constantly emerging and disappearing virtual particles.

The ether should be homogeneous and isotropic, since the constants $\varepsilon_0$ and $\mu_0$ do not show in homogeneity and anisotropy. Ether cannot have voids (voids break homogeneity).

In the absence of ether, vibrations and waves are impossible. Also $c \to \infty$ or $\varepsilon_0 \mu_0 \to 0$. Electric constant was previously called the dielectric constant of vacuum. It is defined as $\varepsilon_0 = \frac{10^7}{4\pi c^2}$, m / Hn. Magnetic constant (or magnetic permeability of vacuum) is used as a coefficient of proportionality in expressions written in SI. So, $\varepsilon_0$ has the meaning of the ether dielectric constant, and $\mu_0$ has the meaning of the ether magnetic permeability.

### 3.2. Analysis of the properties of the Etheric Field
The etheric field is characterized by zero mass. By mass, according to the theory of relativity, we should understand the rest mass. Etheric field fills all space. In its absence, wave processes are impossible. This means that the etheric field should have appeared no later than the appearance of any waves, including light waves. Since all fundamental interactions can be described as physical fields in space-time, it is reasonable to assume that in the absence of etheric field, none of the fundamental interactions would be possible.

The absence of hesitation means "freezing" of space and time. This means that the etheric field is a more fundamental concept than the categories of space-time, and appeared no later than space-time. For the existence and propagation of waves (electromagnetic, gravitational, mechanical) an etheric field is necessary, for the existence of an etheric field there is no need either for waves or in the categories of space-time themselves.

One postulate often gives rise to different hypotheses.

From the above, we can conclude that the etheric field could well have existed before the appearance of space and time (?) or appeared together with these categories. Since the speed of fundamental interactions is limited by the ether field, this field itself can "spread" (outside time and space) instantly with infinite speed.

The following properties and features of the etheric field can be distinguished.

1. The etheric field is a hypothetical substance that limits the speed of light in a vacuum.

2. The etheric field does not show an internal structure, for this reason we do not introduce the concept of ether as some hypothetical substance. Essentially, the etheric field can formally be referred to as energy. The nature of the etheric field is not clear. The carriers of this field are not clear.

3. The etheric field is material. Analysis of its properties will make it possible to determine the properties of the so-called subtle matter (theologians distinguish between complex matters, that is, matter "made up" of something, composite, coarse, and simple or subtle matter [11]). Perhaps this is a step towards understanding the properties of subtle matter.

4. The etheric field can be considered as one of the possible mechanisms of the accelerated expansion of the Universe, as an alternative to the possibly non-existent dark energy. The etheric field should manifest itself in gravitational interaction.

The accelerated expansion of the Universe can be likened to the expansion of a balloon placed in a sealed vessel from which air is rapidly evacuated. In the Universe, near-boundary effects can be responsible for the accelerated expansion. For example, the authors of [12] consider the Casimir effect (a combination of physical phenomena, in particular, the attraction of two parallel mirror surfaces located at a small distance) to be the cause of the expansion. The reason for this effect is the energy oscillations of the physical vacuum due to the constant creation and disappearance of pairs of virtual particles and antiparticles in it (for example, photons and antiphotons, which are identical to photons) [13, 14]. In complex geometry, the Casimir force can be the force of attraction and the force of repulsion. It is possible that there are oscillations of the electromagnetic field of virtual antiphoton photons, possibly of the ether field. As a result, the pressure of virtual photons on one side of the surface turns out to be less than the pressure on them on the other side, where the production of photons is not limited by anything. This phenomenon can be described as negative pressure [14].

5. The etheric field generates the categories of space-time and all wave processes, which means all fundamental interactions. In the absence of the etheric field, the existence of space and time is impossible.

5.2. It is possible that the etheric field, in essence, is space-time. The interaction of physical objects (particles or waves) with the etheric field can lead to distortion of space-time, for example, at high speeds or near large gravitational masses.

6. The introduction of the ether field into consideration does not affect modern physical theories, "imperceptibly" fitting into them. On the one hand, this field does not manifest itself in any way, and there is no need for it to describe physical processes. On the other hand, without it, wave processes and the categories of space-time themselves are impossible. The etheric field is "not intrusive." Its properties and functions can be attributed to physical vacuum or heavy energy.

7. Sometimes in physics, for the convenience of considering certain problems, hypothetical particles and additional fields are introduced (postulated) (for example, an inflaton - a hypothetical elementary particle - a quantum of an inflations field [15]). The introduction of the etheric field is, in essence, one of the attempts to go beyond the categories of space-time, which have been undertaken by physicists in recent decades. All physical objects can only be described in terms of space-time. The etheric field is a macroscopic manifestation of the structure of the vacuum of quantized fields [14].

