UDC 530.145.85

HYPOTHESIS OF THE CONTINUOUS NATURE OF TIME AND BARYON ASYMMETRY

Kenesov N.K.
E-mail: kenesov.nursat04@gmail.com

In both classical and quantum physics, the concept of time holds a special place as a tool for calculation and the description of physical processes. However, paradoxically, relatively little attention is given to understanding the essence of time itself.

To this day, physics lacks a unified and generally accepted conceptual definition of time. For example, in the framework of classical mechanics, time is considered a continuous, a priori given, and undefined characteristic of the universe. It is treated as absolute and identical for all observers. Time is measured through periodic processes — such as the rotation of celestial bodies, the oscillations of pendulums, or the vibrations of crystals in atomic clocks. However, this approach relies not on a definition of time's nature but on its empirical measurability.

In Einstein's special and general theories of relativity, time loses its absoluteness. It becomes relative and dependent on the frame of reference. For instance, if an observer moves at near-light speed or is located near a massive body (such as a black hole) where strong gravitational fields prevail, their perception of time differs from that of a distant observer. This effect is known as time dilation and has been confirmed by numerous experiments.

Yet, despite the rigor of the mathematical formalism of relativity theory, the concept of time itself remains descriptive rather than definitional. In other words, physics can model, measure, and predict the behavior of time, but it does not explain what time actually is. This is similar to describing sodium hydroxide as a colorless liquid without specifying its chemical formula — a description is provided, but the essence is not captured. Even in the Feynman Lectures on Physics, it is emphasized that time is one of those concepts that cannot be strictly defined. According to Feynman, time is merely "something that separates two sequential events." That is, time is a structural property of processes rather than a substance [1].

A popular encyclopedia such as Wikipedia defines time as the continuous progression of existence, occurring in an evidently irreversible sequence from the past, through the present, and into the future [2]. However, this definition, too, remains more of a philosophical description than a physical explanation. In practice, human perception of time is shaped by the observation of periodic motion — such as the movement of the Sun across the sky, the phases of the Moon, or the swing of a pendulum. In modern physics, time is also often regarded as the fourth dimension of spacetime, uniting with the three spatial dimensions to form a unified continuum. So, what is time? Based on my reflections and observations, I propose the following definition: time is a measure of energy — or more precisely, quality that determines the amount or density of the body's total energy.

As is known from the theory of special relativity, when an object with mass moves at a velocity approaching the speed of light in a vacuum, its relativistic mass and, consequently, its momentum increase without bound. This relativistic growth is the fundamental reason why any massive object cannot reach or exceed the speed of light, as doing so would require an infinite amount of energy.

A direct consequence of this relationship is that the total energy of the object also increases with its velocity. In contrast, photons, which always move at the speed of light, possess zero rest mass. Despite this, they carry both momentum and energy. The momentum of a photon does not originate from mechanical motion of mass but is instead an intrinsic property of the electromagnetic field, characterizing its ability to transfer energy and momentum through space.

Furthermore, motion at significant fractions of the speed of light results in time dilation, a phenomenon where time, as measured by an external observer, elapses slower for the moving object. This effect provides a profound connection between kinematics and dynamics: the degree of time dilation is directly related to the total energy of the object. Since these quantities are proportional, one can be expressed in terms of the other. Consequently, the measurement of time dilation can serve as a direct measure of the object's relativistic energy, effectively allowing one quantity to define or substitute for the other within the framework of relativistic physics.

In addition, the utilization of time dynamics, as will be elaborated upon, facilitates a profound unification of the concepts of mass-energy and energy of motion. This unification is possible because an increase in the relativistic mass of an object, resulting from its high velocity, manifests in time dilation effects that are observationally equivalent to those caused by a gravitational field.

§ 1. Expressing the full energy of the body through a change in the time characteristic

According to the principle of equivalence from General Relativity, a body with increased mass-energy (be it from high speed or simply being in a gravitational potential) warps spacetime in a similar manner. Consequently, the rate at which time flows for such a body slows down from the perspective of an external observer. This deceleration of time occurs identically whether the mass-energy increase is due to the object's motion (kinetic origin) or its presence in a gravitational field (mass origin).

Thus, since the degree of time dilation is directly and proportionally related to the total energy content of the system, it can serve as a fundamental metric for energy itself. This provides a unified framework where the energy of motion (kinetic energy) and the energy inherent in mass (rest energy) are not separate entities but different manifestations of the same underlying quantity, measured through their common effect on the fabric of spacetime.

Let's start the calculation, which should result in a relationship between energy and time. To make it easier to understand, I will provide a detailed solution. Let's start with Einstein's equation of total energy, which can be written as follows:

$$E^2 = (pc)^2 + (mc^2)^2.$$

It can also be written as:

$$E^2 = \left(m_p v c\right)^2 + (m_0 c^2)^2.$$

Or:

$$E^2 = E_m^2 + E_p^2. \tag{1}$$

$$E_m = m_0 c.^2 \tag{2}$$

$$E_p = pc = m_p v c. \tag{3}$$

Given that we are considering a static, spherically symmetric object (without rotation or electric charge), we will employ the Schwarzschild metric for our analysis. This metric is particularly convenient for examining the geometry of spacetime in the vicinity of such a mass. Specifically, the Schwarzschild solution can be effectively used to derive the phenomenon of gravitational redshift.

The metric looks like this:

$$ds^2 = -(1 - 2GM/rc^2)\, c^2dt^2 + (1 - 2GM/rc^2)^{-1}\, dr^2 + r^2(d\theta^2 + \sin^2\theta\, d\varphi^2).$$

In this equation, we are only interested in how the rest mass relates to changes in time:

$$d\tau = dt \times \sqrt{1 - \frac{2Gm_0}{rc^2}}. \tag{4}$$

Where τ is how time changes near or directly in the object being studied. And t is defined as the time that passes for an observer who is preferably located in an infinitely distant place and for whom there is no external force and therefore no relativistic effects. Let's find m_0 from here (4):

$$m_0 = \left(1 - \left(\frac{d\tau}{dt}\right)^2\right)\frac{rc^2}{2G}. \tag{5}$$

We need to put this m_0 (5) in the E_m (2) equation:

$$E_m = \left(1 - \left(\frac{d\tau}{dt}\right)^2\right)\frac{rc^4}{2G}. \tag{6}$$

As we can see, $\frac{d\tau}{dt}$ in this equation is the reverse Lorentz factor, which is also defined as $1/\gamma = \sqrt{1 - \frac{v^2}{c^2}}$, or $\sqrt{1 - \frac{2Gm_0}{rc^2}}$ from (4). When this factor approaches zero, time dilation becomes infinite, meaning time appears to stop completely for a distant observer at a specific location known as the event horizon ($r = 2GM/c^2$). When the factor equals one, gravitational time dilation is negligible; this occurs at an infinite distance from the mass or in a flat spacetime geometry. In this case, the coordinate time t of the distant observer elapses at the same rate as the proper time τ of an observer located at that point. The quantity $c^4/(2G)$ is a fundamental constant with the dimensional units of force (Newtons, or kg·m/s²). Its numerical value is approximately 6.051×10^{43} N. Let us denote this constant as K.

Thus, by defining dτ/dt as the time dilation factor ($\frac{1}{\gamma} = \alpha$) and $K = c^4/(2G)$, we can express the equation (6) in the following form:

$$E_m = (1 - \alpha^2)Kr. \tag{7}$$

Now we need to express E_p (3) in terms of α First, we will find m_p from the Lorentz transformation equation for mass:

$$m_p = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{\frac{(1-\alpha^2)Kr}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}} = \frac{(1-\alpha^2)Kr}{c^2\sqrt{1-\frac{v^2}{c^2}}}.$$

We can find the velocity (v) using the reverse Lorentz factor (α):

$$dt = \frac{d\tau}{\sqrt{1-\frac{v^2}{c^2}}};\ \frac{d\tau}{dt} = \sqrt{1-\frac{v^2}{c^2}}\ or\ \alpha = \sqrt{1-\frac{v^2}{c^2}}.$$

then v is equal to:

$$v = c\sqrt{1-\alpha^2}.$$

Let's combine all these formulas to find E_p:

$$E_p = m_p v c = \frac{(1-\alpha^2)Kr}{c^2\alpha} \times c\sqrt{1-\alpha^2} \times c = \frac{1}{\alpha}\sqrt{1-\alpha^2}(1-\alpha^2)Kr. \qquad (8)$$

Combined energy:

$$E^2 = \left((1-\alpha^2)Kr\right)^2 + \left(\frac{1}{\alpha}\sqrt{1-\alpha^2}(1-\alpha^2)Kr\right)^2.$$

The simplified view looks like this:

$$\mathrm{E} = \frac{1}{\alpha}(1-\alpha^2)Kr. \qquad (9)$$

As an addition to the previous one, we can transform the (5) equation to obtain a dependence on the radius vector:

$$m_0 = (1-\alpha^2)\frac{rc^2}{2G};\ r = \frac{2Gm_0}{(1-\alpha^2)c^2}. \qquad (10)$$

If time slows down to a complete stop, then the reverse Lorentz factor becomes equal to zero. As a result, we obtain the formula for the Schwarzschild radius:

$$\frac{2Gm_0}{(1-\alpha^2)c^2}\lim_{\alpha\to 0} = \frac{2Gm_0}{c^2};\ r_0 = \frac{2Gm_0}{c^2}.$$

To visualize our result, we can find graphs of identically dependent functions. For example:

Case A: $E_m = (1-\alpha^2)Kr \rightarrow y = 1 - x^2.$ (figure 1)

Case B: $E_p = \frac{1}{\alpha}\sqrt{1-\alpha^2}(1-\alpha^2)Kr \rightarrow y = \frac{1}{x}\sqrt{1-x^2}(1-x^2).$ (figure 2)

Case C: $\mathrm{E} = \frac{1}{\alpha}(1-\alpha^2)Kr \rightarrow y = \frac{1}{x}(1-x^2).$ (figure 3)

I have labeled each energy formula as three cases (A,B,C). This is necessary for simplifying further discussions.

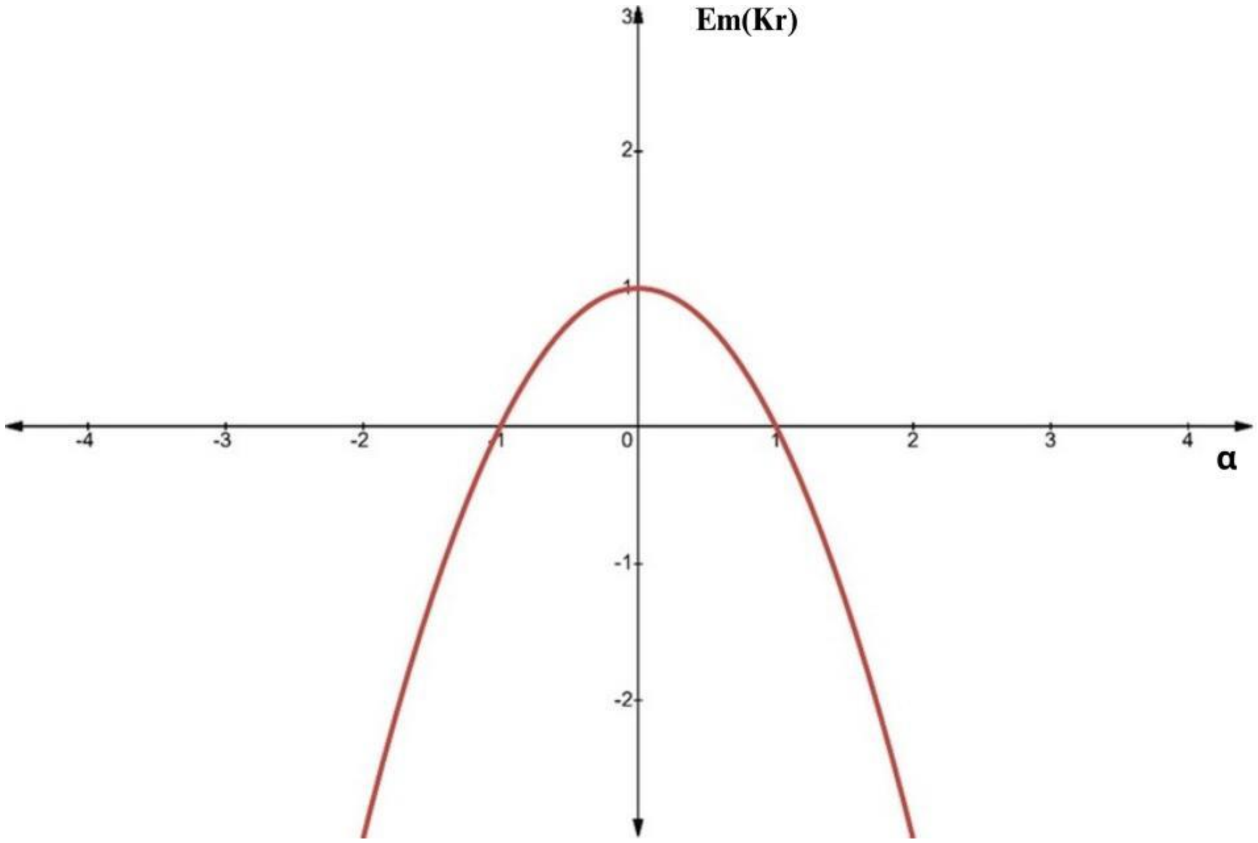

Figure 1

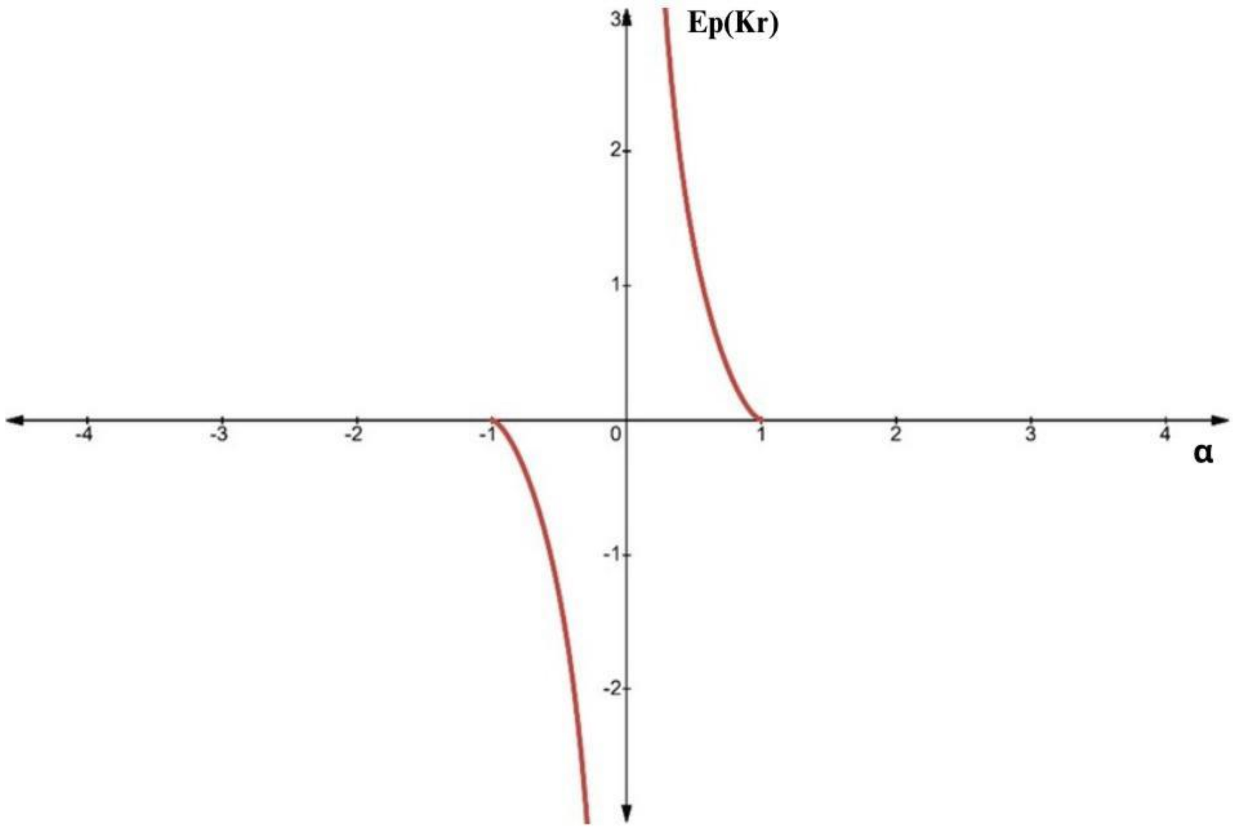

Figure 2

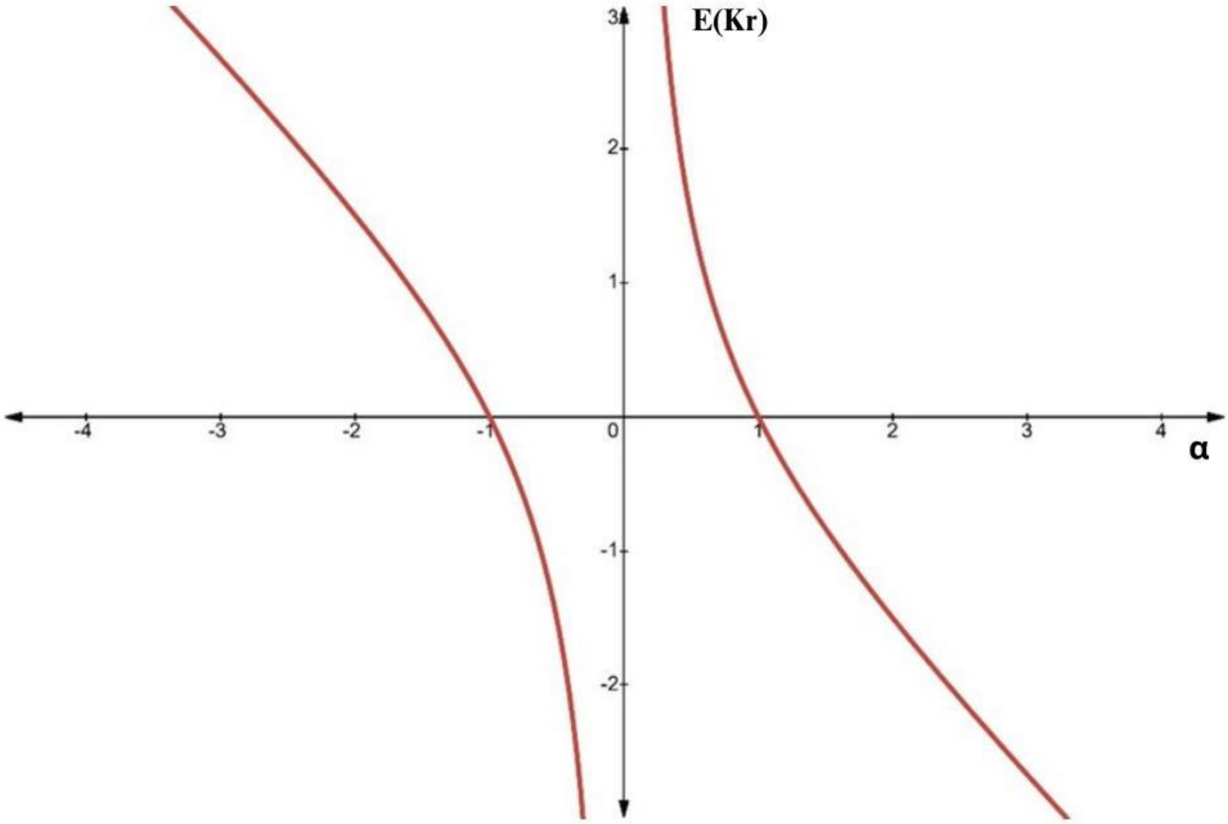

Figure 3

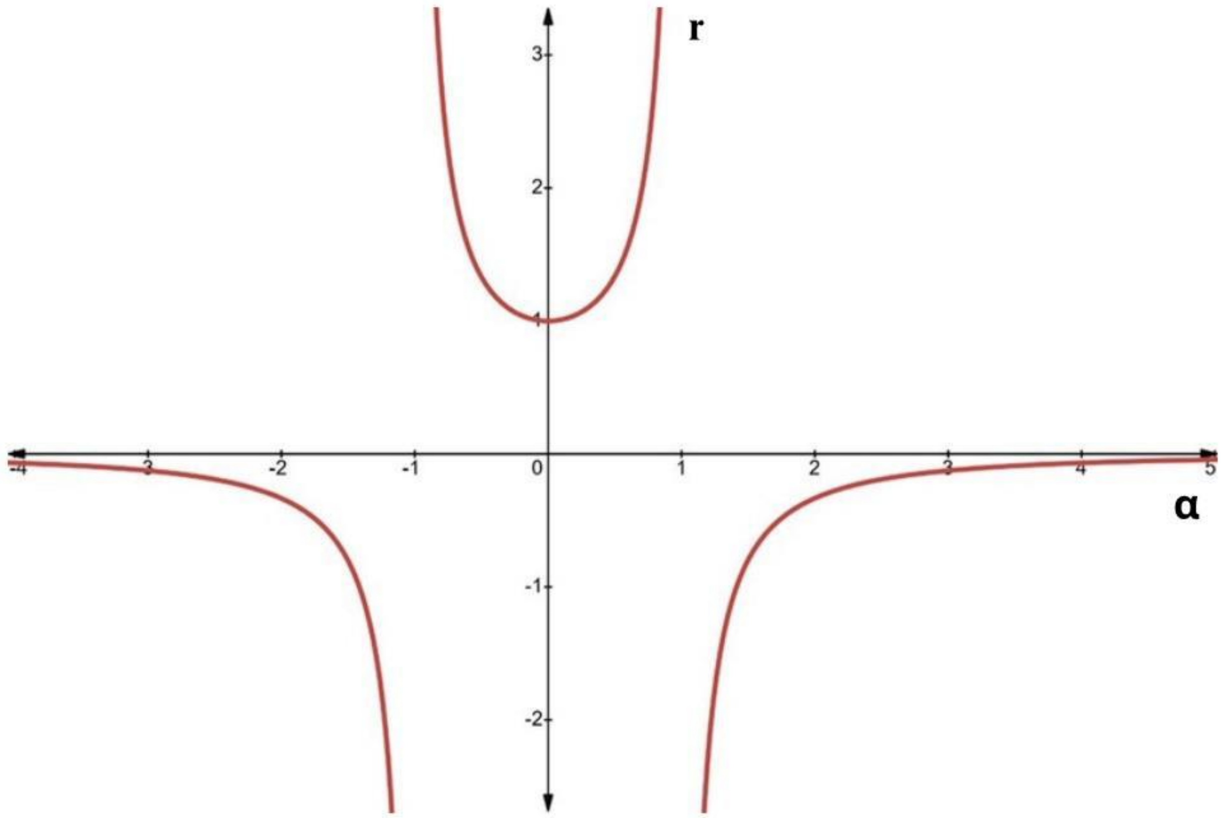

Figure 4

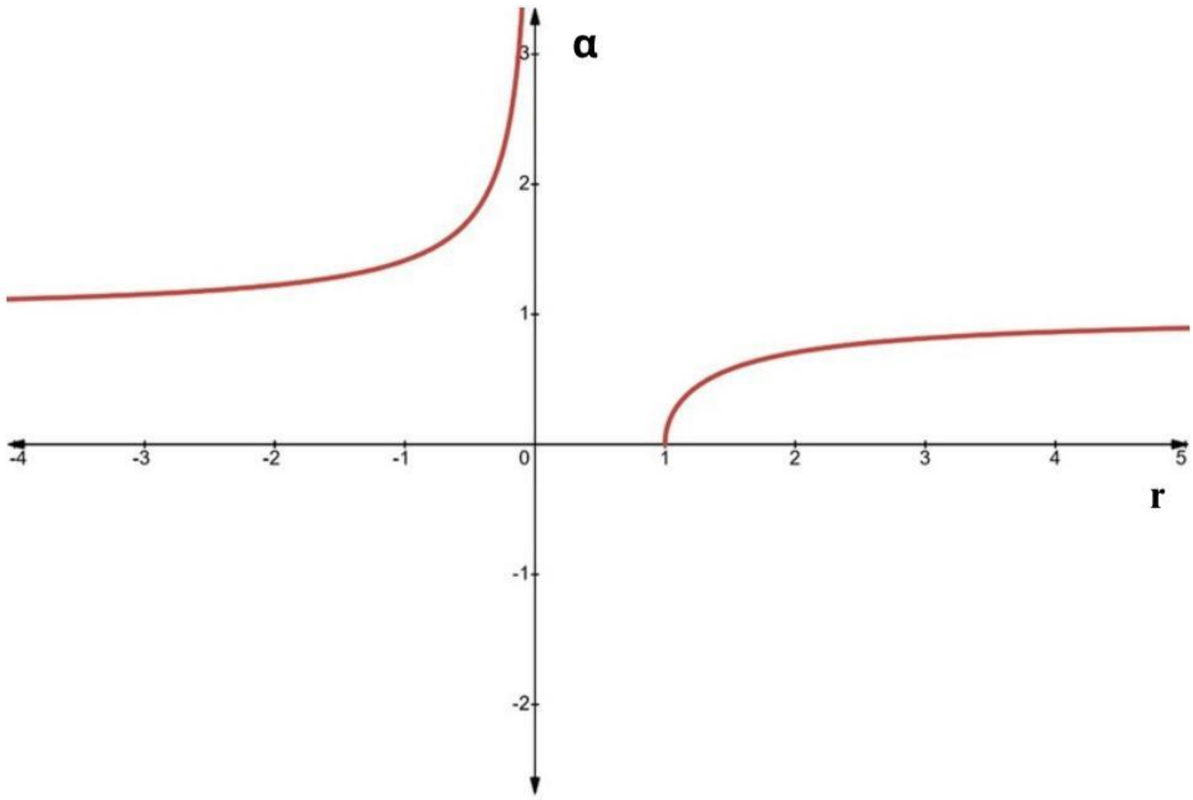

Figure 5

We should also express the radius vector equation (10) as a graph of some functions dependent on α:

$$r = \frac{2Gm_0}{(1-\alpha^2)c^2} \rightarrow y = \frac{1}{1-x^2}. \text{ (figure 4)} \tag{11}$$

If we want to see the dependence of α on the distance (radius vector), we need to find the inverse function of (11).

$$\alpha = \sqrt{1 - \frac{2Gm_0}{rc^2}} \rightarrow y = \sqrt{1 - \frac{1}{x}}. \text{ (figure 5)}$$

It is not hard to see that the inverse function of (11) is the same reverse Lorentz factor that we have already found (4), as it should be. Another consequence is that the inverse function we found is slightly different from the function itself. In particular, it loses the negative region α as a result of extracting the roots. But it doesn't lose its meaning if we use a complex function.

All these graphs show us that the relationship between our components is not as directly proportional as we would intuitively expect. But before proceed to explanation the physical meaning of all these graphs, I would like to describe three cases that we have derived in different regions of α.

To begin, let us take the value $\alpha=\pm 1$ as the normal speed of time flow (NSOT). NSOT can be considered as an isolated system (without external forces) in an absolute vacuum without energy or mass. Let's consider all the cases:

1. $-\infty < \alpha < -1$

Time flows backward (negative direction) faster than NSOT. We use three cases:

A) Energy is negative (E<0). To further accelerate the backward flow of time, one must add negative energy, and to accelerate the forward flow of time, one must add positive energy.

B) Energy of the body is undefined. To accelerate time forward, additional negative energy is required. Backward acceleration of time is impossible.

C) Energy is positive (E>0). To further accelerate the backward flow of time, one must add positive energy, and to accelerate the forward flow of time, one must add negative energy.

2. $\alpha =-1$

Time flows backward (negative direction) with the speed of NSOT.

A) Energy is zero (E=0). This means that maintaining such a state requires no energy. To further accelerate the backward flow of time, negative energy must be added, and to accelerate the forward flow of time, positive energy must be added.

B) Energy is zero (E=0). To accelerate the forward flow of time, negative energy must be added. Backward acceleration of time is impossible.

C) Energy is zero (E=0). To further accelerate the backward flow of time, positive energy must be added, and to accelerate the forward flow of time, negative energy must be added.

3. $-1< \alpha <0$

Time flows backward, but slower than NSOT.

A) Energy is positive (E>0). To further accelerate the backward flow of time, negative energy must be added, and to accelerate the forward flow of time, positive energy must be added.

B) Energy is negative (E<0). To further accelerate the backward flow of time (up to $\gamma=-1$), positive energy must be added, and to accelerate the forward flow of time, negative energy must be added.

C) Energy is negative (E<0). To further accelerate the backward flow of time, positive energy must be added, and to accelerate the forward flow of time, negative energy must be added.

4. $\alpha =0$

Time is completely stopped.

A) Energy is maximal (E=1 or E=Kr). Here, an interesting situation arises. In order for time to flow either backward or forward, negative energy must be added. Which direction nature chooses seems to be pure probability.

B) Energy is infinitely positive or infinitely negative ($E=\pm\infty$). For time to flow backward, positive energy must be added; for time to flow forward, negative energy must be added.