8. The physical vacuum can pretend to be the etheric field. Perhaps this field is the physical vacuum plus the categories of space and time. Note that in quantum physics the physical vacuum is understood as the ground energy state of the quantized field, which has zero momentum, angular momentum, and other quantum numbers. This state does not necessarily correspond to emptiness [16].

In physics, there are many theories suggesting the existence of the ether as a substance or field that fills all space, which would serve as a medium for the propagation of electromagnetic and gravitational interactions. However, electromagnetic and gravitational waves do not need such a mediator. But could they spread outside the physical vacuum and outside the categories of space-time?

### 3.3. Ether field quantum

Before the Planck era, there was a single interaction that combined strong, electromagnetic, weak and gravitational. The unification of all four types of fundamental interactions (a single super symmetric interaction) corresponds to energy of $\sim 10^{19}$ GeV (Planck energy), an interaction radius of $\sim 10^{-33}$ cm (Planck length) [17].

It can be assumed that the quantum of the unified interaction is the maximon, that is, an elementary particle of the maximum possible mass (Planck mass), in other words, the cosmological singularity. Maximon can also be considered a quantum of the etheric field. It is a fundamental particle, that is, it does not consist of other particles. A maximon cannot be a composite particle also for the reason that a size smaller than the Planck length (the characteristic size of a maximon) has no physical meaning.

## 4. Discussion and analysis of results

### 4.1. Expanding the Possibilities of Physics: New Physics Objects

The definition of physics as a science in the 20th century has changed several times. This is due to the refinement of what can be considered a physical object. It is safe to say that physics studies material objects that can be described in terms of space-time. So far, there have been no successful attempts to extend physics either to immaterial objects or to subtle matter. The concept of subtle matter (St. Ignatius Brianchaninov sometimes calls it ether or etheric body [18]) was introduced by theologians to describe the spiritual world, its difference from the material (or material) world [11]. In theology, simple and complex objects (subjects) are distinguished. Complex (stacked from others) have an internal structure. For example, a neutron consists of interacting quarks, a molecule consists of atoms, and a person consists of organs. There is a concept of fundamental particles that do not consist of others. An example is leptons, quarks. Simple (in the sense of not composite, as opposed to "gross" or "complex" - "composed of other particles or objects" of matter) spiritual (incorporeal) objects or subjects are referred to as subtle matter. Subtle matter has its own gradations depending on the complexity, on the "degree of materiality" in our understanding. (Examples: God, disembodied spirits, soul.) But it is still matter [19]. (Sometimes God is referred to as pure spirit, that is, not material.) For the existence of subtle matter there is no need for the categories of space-time, it is assumed that it existed before the appearance of these categories.

The ethereal field proposed by the authors may turn out to be some kind of connecting substance between gross and subtle matter. (Then subtle matter can be conditionally called ether. Among the subjects of subtle matter, one can single out a certain "absolute", "absolute frame of reference" or God.)

The etheric field is a kind of basis for the categories of space-time and for the substance described within these categories. Of course, many will think this is a pseudoscience, but the main thing is that physics as a natural science, as the basis of natural science, for the first time has a fundamental opportunity to go beyond the limits of space-time.

The word "world" is used as a synonym for the Universe in philosophy. The philosophical world contains material and spiritual components. The first of them is the material Universe (in the language of philosophers and theologians, this is rough matter), described in terms of space-time. The second is subtle matter and eternity, capable of existing outside the categories of space-time, since space-time is a form of existence of gross matter.

Is it possible to determine the properties of non-physical objects? The only way is to select from the entire philosophical world a subset containing coarse matter (as opposed to fine), along with fine. We cannot exclude subtle matter and eternity from this subset, since they fill the entire philosophical world. Further, one can investigate the selected subset by physical scientific methods, determine the characteristic properties of gross matter, characteristic of space-time, and then exclude these properties when analyzing the spiritual world: subtle matter and eternity. This is the approach used by the authors of the article.

In nature, there are phenomena and objects that are almost impossible to describe within the framework of existing physical theories. Such physical objects can equally include dark energy

(included in the mathematical model of the Universe to explain its accelerated expansion) [20, 21], "quantum" cosmological vacuum (the theory of D.B. Zel'dovich [22]) and the ether field (which may turn out to be precisely this physical vacuum), to phenomena - gravity and antigravity.

To analyze such phenomena and objects, it is reasonable to use heuristic or contemplative approaches. Note that sometimes several different vacua (vacuum states) are introduced into consideration, differing in physical parameters (energy density, etc.).