C) Energy is infinitely positive or infinitely negative ($E=\pm\infty$). For time to flow backward, positive energy must be added; for time to flow forward, negative energy must be added.

5. $0< \alpha <1$

Time flows forward, but slower than NSOT.

A) Energy is positive (E>1). To slow down time (movement toward negative γ), positive energy must be added; for time to flow forward and accelerate, negative energy must be added.

B) Energy is positive (E>1). To slow down time (movement toward negative γ), positive energy must be added; for time to flow forward (up to γ=1) and accelerate, negative energy must be added.

C) Energy is positive (E>1). For time to flow backward (slowing down), positive energy must be added; for time to flow forward (acceleration), negative energy must be added.

6. α =1

Time flows normally (NSOT). It can be considered as the flow of time in a massless vacuum without external forces and relativistic effects.

A) Energy is zero (E=0). To slow down time (movement toward negative γ), positive energy must be added; for time to flow forward and accelerate, negative energy must be added.

B) Energy is zero (E=0). To slow down time (movement toward negative γ), positive energy must be added; for time to flow forward (up to γ=1) and accelerate, negative energy must be added.

C) Energy is zero (E=0). For time to flow backward (slowing down), positive energy must be added; for time to flow forward (acceleration), negative energy must be added.

7. 1< α <+∞

The speed of the flow of time is greater than NSOT, in the positive direction of acceleration.

A) Energy is negative (E<0). To slow down time (movement toward negative γ), positive energy must be added; for time to flow forward and accelerate, negative energy must be added.

B) Energy is undefined. To slow down time (movement toward negative γ), positive energy must be added. Forward acceleration of time is impossible.

C) Energy is negative (E<0). For time to flow backward (slowing down), positive energy must be added; for time to flow forward (acceleration), negative energy must be added.

If we look at figure 1, we can see that there is a certain value of E when α=0, which is different from figures 2 and 3. The reason for this is that for a body that does not have a velocity, we can achieve time dilation by increasing the mass and, consequently, the total rest energy. Examples of this include quasars and black holes, which have a radius smaller than the Schwarzschild radius. As a result, the density of energy or mass is infinite at the center of these celestial bodies. It is also assumed that time stops at the center compared to an external observer.

The situation is different with case B. It is noteworthy that in Figure 2, the function is discontinuous, and there are no values for the time coefficients or the momentum energy values for α >1 or α<-1. This can be explained by the fact that in Figure 2, the energy of a body depends primarily on its velocity rather than its mass. In other words, this is the case of mass particles moving at a specific velocity. The exception is photons, which do not have a rest mass. Due to the discontinuity of the graph, we can see that for any value of α, the result does not have negative velocity values. This sounds completely absurd. But in this case, the phrase "negative speed" has nothing to do with a negative vector speed, which is determined by the direction of movement in a specific space (2D, 3D). Simply put, in our case, we are considering a speed module that is positive in any of its directions. That is, regardless of how the body is moving, regardless of how fast it is moving, it is impossible to speed up the flow of time (regardless of whether it is flowing forward or backward) near a moving body whose momentum is determined only by its mass, rather than its wave nature, compared to an infinitely distant object for which there are no relativistic effects. From this, it naturally follows that there are only two possible states for a body, which indicate its non-mirror nature: either the body is moving or it is at rest, and there is no third state. Figure 3 indicates a combination of these two equations. It can be seen that the acceptable values of $\alpha > 1$ and $\alpha < -1$ arise purely from the case of A.

This raises another question. Let's imagine a photon traveling at the speed of light. As a thought experiment, let's assume that the photon has an internal, precise clock, which we'll call A. Additionally, let's assume that there is another object nearby with a zero velocity and a clock called B. If there were only these two objects in the world, it would be impossible to determine which object is moving at which velocity. But if we assume that a photon only moves at the speed of c (the speed of light), and the observer has some mass and a sufficiently large momentum, then when two bodies approach or recede at the speed of light, we can approximately say that it is the photon that is moving.

Now let's apply the photon's speed to the inverse Lorentz equation:

$$\alpha = \sqrt{1 - \frac{v^2}{c^2}};\ \text{when v=c, then } \alpha\text{=0.}$$

α=0 in our graph is equal to a complete stoppage of time. This would mean that for clock A, 0 seconds (milliseconds, nanoseconds, it doesn't matter) would pass in any amount of time for clock B. If we rephrase it, for a photon to travel any distance, it would need to travel at an infinite speed, which is not the case. This seemingly paradoxical situation arises from a misconception of time. If we view time not as a metric, but as a field originating from a source, we can imagine that time has its own waves moving at a specific speed, which are influenced by changes in this field. If we assume that these "waves of time" do not travel at infinite speed, but rather at the speed of light, our discrepancy becomes resolved. While this may not be a definitive statement, it provides a framework for understanding and explaining certain inconsistencies. Therefore, I am more inclined to the hypothesis of the limited speed of propagation of time waves (or the expansion of the time field).

Here you may have a misunderstanding about the essence of time itself. In many areas of physics, especially in Special Relativity, time is used as something that is directly related to space. For example, the four-dimensional pseudo-Euclidean Minkowski space describes time according to the square of the interval:

$$s^2 = c^2(t_1 - t_0)^2 - (x_1 - x_0)^2 - (y_1 - y_0)^2 - (z_1 - z_0)^2$$

We can see here that the coordinates (x,y,z) have the opposite sign compared to t. In simple words, if a body is moving in a certain direction, its time would slow down compared to a body that is not moving. This means that the body's motion is always directed against the flow of time, which is not surprising and we can expect a similar solution for Figure 2 or formula (8). Additionally, if a body is not moving at all, meaning that its spatial components (x,y,z) do not change, it does not mean that it is not moving in "time space." For example, a table that does not move relative to the ground still moves in time space, because time passes for it in almost the same way as it does for other bodies. This is interpreted as meaning that any material body has full energy not only because it has mass, but also because it is actually moving in time space and slowing down or accelerating its effect on the time-space continuum around it.

§ 2. Defining the concept of antiparticles

Now that we have described all the processes, we can start discussing the physical meaning of the results. At the outset, it is important to note that in our three cases we encounter both positive and negative energy solutions. The idea of negative energy is not new; it naturally emerges from the equations of Paul Dirac formulated in 1928. Dirac's relativistic wave equation for the electron led to the surprising prediction of states with negative energy, which at the time posed a serious theoretical problem. To resolve this apparent paradox, Dirac proposed the existence of a corresponding particle with the same mass and spin as the electron but with opposite electric charge — later identified as the positron.

The existence of such antiparticles was experimentally confirmed in 1932 by Carl D. Anderson, who discovered the positron in cosmic ray experiments, and later systematically studied by Emilio Segrè and Owen Chamberlain in 1955 at the University of California, Berkeley, when they discovered the antiproton. These experimental breakthroughs provided strong validation of Dirac's theoretical framework and marked the beginning of particle–antiparticle physics [3].

By definition, an antiparticle can be understood as the "twin" of an ordinary particle, sharing identical mass, spin, and other intrinsic properties, while differing in certain key quantum numbers. The distinguishing features of antiparticles include:

1. Electric charge — the most obvious and fundamental difference.
2. Baryon and lepton numbers — conserved quantum numbers in particle interactions, which appear with opposite sign for antiparticles.
3. Color charge (for quarks) — in the framework of quantum chromodynamics, quarks and antiquarks carry opposite color charges.
4. Magnetic moment — which reverses sign relative to the corresponding particle due to the opposite charge.

An intriguing interpretation, consistent with Feynman's later reformulation of quantum field theory, is that an antiparticle can be mathematically described as a particle propagating backward in time. In this sense, a positron may be viewed as an electron moving backward through time, an idea that has proven useful in the development of Feynman diagrams and modern quantum electrodynamics.

Let us consider a conditional thought experiment, in which we take the electron as the object of investigation. In reality, the electron exhibits wave–particle duality and, according to quantum mechanics, cannot be localized with absolute precision; it is described by a probability cloud or wavefunction. Nevertheless, for the sake of visualization and simplification, we may represent the electron as a spherical particle endowed with an intrinsic property analogous to rotation.

It must be emphasized that the electron cannot rotate in the classical sense, since it is treated in the Standard Model as a fundamental particle without substructure.

However, the electron possesses an intrinsic magnetic moment, experimentally confirmed with remarkable precision in measurements of the anomalous magnetic moment. This property is directly associated with its intrinsic angular momentum, or spin. Although the term “spin” suggests classical rotation, it is in fact a purely quantum property with no direct classical analogue. Still, in theoretical contexts it is often useful to visualize spin as if it were a kind of rotation, even though such a picture is only metaphorical.

Suppose, for illustrative purposes, that we imagine the electron as rotating clockwise, as depicted in Figure 6. By analogy, the positron—the electron’s antiparticle—would then be imagined as rotating counterclockwise. Since both particles have the same mass and identical spin magnitude, but opposite electric charges, this picture highlights the symmetry between matter and antimatter. The direction of this hypothetical “rotation” is not physically literal, but it provides an intuitive model for distinguishing the behavior of a particle from its antiparticle.

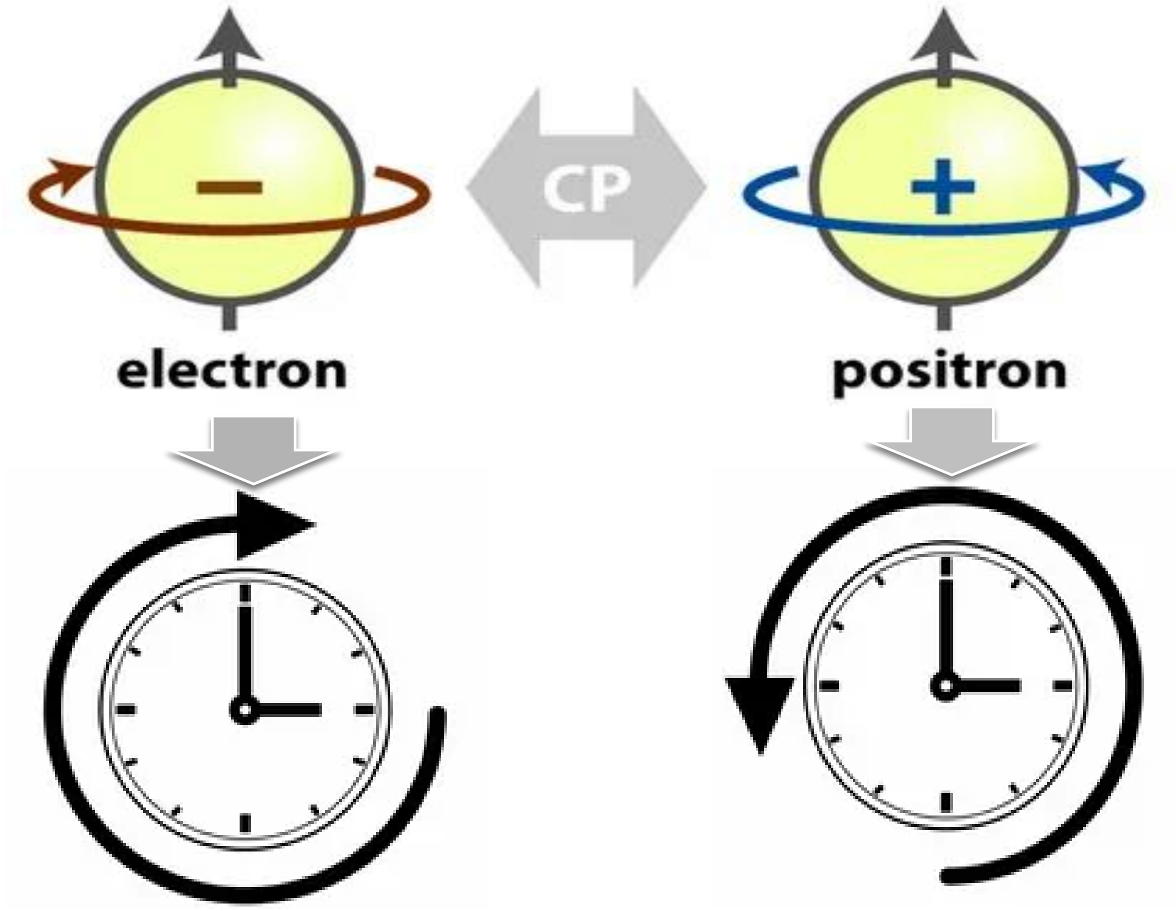

Figure 6

A useful analogy may be drawn with the hands of a clock. When the clock runs forward in time, the hands rotate clockwise. But if time itself were reversed, the hands would rotate in the opposite direction, even though the magnitude of the angular motion remains the same. Similarly, one may interpret the positron as a mirror reflection of the electron’s motion in the time-reversed frame. This heuristic picture resonates with again Feynman’s interpretation, where antiparticles can be described mathematically as particles propagating backward in time.

The same reasoning can be extended beyond electrons to all particle–antiparticle pairs. Regardless of the complexity of a particle's internal quantum state or wave-like behavior, there exists a corresponding antiparticle whose motion can be regarded as a reversed version of the original. This duality has been experimentally confirmed in numerous high-energy physics experiments. For example, in pair production processes, a photon with sufficient energy transforms into an electron–positron pair, demonstrating how the particle and antiparticle emerge simultaneously with mirrored properties. Similarly, annihilation experiments, in which an electron and positron collide and produce photons, provide strong evidence for the symmetric but opposite nature of particles and their antiparticles. Particles and their antiparticles are shown in Table 1.

To see how the direction or spin of an electron and other particles changes, we can consider case A. As we can see, when time accelerates forward, the particle must rotate faster. Therefore, positive energy indicates that the rotating body gains a rotational velocity that aligns with the original direction of rotation. Conversely, when negative energy is added, time slows down and the body accelerates in the opposite direction until it comes to a complete stop. In other words, we can view negative energy as a moment that opposes rotation, while positive energy represents a moment that supports rotation.

Table 1

Particle and symbol	Charge / proton charge	Antiparticle and symbol	Charge / proton charge (antiparticle)	Rest energy / MeV	Interaction
proton p	+1	antiproton $\bar{p}$	−1	938	strong, weak, electromagnetic
neutron n	0	antineutron $\bar{n}$	0	939	strong, weak
electron e^-	−1	positron e^+	+1	0.511	weak, electromagnetic
neutrino ν	0	antineutrino $\bar{\nu}$	0	0	weak
muon μ^-	−1	antimuon μ^+	+1	106	weak, electromagnetic
pions π^+, π^0, π^-	+1, 0, −1	π^- for a π^+; π^+ for a π^-; π^0 for a π^0	−1, 0, +1	140, 135, 140	strong, electromagnetic (π^+, π^-)
kaons K^+, K^0, K^-	+1, 0, −1	Quarks and antiquarks	−1, 0, +1	494, 498, 494	strong, electromagnetic (K^+, K^-)

But as we know, there are also particles in which the antiparticle is equal to the particle itself. Their main difference is that the bottom has no charge. These particles include: photon (γ), Z boson (z^0), Higgs boson (h^0), π^0 (neutral pion), neutral mesons in certain states (for example, k^0 and B^0 do not coincide with their antiparticles, but there are superpositions that can be their own antiparticles), etc. Moreover, some of these particles, such as the photon (1), the Z-boson (1), and the neutrino (½), have spin. To explain the problem, consider the case for massless spin-one particles such as the photon or gluon. Since they always move at the speed of light, their helicity is an invariant of Lorentz transformations. When time is reversed, the direction of the pulse changes, but the helicity remains the same. This is consistent with the fact that the photon and gluon are their own antiparticles: the CPT transformation does not create a new state, but leaves the particle by itself, including its helicity.

To imagine helicality (helicity), you need to think that a particle not only rotates, but also has an internal rotation (spin) in the direction of motion. Let's consider two cases:

1) If the spin is aligned with the direction of motion, it has a right helicality (right rotation).

2) If the spin is aligned against the direction of motion, it has a left helicality. These two cases are fundamentally different.

However, if we rewind time, the particle that was moving to the right now moves to the left. The inner arrow (spin) also flips: if the rotation was clockwise, it becomes counterclockwise, as shown in Figure 7.

Both have changed. Therefore, the "spin relative to motion" ratio remains the same. The screw is still "twisting" in the same style, but now it is moving in the opposite direction.

For massive vector bosons, such as the Z boson, there are three possible spin projections: −1, 0, and +1. When time is reversed, the spin orientation is reversed, but since the Z is a self-conjugate particle, it remains a Z boson with an inverted projection. In the case of W-bosons, the situation is different: since W+ and W− are not their own antiparticles, they transform into each other under time reversal and subsequent C-transformation, i.e., W+ transforms into W− with a corresponding change in spin orientation. Scalar bosons, such as the Higgs boson, have zero spin, so they do not undergo any changes under time reversal. Since the Higgs boson is a self-conjugate particle, it remains unchanged under any CPT transformation.

Neutrinos are of particular interest. If they are Dirac particles, then the antiparticle (antineutrino) has the opposite lepton charge, and time reversal transforms a neutrino into an antineutrino with the opposite spin. If neutrinos are Majorana particles, then they are identical to their antiparticles, and in this case, CPT transformation leaves the neutrino unchanged, only changing its spin orientation or chirality.

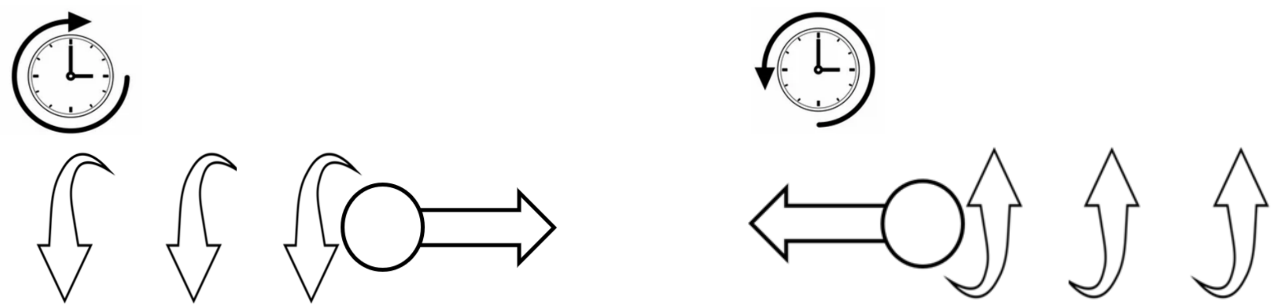

Figure 7

But let's go back to our energy connection. Since we've determined that there is both positive and negative energy, it would be helpful to write this in the form of equations for quantum mechanics. We see that the Einstein's total energy equation (1) and the equation of proportionality between the inverse Lorentz factor and the same energy (9) are equivalent. Therefore, we could use equation (9) as a Hamiltonian and follow the path of solving Paul Dirac's equation to find a similar equation:

$$\left(\frac{1}{\alpha}(1-\alpha^2)Kr\right)\psi = i\hbar\frac{d\psi}{dt}. \tag{12}$$

At the same time, Paul Dirac's equation itself:

$$\left(\beta mc^2 + c\sum_{n=1}^{3}\alpha_n p_n\right)\psi(x,t) = i\hbar\frac{\partial\psi(x,t)}{\partial t}.$$

where $\psi(x, t)$ is the wave function for an electron of rest mass m with spacetime coordinates x, t. p_1, p_2, p_3 are the components of the momentum, understood to be the momentum operator in the Schrödinger equation. c is the speed of light, and $\hbar$ is the reduced Planck constant; these fundamental physical constants reflect special relativity and quantum mechanics, respectively. α_n and β are 4 × 4 gamma matrices [4]. In no case should α_n be confused with α. These two equations are completely equivalent to each other, but they are expressed in different ways.

§ 3. Reversed Maxwell's Equations and the Inverted Electrodynamic World

Classical electrodynamics rests on Maxwell's equations, which provide a unified description of how electric and magnetic fields originate, evolve, and interact with charges and currents. These equations not only reproduce Coulomb's law and Ampère's force law as limiting cases, but they also encode the propagation of electromagnetic waves and the conservation of energy and momentum in the electromagnetic field.

In their conventional form (in SI units), Maxwell's equations are:

$$\nabla \cdot \mathrm{E} = \frac{\rho}{\varepsilon_0}, \qquad \nabla \cdot \mathrm{B} = 0,$$

$$\nabla \times \mathrm{E} = -\frac{\partial \mathrm{B}}{\partial t}, \qquad \nabla \times \mathrm{B} = \mu_0 \mathrm{J} + \mu_0\varepsilon_0\frac{\partial \mathrm{E}}{\partial t}.$$

Here E denotes the electric field, B the magnetic induction, ρ the charge density, and J the current density. These equations are internally consistent and are invariant under certain symmetry operations, including Lorentz invariance.

Let's assume that we imagine a hypothetical universe where all electromagnetic interactions are reversible, or, more specifically, consider the case where α=-1. In such a world, unlike charges would repel each other, and like charges would attract. Similarly, north poles of magnets would attract other north poles, while repelling south poles, thereby inverting the standard magnetic interactions.

To formalize this idea, we impose the following inversion rules:

$$\rho \to -\rho, \qquad \mathrm{J} \to -\mathrm{J}, \qquad \mathrm{E} \to -\mathrm{E}, \qquad \mathrm{B} \to -\mathrm{B}.$$

This transformation can be understood as a simultaneous inversion of charges and fields, closely related to a time-reversal transformation in physics, but applied here in a more restricted sense to enforce an inverted interaction law.

Substituting the inverted quantities into Maxwell's system leads to:

$$\nabla \cdot \mathrm{E}' = -\frac{\rho}{\varepsilon_0}, \qquad \nabla \cdot \mathrm{B}' = 0,$$
$$\nabla \times \mathrm{E}' = +\frac{\partial \mathrm{B}'}{\partial t}, \qquad \nabla \times \mathrm{B}' = -\mu_0 \mathrm{J} - \mu_0 \varepsilon_0 \frac{\partial \mathrm{E}'}{\partial t}. \tag{13}$$

The primed fields $(\mathrm{E}', \mathrm{B}')$ correspond to the inverted world. The most striking feature is the reversal of the signs in Gauss's law for electricity and in both curl equations. This ensures that the new field dynamics are mathematically consistent while yielding qualitatively opposite physical behavior.

Now, it's interesting to see how Coulomb's law will change. In standard electrodynamics, the force between two point charges is:

$$F = k\frac{q_1 q_2}{r^2}.$$

Here, $q_1 q_2 > 0$ implies repulsion, and $q_1 q_2 < 0$ implies attraction. In the inverted electrodynamics, the force law must acquire an additional minus sign:

$$F' = -k\frac{q_1 q_2}{r^2}. \tag{14}$$

Thus, two positive charges attract each other, while opposite charges repel.

You can also perform the same inversion operation for the Lorentz force and the inverted hand rule. For a moving charge q, the standard Lorentz force is:

$$\mathrm{F} = q(\mathrm{E} + \mathrm{v} \times \mathrm{B}).$$

In the inverted system, the effective force becomes:

$$\mathrm{F}' = -q(\mathrm{E}' + \mathrm{v} \times \mathrm{B}'). \tag{15}$$

This inversion can be visualized by switching from the usual right-hand rule to a left-hand rule: the direction of the force reverses relative to the conventional case. The magnetic field lines themselves also invert their polarity, running from what would ordinarily be the south pole toward the north pole.

Let's also consider the energy flow and the Poynting theorem in an inverted system. Electromagnetic energy in standard theory is described by the energy density:

$$u = \frac{1}{2}\left(\varepsilon_0 E^2 + \frac{1}{\mu_0} B^2\right),$$

and the Poynting vector:

$$\mathrm{S} = \frac{1}{\mu_0} \mathrm{E} \times \mathrm{B},$$

which represents the flow of electromagnetic energy. Conservation of energy is expressed through Poynting's theorem:

$$\frac{\partial u}{\partial t} + \nabla \cdot \mathrm{S} = -\mathrm{J} \cdot \mathrm{E}.$$

In the inverted system, both fields and sources change sign, leading to:

$$u' = \frac{1}{2}\left(\varepsilon_0 E'^2 + \frac{1}{\mu_0} B'^2\right),$$
$$\mathrm{S}' = -\frac{1}{\mu_0} \mathrm{E}' \times \mathrm{B}'. \tag{16}$$

Thus the energy density remains positive, but the Poynting vector reverses its direction. Physically, this means that electromagnetic energy in the inverted system appears to flow opposite to the direction it would in our universe.

In vacuum, the wave equations derived from Maxwell's equations are:

$$\nabla^2 \mathrm{E} - \mu_0 \varepsilon_0 \frac{\partial^2 \mathrm{E}}{\partial t^2} = 0, \qquad \nabla^2 \mathrm{B} - \mu_0 \varepsilon_0 \frac{\partial^2 \mathrm{B}}{\partial t^2} = 0.$$

These equations remain unchanged under the inversion, because the overall sign changes cancel out. Therefore, electromagnetic waves still propagate at the speed of light $c = 1/\sqrt{\mu_0 \varepsilon_0}$. What changes is the phase relationship: the electric and magnetic fields are inverted relative to one another, and the direction of energy propagation (given by S') is opposite to the wavevector k.

The electromagnetic momentum density in standard form is:

$$\mathrm{g} = \varepsilon_0 \mathrm{E} \times \mathrm{B}.$$

In the inverted world, this becomes:

$$\mathrm{g}' = -\varepsilon_0 \mathrm{E}' \times \mathrm{B}'. \qquad (17)$$

Thus, not only energy flow but also momentum transport is reversed. Similarly, the Maxwell stress tensor, which determines the pressure and mechanical stress exerted by electromagnetic fields, acquires opposite off-diagonal terms, signifying that forces between conductors and magnets are inverted.

The reversed Maxwell equations provide a mathematically consistent and physically interpretable system. They describe a world where all electromagnetic interactions are inverted, and where energy and momentum flow in opposite directions to those we observe. While such a world does not exist in nature as far as experiments show, the construction mirrors the effect of reversing time in electrodynamics. Indeed, this scenario is closely connected to the CPT symmetry of fundamental physics: by inverting charges (C), spatial directions (P), and time (T), one arrives at an equivalent formulation of the laws of physics.

In summary, the inverted Maxwell system is not contradictory but rather an alternate representation of electrodynamics under time-reversal-like transformations. It preserves the mathematical structure of the theory while offering a radically different physical picture: like charges attract, unlike charges repel, magnetic poles of the same type attract, and electromagnetic energy appears to flow "backward."

§ 4. Antigravity as a consequence of the reverse flow of time

We can also consider the reverse flow of time as antigravity. For example, imagine that in our world, in which $\alpha > 0$ one body attracts another as a result of gravitational forces. Here, the use of gravitational forces may not seem quite right, because the gravitational attraction of bodies is a consequence of the heterogeneity of space time. In other words, according to the theory of General Relativity (GR), the motion of bodies under the influence of gravity can be described not as a force acting at a distance, but as a consequence of the curvature of spacetime caused by mass and energy.

From this perspective, a smaller body does not move towards a more massive one due to a direct attractive force. Instead, it follows a straight-line path (a geodesic) within the curved geometry of spacetime. This curvature, generated by the larger mass, dictates the trajectory of the smaller body, causing it to approach the central mass as if being pulled by gravity. Thus, what we perceive as orbital motion or attraction is essentially the motion of an object along the shortest path in a curved four-dimensional continuum.

Now let's consider the case where $\alpha<0$. In such situations, we can say that the bodies repel each other because they are moving in opposite directions. Indeed, as we can see, two masses that are moving towards each other will separate if we rewind time. Therefore, the curvature of the time-space continuum will be opposite in different regions of α. For example, convexity becomes concavity and vice versa.

Because of these anti-gravity effects, the term negative mass arises. Therefore, if a body is composed entirely of antiparticles, it should have a negative mass.
It would be possible to say many things and processes in the same way. For example, if we were to turn back time, instead of the expansion of the universe, we would see a contraction, instead of a positive charge, we would have a negative charge, and so on.
It can also be observed that the non-existence of antigravitation in our world is directly related to the fact that antiparticles are not widespread in our universe. If our universe were composed entirely of antimatter, then there would be no gravity in this universe, and all antimatter bodies would be repelled by antigravitation.