*4.2. Preliminary conclusions about some fundamental physical properties of the intangible world*
Modern physics can be extended to include objects that never belong to physical objects. On the basis of a heuristic-contemplative approach to a preliminary analysis of the existence of the etheric field, it is possible to determine some fundamental physical properties of the immaterial world (eternity and subtle matter). As noted, the ether field introduced into consideration performs the functions of a "limiter" of physical quantities in nature. Going beyond the space-time, a simple extrapolation can reveal the properties of eternity. Limiting functions in nature (in space-time) are performed by fundamental constants: the speed of light in vacuum, Planck's constant, gravitational constant. On their basis, it is possible to enter Planck time, length and mass, which also perform limiting functions. In other words, the material world described in terms of space-time is quantized. This is its fundamental property.

Excluding the etheric field and everything connected with it, we get the following.

1. In eternity, there are no physical quantities that play a limiting role.

2. The speed of light is infinite. (But this light, apparently, is not photonic.) This means that the cause-and-effect relationships of events can be violated.

3. Planck's constant is zero. Eternity (like subtle matter) is not quantized. It is continuous, isotropic, and has no voids.

4. The gravitational constant is zero. This means that there are no gravitational forces (as well as other forces of fundamental interactions that do not manifest themselves in eternity). In the absence of gravity, gravitational mass loses its meaning. Objects of eternity (subtle matter) are pure energy that can pass into matter in the area of the world described by the categories of space-time, i.e. in the material Universe (since Einstein's formula $E = mc^2$ is applicable in this area).

The absence of the etheric field indicates the absence of wave (oscillatory) processes in eternity and subtle matter.

## 5. Conclusion
On the basis of a heuristic approach, a hypothesis is formulated about the existence of a certain material substance that limits the speed of propagation of light in a vacuum. In the absence of such a substance, the speed of light is infinite. By analogy with the ether of classical physics, this substance is conventionally called the ether field. Slowing down of light is one of the manifestations of the etheric field.

The etheric field is a material substance with zero (or close to zero) density, characterized by dielectric constant (electric constant) and magnetic permeability (magnetic constant). Ether can have elastic properties and be characterized by pressure. The etheric field can pretend to be dark energy.

In the absence of the etheric field, wave processes are impossible, fundamental interactions are impossible, the categories of space and time are impossible. The etheric field is a kind of mediator of fundamental interactions. The ether introduced into consideration performs the functions of a "limiter" of physical quantities in nature. He is responsible for implementing all kinds of fundamental interactions. The etheric field is responsible for the implementation of the principle of short-range action. The etheric field can manifest itself in the expansion of the Universe.

The etheric field can manifest itself in limiting the speed of light and, possibly, in the expansion of the Universe, in limiting the speed of fundamental interactions, their intensity and forces, in limiting some physical quantities. (For example, the Coulomb force of interaction of two electric charges and the electric field strength at $\varepsilon_0 = 0$ are infinite. The magnetic induction and magnetic field strength at $\mu_0 = 0$ are infinite.)

In the absence of the ether field: $c \rightarrow \infty$ or $\varepsilon_0\mu_0 \rightarrow 0$. The ether field is a material substance with zero density, can have elastic properties and be characterized by pressure, is characterized by dielectric constant (electric constant) and magnetic permeability (magnetic constant).

The internal structure of the etheric field is not clear. So far, nothing says about its quantization. At the same time, the quantum of this field can be a maximon - a cosmological singularity. The speed of light in a vacuum, like Planck's constant, has a limiting meaning in physics. In the absence of the etheric field, there are no such restrictions. The etheric field can claim to be dark energy responsible for the expansion of the Universe. The etheric field is not an absolute frame of reference. It is a kind of mediator of all fundamental interactions, hence all physical processes.

Thus, the introduced ether field, which claims to be dark energy, performs the functions of a "limiter" of physical quantities in nature, responsible for the implementation of fundamental interactions and the implementation of the principle of short-range action. The etheric field performs the functions of a substance that expands the Universe.

The etheric field is not connected by the categories of space-time. This means that it can exist everywhere in the world, inside and "outside" the material Universe. Due to the existence of this material field in the Universe, we can apply physics to study it, in other words, the etheric field is a physical object. The properties of the ether field inside the Universe and "outside" it should not change. The etheric field unites the material world and separates it from the immaterial. By "switching off" the etheric field, we can obtain the properties of the non-material world.

Thus, we expand the range of problems that physics can solve, limiting the scope of research to the categories of space-time and extrapolating their results into eternity. Due to the existence of subtle matter inside and "outside" the Universe, we can also conditionally consider it as a physical object, using for research the contemplative-heuristic scientific approach that has become modern.

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