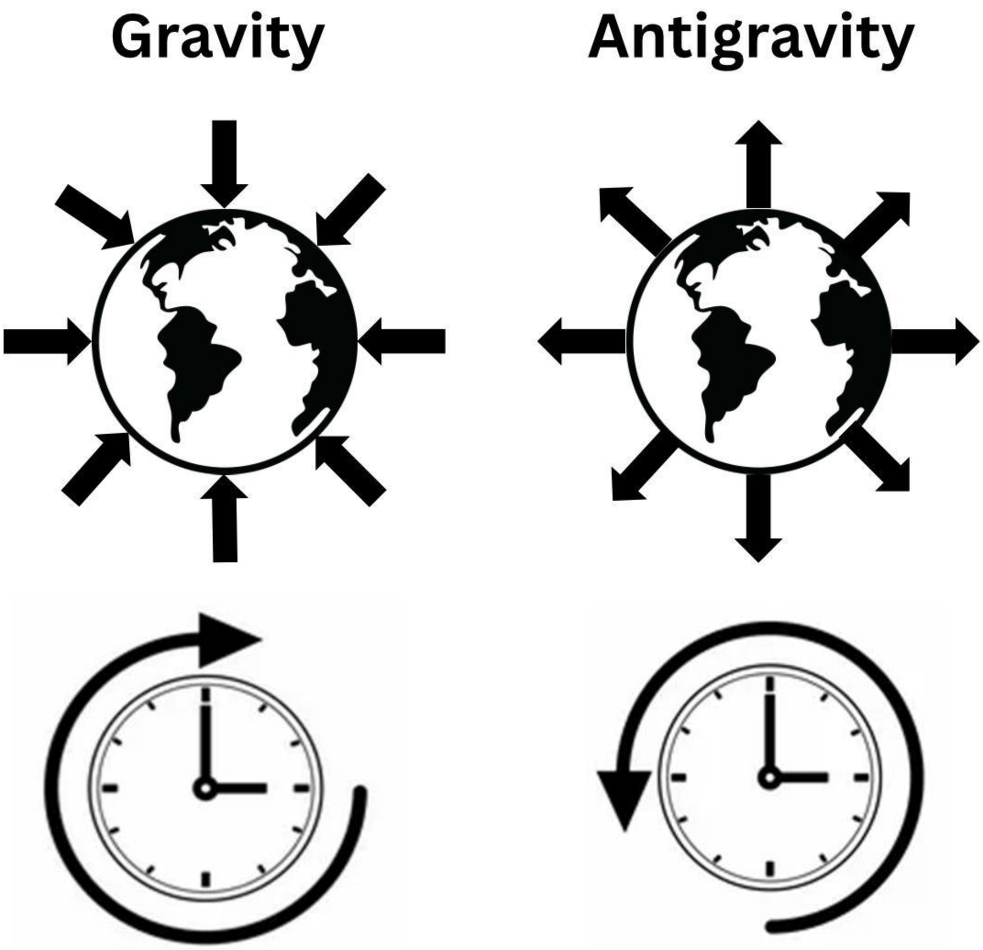

Figure 8

In classical Newtonian gravity, the interaction between two material points is determined by the law of universal gravitation. Let the masses of the bodies be $m_1$and m_2, and let their relative position vector be defined as $\mathrm{r} = \mathrm{r}_2 - \mathrm{r}_1$, where $r =| \mathrm{r} |$and $\hat{\mathbf{r}} = \mathbf{r}/r$is the unit vector from the first body to the second. The force acting on the second body due to the first one is given by

$$\mathrm{F}_{2\leftarrow1} = -G\,\frac{m_1 m_2}{r^2}\,\hat{\mathrm{r}},$$

where $G > 0$ is Newton's gravitational constant. Similarly, the force acting on the first body is

$$\mathrm{F}_{1\leftarrow2} = -\mathrm{F}_{2\leftarrow1} = +G\,\frac{m_1 m_2}{r^2}\,\hat{\mathrm{r}}.$$

These forces are directed toward each other, producing mutual attraction. Accelerations follow from Newton's second law:

$$\mathrm{a}_1 = \frac{\mathrm{F}_{1\leftarrow2}}{m_1} = +G\,\frac{m_2}{r^2}\,\hat{\mathrm{r}}, \mathrm{a}_2 = \frac{\mathrm{F}_{2\leftarrow1}}{m_2} = -G\,\frac{m_1}{r^2}\,\hat{\mathrm{r}}.$$

Thus, the relative acceleration of the pair is

$$\ddot{\mathrm{r}} = \mathrm{a}_2 - \mathrm{a}_1 = -G\,\frac{m_1 + m_2}{r^2}\,\hat{\mathrm{r}},$$

and since $m_1 + m_2 > 0$, the distance $r$decreases with time. Energetically, the interaction is described by the gravitational potential $\varphi(\mathbf{r}) = -Gm/r$ for a point mass $m$and the potential energy of the system

$$U(r) = -G\,\frac{m_1 m_2}{r}.$$

The sum of the kinetic and potential energies,

$$E = T_1 + T_2 + U,$$

is conserved in time, reflecting the fundamental laws of motion.

Let us now turn to the hypothetical case in which both masses are negative:

$$m_1 = -m_a, m_2 = -m_b, \qquad m_a, m_b > 0,$$

while the gravitational constant remains positive ($G > 0$). In this situation the product of the masses is positive,

$$m_1 m_2 = (-m_a)(-m_b) = +m_a m_b,$$

and the force takes the form

$$\mathrm{F}_{2\leftarrow1} = -G\,\frac{m_a m_b}{r^2}\,\hat{\mathrm{r}}. \tag{18}$$

Formally, the force is directed toward the first body, as in the usual case. However, since the inertial masses are negative, division by them reverses the direction of the accelerations. For the second body we obtain

$$\mathrm{a}_2 = \frac{\mathrm{F}_{2\leftarrow1}}{m_2} = \frac{-G\,\frac{m_a m_b}{r^2}\,\hat{\mathrm{r}}}{-m_b} = +\frac{Gm_a}{r^2}\,\hat{\mathrm{r}},$$

and for the first body

$$\mathrm{a}_1 = \frac{\mathrm{F}_{1\leftarrow2}}{m_1} = \frac{+G\,\frac{m_a m_b}{r^2}\,\hat{\mathrm{r}}}{-m_a} = -\frac{Gm_b}{r^2}\,\hat{\mathrm{r}}. \tag{19}$$

This shows that the bodies accelerate away from each other. The relative acceleration is

$$\ddot{\mathrm{r}} = \mathrm{a}_2 - \mathrm{a}_1 = +G\,\frac{m_a + m_b}{r^2}\,\hat{\mathrm{r}}, \tag{20}$$

which clearly indicates that the distance r increases with time. In this hypothetical framework, negative masses behave as if they mutually repel, in exact contrast to ordinary attraction.

The potential energy formally retains its usual expression,

$$U(r) = -G\,\frac{m_a m_b}{r},$$

and is negative, while the kinetic energies become negative because the inertial masses are negative:

$$T_1 = \frac{1}{2}m_1 v_1^2 = -\frac{1}{2}m_a v_1^2, T_2 = \frac{1}{2}m_2 v_2^2 = -\frac{1}{2}m_b v_2^2.$$

Nevertheless, the total energy

$$E = T_1 + T_2 + U$$

remains an integral of motion. In such a hypothetical universe, bodies do not fall toward each other but instead accelerate apart, as though time itself were reversed and gravity operated in a “mirror” mode.

Summing up all our observations and calculations, we can visualize the result as a diagram in Figure 9.

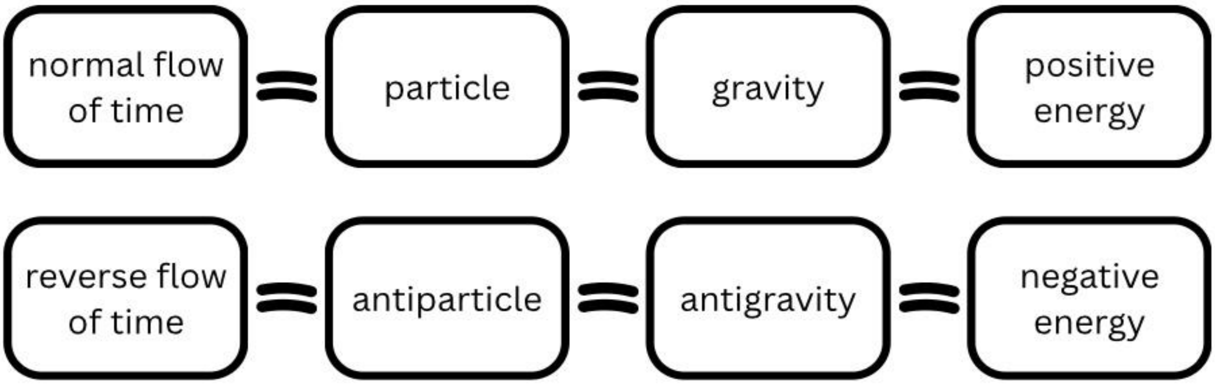

Figure 9

It's important to note that this is not a general case. For example, in case A, positive energy dominates between - α and 0, which contradicts this diagram. However, it provides a simple representation for easy understanding. This raises the question: Can we verify this relationship directly through experimentation? If we create a massive planet composed entirely of antimatter, will nearby objects experience their clocks running faster than the surrounding time? The answer is likely yes. However, due to the challenges of obtaining antiparticles and their short lifespan, this experiment is currently nearly impossible to conduct. The small fractions of antiparticles that could be produced by accelerators would barely noticeably change the space and time around them, and the relativistic effects of time would be as negligible as possible. However, this does not preclude the possibility of further verification and improvement of our understanding of quantum and relativistic effects, which could lead to alternative and more convincing proofs of these claims.

§ 5. The potency of time

Consider a large celestial body, which we will designate as an Imaginary Object (IO). This object exists in isolation, surrounded by an absolute vacuum. A fundamental principle in physics is the freedom to choose a reference system. This principle applies not only to spatial coordinates and velocity but also to the definition of energy fields and potentials. Conventionally, the vacuum state is often assigned a gravitational or energy potential of zero. Under this convention, the celestial body, by virtue of its mass-energy, possesses a positive potential.

However, instead, we'll see what happens if we adopt an alternative frame of reference. We define the potential of the IO itself to be zero. This choice implies that the universe in our thought experiment possesses a minimum energy density equivalent to that of the IO's composition.

This raises the question of how the universe can have an absolute vacuum, as the lowest density should be zero. However, we do not need to worry about this question at the moment, as we have simply «taken» IO and placed it in our world.

The model is constructed simply by introducing the IO into a pre-existing universe; thus, the IO serves as our new reference point of zero potential, and the vacuum is redefined as a region of negative potential relative to it. Therefore, our main object of study, the absolute vacuum, will act as a negative energy and accelerate time relative to the IO. In fact, this thought process is not entirely far from reality. We can say that massive bodies slow down time, just as a body with less energy density accelerates it. We observe that with any choice of potential as equal to zero, the essence of this principle does not change.

With the help of these arguments, we will come to two consequences. The first thing is that we are free to choose the point of the energy levels report. Secondly, it is possible to accept time as something spatial, something where its flow differs, and changes with increasing body mass. Since we have found the similarity of energy itself with time, we could consider the latter not only as energy itself, but also as its potential. And since we are free to choose the starting point of the potential, we will take the fact that in the centers of black holes the potential of the time field will be maximum and in an absolute vacuum the potential should be zero. Therefore, it is the mass that can be considered as the source of this field. Let's imagine that the bodies do not move, but remain in one place, in other words, case A. And also remember that our body has a spherical shape. And one more remark about the signs. Since we have found that there must be both positive and negative α (or antigravity, gravity), then we will assume that there is both repulsion and attraction for the so-called "time field". Let's find the potential of this so-called "time field". First, we need to find the mass density using equation (5):

$$\rho = \frac{m_0}{V} = \frac{\frac{(1-\alpha^2)rc^2}{2G}}{\frac{4}{3}\pi r^3} = \frac{3(1-\alpha^2)c^2}{8\pi r^2 G}. \qquad (21)$$

Let's put it in the Poisson equation:

$$\Delta\varphi = 4\pi G\rho = 4\pi G \times \frac{3(1-\alpha^2)c^2}{8\pi r^2 G}.$$

here Δ is the Laplace operator. It is equal to ∇^2. If you write the equation in a normal form:

$$\nabla^2\varphi(r) = \mp\frac{3c^2\left(1-\alpha^2(r)\right)}{2r^2}, \qquad \varphi = \varphi(r). \tag{22}$$

If we take $f(r) = 1-\alpha^2(r)$, and solve this expression, we get this result:

$$\varphi(r) = \pm\frac{3c^2}{2}\left[\frac{1}{r}\int_0^r f(s)\,ds + \int_r^\infty \frac{f(s)}{s}ds\right] + C. \tag{23}$$

where s is the integration variable, and C is a free constant, fixed by the boundary conditions (usually φ(∞)=0⇒C=0). The ± sign appears because of whether we consider attraction or whether we consider repulsion. What is the meaning of this equation? This is essentially the same as the formula for the gravitational field, but it takes into account the case of antigravity and is expressed in terms of α.

Now we should check how the potential changes with different α.

1) α= ± 1. Then $f_0 = 1-\alpha^2 = 1-1 = 0$. We get: $\varphi_{in}(r) = 0,\ \ \varphi_{out}(r) = 0$. Indeed, there is no source, and the field is zero. Everything matches and is correct.
2) α=0. $f_0 = 1-\alpha^2 = 1-0 = 1$. $\varphi_{in}(r) = \pm\frac{3c^2}{2}\left(1+\ln\frac{R}{r}\right)$, $\varphi_{out}(r) = \pm\frac{3c^2R}{2r}$ The external potential decreases as - 1/r (monopole), and there is a logarithmic term inside → φ in→±∞ as r→0. Therefore, if α=0 everywhere inside, the center is singular. This is also the result we expected.
3) If α>1or α<-1. If we set the value of α to ±∞, we would get infinite large results again, such as an inflating potential. To avoid getting an meaningless answer, it would be better to use a specific value, such as α=2. $f_0 = 1-\alpha^2 = 1-4 = -3$ $\varphi_{in} = \mp\frac{9c^2}{2}\left(1+ln\frac{R}{r}\right),\quad \varphi_{out} = \mp\frac{9c^2R}{2r}$. To understand the physical and directional interaction, let's add force. Force is usually taken as: $F = -\nabla\varphi$. For α=2: $F_r = -\varphi'_{in} = \mp\frac{9c^2}{2r},\quad F_r = -\varphi'_{out} = \mp\frac{9c^2R}{2r^2}$. For comparison, as we determined, if α=0, the outer coefficient would be $\pm\frac{3c^2R}{2r}$. So:

$$\frac{\varphi_{out}(\alpha=2)}{\varphi_{out}(\alpha=0)} = \frac{\mp 9}{\pm 3} = -3.$$

that is, α=2 gives a magnitude that is 3 times larger in modulus, but with the opposite sign (repulsion instead of attraction). Therefore, when α>1 or α<-1, the sign of the force will be opposite to that of -1< α<+1 as shown in Figure 1.

It would be useful to see the connection between the obtained equation (23) with the gravitational potential equation directly. To do this, we write the gravitational potential equation itself, which is created by a point mass M located at the origin of the coordinate system:

$$\varphi_{gravity}(\vec{r}) = -\frac{GM}{r} + C.$$

We can omit C here because we choose φ=0 at infinity. We can replace the mass with equation (5) by taking M = m_0:

$$M = -\,(1-(\alpha)^2)\frac{rc^2}{2G}.$$

Then we get the gravitational potential equation expressed in terms of α:

$$\varphi_{gravity}(\vec{r}) = (1-\alpha^2)\frac{c^2}{2} \;\; or \;\; \varphi_{gravity}(\vec{r}) = \frac{c^2}{2}f(r).$$

Expressing the potential of time through the potential of gravity, we obtain:

$$\varphi_{time}(r) = \mp 3\left[\frac{1}{r}\int_0^r \varphi_{gravity}(s)\,ds + \int_r^{\infty}\frac{\varphi_{gravity}(s)}{s}ds\right] + C.$$

and is equivalent in differential form:

$$\frac{d}{dr}\left(r^2\varphi'_{time}(r)\right) = 3\varphi_{gravity}(r).$$

from it we can express f(r):

$$f(r) = \frac{2}{3c^2}\frac{d}{dr}\left(r^2\varphi'_{time}(r)\right).$$

An interesting observation is that these two functions are not related to each other by the constant constants c and G, and differ only in their apparent distances.

We see the similarity of the gravitational force with the so-called "time force." Both are affected by mass, and both seem to have waves and potential. However, there are significant differences between them. Perhaps the most important difference is the change in force with distance, which is determined by $1/r^2$ in gravity and 1/r in time effects. Additionally, in the region of α>1 and α<-1, the sign of gravity should not change. The fact that the sign does not change in gravitational and antigravitational interactions in these regions can be intuitively understood. Let's say we have a ball in our hands and we are standing on the planet Earth. We let go of the ball, and as expected, it falls to the ground. Now, let's repeat the same scenario but with time accelerated, let's say, twice as fast. It's easy to see that the ball will fall faster, making it appear as if its weight has increased. However, it's important to note that the sign of attraction or the direction of motion has not changed in any way. Gravity is still attractive. We will get another opposite result from equation (23).

§ 6. About the problem of time discreteness

Now let's move on to the question of the discreteness of time. As you will soon see, this question is directly related to the discreteness of gravity and energy itself. This follows from our equation of time and energy (9). If time is discrete, then energy must also be discrete, and if time is continuous, then energy must also be continuous. More specifically, if the distance of the radius vector, or more simply, space, is discrete like time itself, then energy and gravity must also be discrete. This is because the energy of the body also depends on the radius vector in our equation.

Let us now consider the theoretical scenarios in which time might be discrete. A corollary to this proposition is that if time is indeed quantized, its behavior and perceived flow would likely differ profoundly between the quantum microcosm and the classical macrocosm.

What is the basis for this supposition? We can elucidate this concept through an analogy with Brownian motion. Consider a thought experiment involving two distinct bodies, A and B, suspended in an isotropic fluid composed of molecules in constant, random thermal motion.

- Body A is macroscopic, with dimensions vastly exceeding those of an individual fluid molecule.

- Body B is microscopic, with a size comparable to that of the surrounding molecules.

Due to its immense size, Body A experiences a tremendous number of molecular collisions per unit time from all directions. While each individual collision imparts a minuscule impulse, the statistical distribution of these impacts is effectively uniform. The forces exerted by molecules from one direction are, on average, perfectly balanced by forces from the opposite direction. This compensation results in a net force of zero, and Body A remains stationary or follows a deterministic trajectory governed by classical mechanics, unaffected by the underlying discrete, particulate nature of the fluid.

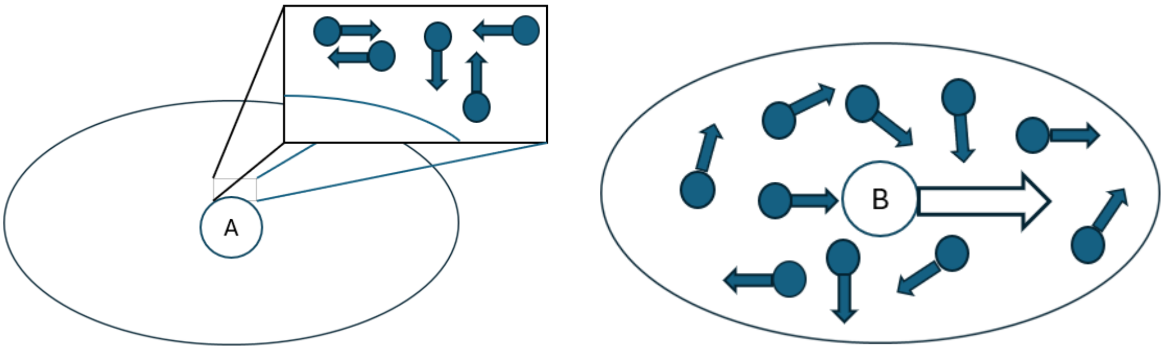

Figure 10

In stark contrast, Body B, being of a similar scale to the fluid molecules, experiences only a limited number of collisions within any given time interval. The statistical averaging and force cancellation observed with Body A do not occur. Each collision delivers a significant, uncompensated impulse, causing Body B to undergo a random, jittery path—the hallmark of Brownian motion. The discrete, granular nature of the fluid is directly and visibly manifest in the dynamics of the microscopic body.

This analogy serves as a powerful metaphor for the potential discreteness of time. If time possesses a fundamental quantum, a "chronon" (a hypothetical minimal unit of time), its effects would be scale-dependent:

1) In the macroscopic realm (e.g., celestial mechanics, human experience), processes involve an immense number of these temporal quanta. Any fluctuation or "jitter" associated with a single chronon would be averaged out over vast scales, resulting in the smooth, continuous, and deterministic flow of time described by general relativity and classical physics.

2) In the quantum realm, however, processes occur on scales comparable to the proposed chronon. At this level, the discrete graininess of time would not be averaged out. It could manifest as fundamental uncertainty in energy and time measurements (as hinted by the time-energy uncertainty principle), impose limits on the simultaneity of events, or lead to observable deviations from the predictions of continuous quantum mechanics.

That is, in our example, the liquid made up of molecules was an analogy of time made up of discrete particles. And bodies A and B, respectively, served as indicators to see how the same object behaves in different situations. But here comes another problem, that if the particles of time are small enough and for even quanta, so that time flows the same for micro and macro world but still discrete. That is to say in simple words in case when even quanta will be large enough in comparison with chronom as body A in comparison with molecules.

Therefore, we will confine our present discussion to the question of whether time is discrete, analogous to the quantization observed in fundamental particles. As a preliminary step, it is instructive to consider the defining characteristics of these quantum particles.

A quantum particle is defined by a set of intrinsic properties. Among the most fundamental are:

1. Spin: This is a form of intrinsic angular momentum, which manifests in the particle's magnetic moment. Different classes of particles possess distinct spin values. For instance, fermions (e.g., electrons, quarks) have half-integer spin (e.g., ħ/2), bosons (e.g., photons, gluons) have integer spin (e.g., 1ħ), and some particles, like mesons, have a spin of 0.

2. Mass: The mass of a particle determines its inertia and, via mass-energy equivalence, its rest energy ($E = mc^2$).

3. Charge: Particles may carry electric charge (positive or negative), which governs their electromagnetic interactions. Other charge-like quantum numbers also exist, such as color charge for quarks and gluons, which governs the strong interaction.

While other quantum numbers exist (e.g., isospin, parity, flavor), the trio of spin, mass, and electric charge serves as a primary descriptor for a particle's identity and behavior.

To visualize this set of properties, one might propose an abstract parameter space defined by three orthogonal axes (Figure 11).

- The X-axis could represent the particle's spin quantum number.
- The Y-axis could represent its mass (or rest energy).
- The Z-axis could represent its electric charge.

In this model, every known particle would correspond to a unique point in this abstract space, with coordinates (Spin, Mass, Charge). For example, an electron might be located at (1/2, 0.511 MeV/c^2, -1), while a proton would be at (1/2, 938 MeV/c^2, +1), and a photon at (1, 0, 0).

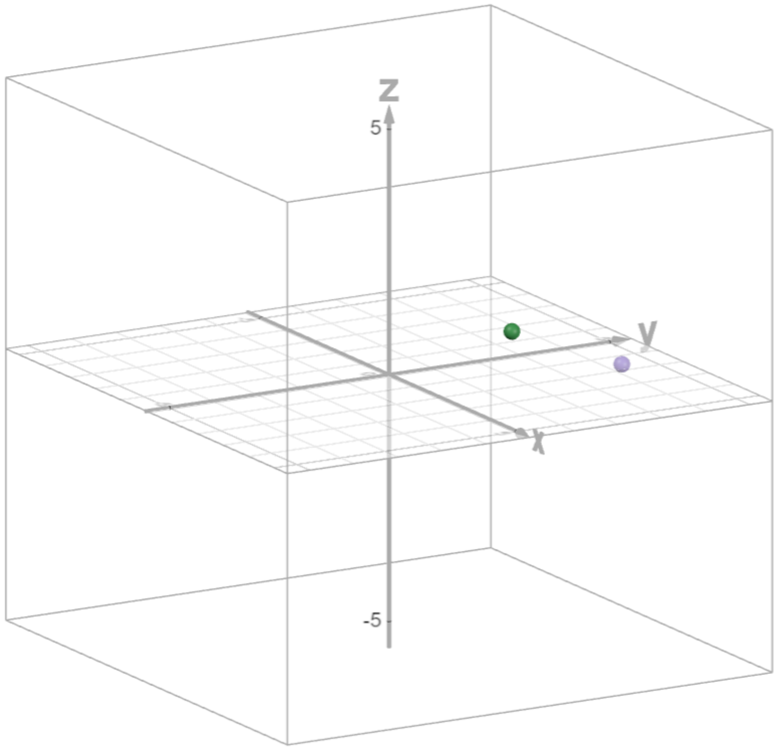

Figure 11. The position of the upper quantum u (green) and the lower quantum d (blue) in our 3d space with axes X (spin), Y (mass in MeV/s^2), Z (charge).

It may seem to us that the X and Y axes are in the same relationship as shown in Figures 1, 2, and 3. The relationship between rotation and our inverse Lorentz factor α may be intuitive to you. However, they actually have different properties, although they are very similar. For example, if α=0, the spin will be zero, and if α=1, the spin will also be one. However, the spin does not have a negative value, unlike α. Here, we will not consider the spin, which has no direction and is a scalar property, but the vector spin, which indicates the direction in which the quantum is "rotating." This is similar to how we initially considered the spin as a trajectory with only positive values, but now we need to consider it as a displacement.

An interesting point is that at first glance, the mass, charge, and spin of a particle are completely independent of each other and act as independent components of the particle. A detailed table of characteristics of elementary particles is given in Table 2.

Table 2

Class	Subclass	Name	Symbol	Antiparticle	Charge (e)	Spin	Mass	Notes
Fermion	Quark	Up (u)	u	ū	+2/3	1/2	~2.5 MeV/c²	Lightest quark, part of protons and neutrons
		Down (d)	d	đ	-1/3	1/2	~5 MeV/c²	
		Charm (c)	c	c̄	+2/3	1/2	~1.27 GeV/c²	
		Strange (s)	s	s̄	-1/3	1/2	~100 MeV/c²	

		Top (t)	t	$\bar{t}$	+2/3	1/2	~173 GeV/c²	Heaviest, decays in ~10^{-25} s
		Bottom (b)	b	$\bar{b}$	-1/3	1/2	~4.2 GeV/c²	
	Lepton	Electron	e^-	e^+	-1	1/2	0.511 MeV/c²	Stable, forms atoms
		Muon	μ^-	μ^+	-1	1/2	106 MeV/c²	Unstable (~2.2 μs)
		Tau lepton	τ^-	τ^+	-1	1/2	1777 MeV/c²	Unstable (~0.3 ps)
		Electron neutrino	ν_e	$\bar{\nu}_e$	0	1/2	< 1 eV/c²	Extremely light, weakly interacting
		Muon neutrino	ν_μ	$\bar{\nu}_\mu$	0	1/2	< 0.2 MeV/c²	
		Tau neutrino	ν_τ	$\bar{\nu}_\tau$	0	1/2	< 20 MeV/c²	
Boson	Gauge boson	Photon	γ	—	0	1	0	Carrier of electromagnetic interaction
		Gluon	g	—	0	1	0	Carrier of strong interaction (8 types)
		W boson	W^+	W^-	±1	1	80.4 GeV/c²	Carriers of weak interaction
		Z boson	Z^0	—	0	1	91.2 GeV/c²	
	Scalar	Higgs boson	H^0	—	0	0	125 GeV/c²	Provides mass to other particles
Hadron	Baryon	Proton	p	$\bar{p}$	+1	1/2	938 MeV/c²	Composition: (uud), stable
		Neutron	n	$\bar{n}$	0	1/2	940 MeV/c²	Composition: (udd), stable only in nuclei
	Meson	Pi-plus meson	π^+	π^-	+1	0	140 MeV/c²	Composition: (u đ)
		Pi-zero meson	π^0	—	0	0	135 MeV/c²	Quantum mixture (uū, dd̄)
		Pi-minus meson	π^-	π^+	-1	0	140 MeV/c²	Composition: (d ū)

As we can see from the table, all stable elementary particles have a spin of no more than 1. But this does not mean that particles above spin 1 do not exist. Particles with high spin (3/2, 2, 3, 4...) — These are, as a rule, unstable excited states that are born in high-energy collisions (for example, in the Large Hadron Collider) and disintegrate almost instantly. They are not part of ordinary matter, but they are an important object of study in high-energy physics.

But let's go back to the problem of time discreteness. We observe an effect where spins have only certain values, such as 0, 1/2, and 1. At the same time, the mass of particles can have almost any value and does not have a specific degree of variation in mass characteristics. It is important to distinguish between the energy of bound particles and the energies associated with free particles. Let's break it down into parts.

1. Free particle: energy is not discrete (it is continuous)

Imagine a single electron flying in an endless empty space. Nothing limits him. Its energy is purely kinetic and is calculated using the classical formula E = p^2/ (2m), where p is its momentum. In quantum mechanics, the momentum of such a free particle is not quantized. It can have any value of momentum, and hence any (continuous spectrum) energy value. The energy here is not discrete, but continuous.

2. Bound particle: energy is discrete (quantized). Now imagine the same electron, but not in the void, but inside the atom, bound by the electric field of the nucleus. He is no longer free — he is "trapped" in a potential pit. This is where the quantization rule comes into effect. The electron's wave function must "fit" into the orbit so that it is stable (forming a standing wave). This is possible only at certain, strictly defined energy values. The energy spectrum becomes discrete. An electron can only be at the levels E_1, E_2, E_3... and it cannot have energy between them (for example, E_1 + 0.0001). These are the very "energy levels" of Niels Bohr.

The energy of this arousal can be any. A photon (a quantum of light) can have any energy within its spectrum. The energy of a laser beam or radio wave is not discrete.

However, the process of energy absorption or emission by the field itself occurs in portions, quanta. You can't absorb half a photon. You absorb a whole photon with a certain energy. As for the discreteness of time, the task is slightly different. Writing the equation of the relationship of the total energy of a body with a change in time, or the factor α:

$$\mathrm{E} = \frac{1}{\alpha}(1-\alpha^2)Kr.$$

We see that only if time and space is smooth and continuous, does energy also become continuous. Einstein described space-time as a smooth, continuous continuum, a "fabric" that can bend under the influence of mass and energy. In this model, there is no indication of discreteness. You can mentally divide any part of space in half indefinitely, and you will always get a smaller but still continuous segment. In conclusion, it is likely that gravity and time are discrete, meaning that I assume the existence of the graviton and the chronon.

So we have two choices:

1) Time, like energy itself, is continuous.

2) The nature of time is closely related to the spin of elementary particles and therefore has a discrete nature.

Let's start by considering what happens when time is discrete and its result manifests as the spin of a particle. If spin is the result of the discreteness of time, it is normal to wonder how it will change in large macroscopic sizes. We see that spin is very pronounced in the quantum world, and according to our assumption, time also goes "step by step" in such small sizes. Now let's see what happens to bodies with a higher number of molecules. Let's start with the structure of nucleons. Take a proton, for example. It has a spin of 1/2, although the three quarks that make it up (u, u, and d) also have a spin of 1/2 each. The fact that the proton, composed of three spin -1/2 quarks, also has a total spin of 1/2 is a consequence of quantum mechanics and the complex internal structure of the proton.

The simplistic notion that the proton's spin is simply the sum of the spins of its three valence quarks (s = 1/2 + 1/2 - 1/2 = 1/2) is incomplete. Experimental data (from deep inelastic scattering) reveals that the spins of the three valence quarks account for only about 30% of the proton's total spin.

The remaining spin arises from other sources:

1. Orbital Angular Momentum (OAM): The quarks carry significant orbital angular momentum as they move relativistically inside the proton due to the strong force. This OAM makes a substantial contribution to the total spin.
2. Gluon Spin: The gluons, the carriers of the strong force, themselves have spin. The polarization of these gluons within the proton contributes significantly to its overall spin.
3. Gluon Orbital Angular Momentum: The gluon fields can also carry orbital angular momentum.

Thus, the proton's spin is a complex sum:

Proton Spin = Σ Quark Spins + Σ Quark OAM + Σ Gluon Spins + Σ Gluon OAM.

In Quantum Chromodynamics (QCD), the spin of a composite particle is not just the sum of the spins of its constituent particles; it is the total angular momentum of the entire system, which includes these additional, dynamically generated contributions.

The progression of spin from fundamental particles to macroscopic objects illustrates a fundamental principle of quantum-classical transition. In quantum theory, spin is understood as an intrinsic form of angular momentum, a fundamental property of elementary particles that does not arise from spatial rotation but is instead an irreducible representation of the Lorentz group. For fermions such as quarks and leptons, spin takes half-integer values, while for bosons it is expressed in integer units of $\hbar$. At the microscopic level, spin defines the very structure of matter, constraining how particles may combine under the Pauli exclusion principle and thereby shaping the properties of protons, neutrons, atoms, and nuclei.

When we move to composite systems, the role of spin becomes increasingly subtle. In the proton, for example, three valence quarks, each carrying spin one-half, do not simply add their spins in a straightforward manner; rather, their spins and orbital angular momenta couple dynamically, with contributions from gluons and quark–antiquark pairs in the quantum chromodynamic vacuum. The result is that the proton as a whole possesses spin one-half, even though the internal distribution of angular momentum is highly nontrivial. In atomic nuclei, electrons and nucleons, the addition of angular momenta follows the rules of quantum coupling, leading to total spin values that may range from large half-integers to complete cancellation, depending on the pairing structure.

As systems grow more complex, such as in molecules or condensed phases of matter, individual spins overwhelmingly tend to pair in opposite directions, producing singlet states that cancel the net angular momentum. Thus, although each constituent retains its intrinsic spin, the observable spin of the whole system is typically vanishingly small. In condensed matter, where the number of microscopic constituents is on the order of Avogadro's number, spin effects usually average out completely, unless special conditions such as ferromagnetic alignment or superconducting coherence impose residual macroscopic order.

The situation changes even more radically when one passes from microscopic and mesoscopic systems to macroscopic bodies such as rocks, moons, or planets. In such cases, the intrinsic spin of the constituent particles is still present at the fundamental level, but it no longer manifests as an observable global property of the body. Instead, what dominates is the classical notion of rotation: the bulk orbital angular momentum of the body about its axis. Compared to this overwhelmingly large classical quantity, the residual net spin of elementary particles becomes negligible, suppressed by many orders of magnitude. For example, even if one could coherently align all the spins of electrons in the Earth, their total contribution would still be vanishingly small compared with the angular momentum associated with the Earth's daily rotation.

From a theoretical standpoint, one may say that as matter organizes into ever larger structures, the net intrinsic spin of the composite system asymptotically approaches zero. This does not mean that spin disappears — it is always present at the microscopic level and can never be eliminated — but its collective influence becomes negligible in proportion to the scale of the system. In the thermodynamic and macroscopic limit, the contribution of intrinsic spin is so suppressed that it becomes unobservable for all practical purposes, and classical mechanics suffices to describe the body's rotation. Thus, one can conclude that spin, while central to the physics of the micro-world, progressively loses direct relevance as one passes into the macroscopic domain. It tends ever closer to zero in effective description, yet never vanishes completely, thereby preserving its fundamental role as a quantum attribute of matter.

It is also possible to use the spin connection of a body with a reverse Lorentz factor α. As the mass of the body increases, the spin and the factor α approach zero. In simpler terms, time for small bodies behaves like a discrete characteristic that is inherent in the body, similar to the charge, which is also quantized and not continuous.

It seems that this hypothesis is valid until we start to delve into the pitfalls of this assumption. The first problem is that this hypothesis does not agree with the coherence of energy and time. As we can see from Figure 11, the relationship between mass and spin is not obvious, and even if there is a connection, it is extremely complex. In our previous discussions, we obtained a simple connection that can be defined as (9).

The second problem is directly related to the spin moment. For an elementary particle such as the photon, "spin" refers to an intrinsic quantum number. Let's compare its total spin with the spin of a small particle-wave, such as a photon. A photon is a massless spin-1 particle; physically it has helicities ± 1, so the longitudinal-projection values are $\pm\hbar$. The operator S^2 for a spin-1 particle has eigenvalue $s(s+1)\hbar^2 = 2\hbar^2$, but for a propagating photon the measurable projection (helicity) is $\pm\hbar$.

For a composite macroscopic body one usually speaks of the total angular momentum J, which is the sum of (i) intrinsic spins of constituents, (ii) orbital angular momentum of constituents, and (iii) any electromagnetic field angular momentum. The relevant comparison to a photon's "one $\hbar$" is to express the body's total angular momentum in units of $\hbar$.

A simple estimate for a magnet: if N_{aligned} electrons have aligned spins, the intrinsic spin contribution is

$$S_{\text{tot}} \approx N_{\text{aligned}} \frac{\hbar}{2}.$$

For a 5-kg piece of ferromagnetic iron one can plausibly have N_{aligned} on the order $10^{27} - 10^{28}$(this depends on the number density and how many 3d electrons per atom contribute). Putting numbers:

$$S_{\text{tot}} \sim 10^{28} \cdot \frac{\hbar}{2} \approx 5 \times 10^{-7} \text{ J\c·p.}$$

$$\frac{S_{\text{tot}}}{\hbar} \sim 5 \times 10^{27}.$$

Thus the macroscopic intrinsic spin (if the magnet is strongly magnetized) corresponds to roughly $10^{27} - 10^{28}$times the spin projection of a single photon (one $\hbar$). In other words, a single photon carries $\sim 1\hbar$, while the magnet's aligned-spin angular momentum corresponds to $\sim 10^{27}\hbar$.

If the body is not magnetized (random spin orientations or paired singlets), the net microscopic spin cancels and the total intrinsic spin can be essentially zero (much less than $1\hbar$). Also note that the classical rotational angular momentum of a macroscopic body (e.g., a rotating 5-kg magnet) is typically many orders of magnitude larger than the intrinsic spin contribution above; thus intrinsic spin is usually irrelevant for mechanical rotation but is crucial for electromagnetic properties of magnets. If we assumed that α has the same nature as spin, then a large moment in a magnet would also result in a large value of α, which is meaningless and incorrect.

Finally, the third reason why spin is most likely not a result of time discreteness is that even for non-magnetized macro objects, the function of spin reduction with increasing size is very different from the functions where our α decreases with increasing mass.

Therefore, I am more inclined to the conclusion that time is continuous, as is gravity, space, and the energy of the body. This would mean that I do not believe that chronons and gravitons do not exist in nature. At the very least, only an experiment can confirm or deny the hypothesis of the continuity of time and space, as well as the continuous smooth structure of gravitation.

§ 7. General theory of relativity for continuous time

Let's start with the standard form of Einstein's equations in four-dimensional space-time:

$$G_{\mu\nu} = R_{\mu\nu} - \tfrac{1}{2} g_{\mu\nu} R = kT_{\mu\nu}, \; k = \tfrac{8\pi G}{c^4}. \qquad (24)$$

Here $R_{\mu\nu}$ is the Ricci tensor, $R = g^{\mu\nu} R_{\mu\nu}$ is the curvature scalar, $g_{\mu\nu}$ is the metric tensor. Einstein's field equations of gravitation establish a local relationship between the Ricci curvature tensor and the energy-momentum tensor — a symmetric tensor field $T_{\mu\nu}$ that encompasses the energy density, momentum density, momentum flux, pressure, and shear stress of matter, radiation, and the vacuum. However, the Ricci tensor provides only limited information about spacetime curvature, as the complete curvature is encoded in the Riemann tensor, not merely in its trace—the Ricci tensor. Therefore, I decided to use the Riemann tensor for our purpose. The Ricci tensor is the convolution of the Riemann tensor:

$$R_{\mu\nu} = R^{\rho}\mu\rho\nu.$$

By modifying formula (15), we obtain:

$$R_{\mu\nu} = k\left(T_{\mu\nu} - \frac{1}{2} g_{\mu\nu} T\right).$$

Where:

$$R = -kT.$$

$$T = g^{\mu\nu} T_{\mu\nu}.$$

In 4-dimensional space, any Riemann tensor can be decomposed into three parts: the Weyl tensor, symmetrized combinations of Ricci, and a scalar part. Formally:

$$R_{\mu\nu\rho\sigma} = W_{\mu\nu\rho\sigma} + \frac{k}{2}\left(g_{\mu\rho}T_{\nu\sigma} - g_{\mu\sigma}T_{\nu\rho} - g_{\nu\rho}T_{\mu\sigma} + g_{\nu\sigma}T_{\mu\rho}\right) - \frac{k}{6}T\left(g_{\mu\rho}g_{\nu\sigma} - g_{\mu\sigma}g_{\nu\rho}\right). \quad (25)$$

We can find the Weyl tensor ($W_{\mu\nu\rho\sigma}$) from our previously found potential equation (14). I will work in the usual spherical (Schwarzschild) coordinates (t,r,θ,φ) and take the metric in the standard static spherically-symmetric form, in the form of:

$$ds^2 = -A(r)\,dt^2 + B(r)\,dr^2 + r^2(d\theta^2 + \sin^2\theta\,d\varphi^2).$$

Next, I will accept a convenient (and frequently used) specialization:

$$B(r) = \frac{1}{A(r)}, A(r) = 1 + 2u(r), u(r) \equiv \frac{\varphi(r)}{c^2},$$

which corresponds to the usual "Schwarzschild-like" radial gauge (and in a weak field $u \ll 1$ gives $g_{tt} \approx -(1 + 2\varphi/c^2)$).

Let's find the Weyl tensor through the potential equation that we found:

$$\varphi(r) = \pm\frac{3c^2}{2}\left[\frac{1}{r}\int_0^r f(s)\,ds + \int_r^\infty \frac{f(s)}{s}\,ds\right] + C$$

Define:

$$u(r) \equiv \frac{\varphi(r)}{c^2} = a\,S(r) + b, \text{ where } a = \pm\frac{3}{2},\ b = \frac{C}{c^2},$$

and

$$S(r) = \frac{1}{r}I(r) + J(r), \qquad I(r) = \int_0^r f(s)\ ds, \qquad J(r) = \int_r^\infty \frac{f(s)}{s}\,ds.$$

The required function W(r) is equal to:

$$W(r) = \frac{r^2u''(r) - 2ru'(r) + 2u(r)}{3r^2}.$$

Then the nonzero (independent) components of the Wylie tensor in the coordinate basis (t,r,θ,φ) can be written as follows (all the others are obtained by symmetries $C_{\mu\nu\rho\sigma} = -C_{\nu\mu\rho\sigma} = -C_{\mu\nu\sigma\rho}$ and so on).

$$C_{trtr} = W(r),$$
$$C_{t\theta t\theta} = -\frac{1+2u(r)}{2}\, r^2\, W(r), C_{t\varphi t\varphi} = C_{t\theta t\theta}\sin^2\theta,$$
$$C_{r\theta r\theta} = \frac{r^2}{2(1+2u(r))}\, W(r), C_{r\varphi r\varphi} = C_{r\theta r\theta}\sin^2\theta,$$
$$C_{\theta\varphi\theta\varphi} = -r^4\sin^2\theta\, W(r).$$

Our task is to express W through f, I, J.

Let's find the derivatives S', S'':

1. $S(r) = I(r)/r + J(r)$.
2. $I'(r) = f(r)$. For J we have $J'(r) = -\frac{f(r)}{r}$ (according to Leibniz's rule for the lower limit).
3. Calculate S':

$$S'(r) = \frac{d}{dr}\left(\frac{\mathrm{I}}{\mathrm{r}}\right) + J'(r) = -\frac{I(r)}{r^2} + \frac{f(r)}{r} - \frac{f(r)}{r} = -\frac{I(r)}{r^2}.$$

(here $\frac{d}{dr}(I/r) = I'/r - I/r^2 = f/r - I/r^2$, and adding $J' = -f/r$ gives $-I/r^2$.)

4. Calculate S'':

$$S''(r) = \frac{d}{dr}\left(-\frac{I}{r^2}\right) = -\frac{f(r)}{r^2} + 2\frac{I(r)}{r^3} = \frac{2I(r) - rf(r)}{r^3}.$$

(these two expressions are for $S'$and S''.)

Constructing an expression under the numerator

We substitute $u = aS + b$ в $N(r) = r^2u'' - 2ru' + 2u$:

$$N(r) = a(r^2S'' - 2rS' + 2S) + 2b.$$

Calculate the inner bracket $T \equiv r^2S'' - 2rS' + 2S$ using the found S', S'':

$$r^2S'' = r^2 \cdot \frac{2I - rf}{r^3} = \frac{2I - rf}{r}.$$
$$-2rS' = -2r \cdot \left(-\frac{I}{r^2}\right) = \frac{2I}{r}.$$

The sum of the first two gives $\frac{4I - rf}{r}$.

$$2S = 2\left(\frac{I}{r} + J\right) = \frac{2I}{r} + 2J.$$

Putting everything together:

$$T = \frac{4I - rf}{r} + \frac{2I}{r} + 2J = \frac{6I - rf}{r} + 2J.$$

Simplify it: $\frac{6I - rf}{r} = \frac{6I}{r} - f$. Means

$$T = \frac{6I}{r} - f + 2\int_r^\infty \frac{f(s)}{s}\, ds.$$

And finally,

$$N(r) = a\left(\frac{6I}{r} - f + 2\int_r^\infty \frac{f}{s}\right) + 2b.$$

Divide by $3r^2$:

$$W(r) = \frac{N(r)}{3r^2} = \frac{a}{3r^2}\left(\frac{6I}{r} - f + 2\int_r^\infty \frac{f}{s}\right) + \frac{2b}{3r^2}.$$

Substitute $a = \pm\frac{3}{2}$. Then the coefficients become:

$$\frac{a}{3}\cdot\frac{6I}{r} = \pm\frac{3I}{r}, \qquad \frac{a}{3}\cdot(-f) = \mp\frac{f}{2}, \qquad \frac{a}{3}\cdot 2\int_r^\infty \frac{f}{s} = \pm\frac{1}{r^2}\int_r^\infty \frac{f}{s}\,ds\cdot r^2$$

After the abbreviations, we get exactly:

$$W(r) = \pm\left(\frac{3}{r^3}\int_0^r f(s)\,ds + \frac{1}{r^2}\int_r^\infty \frac{f(s)}{s}\,ds - \frac{f(r)}{2r^2}\right) + \frac{2}{3}\frac{C}{c^2}\frac{1}{r^2}. \qquad (26)$$

We have obtained the direct result of symbolic differentiation of $u(r) = aS + b$ by definition W.

The formula is correct provided that:

1. f is smooth enough (at least piecewise continuous) for there to exist $f(r)$ and the integrals/derivatives made sense. We have already proven that α does not have to be discrete.
2. The integral $J(r) = \int_r^\infty \frac{f(s)}{s}\,ds$ converges (the behavior of $f(s)$ as $s \to \infty$ is especially important).
3. As $r \to 0$ the integral $I(r) = \int_0^r f$ must behave in such a way that $I(r)/r^3$ does not give a strong singularity in W (otherwise, W may diverge at 0).

In the latter, let's consider the vacuum case outside the source. Then, as we know, α will be equal to one, as there will be no time dilation, and our function $f(r) = 1 - \alpha^2(r)$ will become zero. As a result, many of the components in the Weyl equations will be zeroed out, leaving us with the following form:

$$W(r) = \frac{2}{3}\frac{C}{c^2}\frac{1}{r^2}.$$

This is exactly the Weyl tensor for Schwarzschild spacetime.

§ 8. Finding the Lagrangian for a model with a time parameter.

We start from the variational principle

$$\delta S = 0, S = \int d^4x\sqrt{-g}\,\mathcal{L},$$

where $\mathcal{L}$ is the Lagrangian density that encodes gravity, the new scalar "time--field" $\phi(x)$, the electromagnetic field A_μ and matter. The goal is to write a physically sensible $\mathcal{L}$, vary it with respect to the independent fields $(g_{\mu\nu}, \phi, A_\mu)$ and obtain the Euler--Lagrange equations. We will also discuss gauge invariance, charge conservation, energy positivity and (in)stability issues. We want a model in which a dynamical scalar field ϕ controls the effective electromagnetic coupling/sign in a smooth, local way. The minimal design guidelines are:

1. Keep the electromagnetic kinetic term with the standard sign $(-\frac{1}{4}F_{\mu\nu}F^{\mu\nu})$ to avoid ghost excitations.

2. Introduce a smooth function $h(\phi)$ such that the effective coupling entering Maxwell's equations is $q_{\text{eff}} = q\, h(\phi)$. When $h(\phi) = 1$ we recover usual electrodynamics; when $h(\phi) = -1$ the electric coupling effectively flips sign in that region (the "reversed" electrodynamics).
3. Allow an optional pseudoscalar coupling $\theta(\phi)F\tilde{F}$ to model E--B asymmetries and CP/T-like effects.
4. Keep a standard scalar kinetic term and a potential $V(\phi)$ to allow domain structure, metastability, etc.
5. Include gravity through the Einstein--Hilbert term.
   We will find the explicit Lagrangian density. A compact, minimal and physically transparent form is:

$$\mathcal{L} = \frac{1}{2\kappa}R - \frac{1}{2}\nabla_\mu\phi\,\nabla^\mu\phi - V(\phi) - \frac{1}{4}F_{\mu\nu}F^{\mu\nu} - \frac{1}{4}\,\theta(\phi)\,F_{\mu\nu}\tilde{F}^{\mu\nu} - q\,h(\phi)\,A_\mu J^\mu - \mathcal{L}_{\text{matter}}^{\text{rest}}, \quad (27)$$

with the definitions:

$F_{\mu\nu} \equiv \nabla_\mu A_\nu - \nabla_\nu A_\mu$, $\tilde{F}^{\mu\nu} \equiv \frac{1}{2}\varepsilon^{\mu\nu\alpha\beta}F_{\alpha\beta}$, $\kappa = 8\pi G$, R is the Ricci scalar, $V(\phi)$ is a chosen scalar potential (e.g. a double-well if domain walls/metastability are desired), $h(\phi)$ is a smooth function mapping $\mathbb{R} \to \mathbb{R}$ (typical choice: $h(\phi) = \tanh(\phi/\phi_0)$ so $h \to \pm 1$ asymptotically). This function is our very own α, and they are equal to each other in the following way: α(x) =h(ϕ(x))=f(ϕ(x)). $\theta(\phi)$ is an optional pseudoscalar function (small in magnitude to respect experimental CP limits), J^μ is the (macroscopic) conserved current supplied by matter; $\mathcal{L}_{\text{matter}}^{\text{rest}}$ contains the remaining matter Lagrangian not explicitly written here (kinetic + mass terms of fermions, etc.).

The interaction is written in the simple effective form $-q\,h(\phi)\,A_\mu J^\mu$. This is explicit and convenient for deriving the modified Maxwell equations. Two important caveats follow:

If one models J^μ microscopically by fermions ψ with minimal coupling $i\bar{\psi}\gamma^\mu(\nabla_\mu - iqh(\phi)A_\mu)\psi$, then if $h(\phi)$ varies in space-time the standard gauge transformation $\psi \to e^{iq\Lambda}\psi$, $A_\mu \to A_\mu + \nabla_\mu\Lambda$ is not manifestly preserved unless the full UV completion supplies compensating fields. Thus the form above is best interpreted as an effective low-energy description, or else one must build a gauge-consistent microscopic model.

We vary the action with respect to A_μ. For clarity we show the main steps.

Relevant terms in $\mathcal{L}$ depending on A_μ:

$$\mathcal{L}_A = -\frac{1}{4}F_{\mu\nu}F^{\mu\nu} - \frac{1}{4}\,\theta(\phi)\,F_{\mu\nu}\tilde{F}^{\mu\nu} - q\,h(\phi)\,A_\mu J^\mu.$$

Variation. Use $\delta F_{\mu\nu} = \nabla_\mu\delta A_\nu - \nabla_\nu\delta A_\mu$. Then:

$$\delta(-\frac{1}{4}F^2) = -\frac{1}{2}F^{\mu\nu}\,\delta F_{\mu\nu} = -F^{\mu\nu}\nabla_\mu\delta A_\nu.$$

Integrating by parts and discarding boundary terms (assume δA_μ vanishes on the boundary), we get:

$$\int d^4x\,\sqrt{-g}\,\nabla_\mu F^{\mu\nu}\,\delta A_\nu.$$

For the $\theta(\phi)F\tilde{F}$ term,

$$\delta(-\frac{1}{4}\theta(\phi)F_{\mu\nu}\tilde{F}^{\mu\nu}) = -\frac{1}{2}\theta(\phi)\tilde{F}^{\mu\nu}\,\delta F_{\mu\nu} = -\theta(\phi)\tilde{F}^{\mu\nu}\nabla_\mu\delta A_\nu.$$

Integrating by parts gives a contribution $\nabla_\mu(\theta(\phi)\tilde{F}^{\mu\nu})\delta A_\nu$. Using $\nabla_\mu\tilde{F}^{\mu\nu} = 0$ (Bianchi identity), this simplifies to $(\partial_\mu\theta)\tilde{F}^{\mu\nu}\delta A_\nu$. Finally, the explicit source term variation yields $-qh(\phi)J^\nu\delta A_\nu$.

Euler--Lagrange result. Collecting terms:

$$\nabla_\mu F^{\mu\nu} + (\partial_\mu\theta(\phi))\,\tilde{F}^{\mu\nu} = q\,h(\phi)\,J^\nu. \tag{28}$$

This is the central modification of Maxwell's equations. If $\theta =$ const and $h(\phi) = 1$, it reduces to the usual Maxwell equations in curved spacetime.

Notes:

- Writing out components in a 3+1 split recovers modified Gauss's and Ampère's laws.
- The extra $(\partial\theta)\tilde{F}$ term sources effective currents if $\theta(\phi)$ varies.

Now let's calculate the variation with respect to ϕ: the scalar field equation (Klein-Gordon with sources). Collect the ϕ-dependent pieces:

$$\mathcal{L}_\phi = -\frac{1}{2}\nabla_\mu\phi\,\nabla^\mu\phi - V(\phi) - \frac{1}{4}\theta(\phi)F_{\mu\nu}\tilde{F}^{\mu\nu} - qh(\phi)A_\mu J^\mu + \cdots$$

Varying ϕ gives:

From kinetic term: $\delta(-\frac{1}{2}(\nabla\phi)^2) \to (\Box\phi)\,\delta\phi$.

From potential: $-V'(\phi)\,\delta\phi$.

From $-\frac{1}{4}\theta(\phi)F\tilde{F}$: $-\frac{1}{4}\theta'(\phi)F\tilde{F}\,\delta\phi$.

From $-qh(\phi)A\cdot J$: $-qh'(\phi)A_\mu J^\mu\,\delta\phi$.

Hence the scalar equation is

$$\Box\phi - V'(\phi) = \frac{1}{4}\,\theta'(\phi)\,F_{\mu\nu}\tilde{F}^{\mu\nu} + q\,h'(\phi)\,A_\mu J^\mu. \tag{29}$$

Interpretation. Electromagnetic field configurations and current densities act as sources for ϕ. This provides a back-reaction mechanism: where fields or currents are strong, ϕ can be driven to new values, possibly flipping $h(\phi)$.

Varying the full action with respect to the metric gives the Einstein field equations:

$$\frac{1}{\kappa}G_{\mu\nu} = T^{(\phi)}_{\mu\nu} + T^{(EM)}_{\mu\nu} + T^{(\theta)}_{\mu\nu} + T^{(\mathrm{int})}_{\mu\nu} + T^{\mathrm{matter(rest)}}_{\mu\nu},$$

where the main contributions are:

Scalar field energy--momentum tensor

$$T^{(\phi)}_{\mu\nu} = \nabla_\mu\phi\,\nabla_\nu\phi - g_{\mu\nu}(\frac{1}{2}\nabla_\alpha\phi\,\nabla^\alpha\phi + V(\phi)).$$

Electromagnetic tensor (from $-\frac{1}{4}F^2$ term)

$$T^{(EM)}_{\mu\nu} = F_{\mu\alpha}F_\nu{}^\alpha + \frac{1}{4}g_{\mu\nu}F_{\alpha\beta}F^{\alpha\beta}.$$

(This is the standard symmetric, traceless piece for free EM in vacuum; if $\theta(\phi)$ depends on ϕ, additional small contributions appear.)

Contributions from the $\theta(\phi)F\tilde{F}$ term and the interaction term $-qh(\phi)A_\mu J^\mu$ add further elements; in particular, domain walls (regions where ϕ varies rapidly) carry stress-energy concentrated in the wall.

All such contributions are computable by standard variation; explicit component formulae can be provided on demand.

Consistency checks and physical interpretation.

1. Gauge invariance and interpretation of the interaction term.

If the interaction is written as $-qh(\phi)A_\mu J^\mu$ with J^μ an external conserved *current* ($\nabla_\mu J^\mu = 0$), then the variation above is perfectly consistent as an effective description. However, if J^μ is obtained from minimally coupled dynamical fermions ψ via $J^\mu = \bar{\psi}\gamma^\mu\psi$, and if the microscopic matter Lagrangian contains $i\bar{\psi}\gamma^\mu(\nabla_\mu - iqh(\phi)A_\mu)\psi$, then the usual local U(1) gauge invariance is not manifest when $h(\phi)$ depends on position/time. That is because the gauge transformation of ψ and A_μ must be redefined in a way that depends on ϕ; this requires a UV-complete mechanism (for example, integrating out heavy charged fields can produce an effective position-dependent coupling while maintaining overall gauge invariance in the full theory).

Interpretation: treat the present Lagrangian as an effective field theory valid in an energy window where the gauge-breaking artifacts are negligible or are in fact matched by heavier-sector degrees of freedom. Alternatively, keep $h(\phi)$ slowly varying on scales of interest so local gauge effects are small.

2. Charge conservation and divergence identity.

Take the covariant divergence of the modified Maxwell equation:

$$\nabla_\nu(\nabla_\mu F^{\mu\nu} + (\partial_\mu\theta)\tilde{F}^{\mu\nu}) = \nabla_\nu(qh(\phi)J^\nu).$$

Leftmost term vanishes by antisymmetry and Bianchi identity except for the θ gradient piece, hence

$$\nabla_\nu(qh(\phi)J^\nu) = -\nabla_\nu((\partial_\mu\theta)\tilde{F}^{\mu\nu}).$$

Therefore $qh(\phi)J^\nu$ is not, by itself, conserved if $\theta(\phi)$ varies. In a microscopic model total charge is still conserved: the divergence above is balanced by ϕ dynamics (see scalar equation). Practically, this means current/charge can be exchanged with the ϕ-sector (consistent with energy--momentum exchange) --- not a fundamental violation of charge conservation, but a redistribution of charge/current between sectors in the effective description.

3. Avoiding ghosts and energy positivity.

We deliberately do not modify the sign of the kinetic electromagnetic term $(-\frac{1}{4}F^2)$. Changing it by an $f(\phi)$ factor that crosses zero creates regions with negative kinetic energy (ghosts) and makes the theory unstable. Thus the choice $h(\phi)$ multiplying the interaction rather than the kinetic term is safer.

The scalar kinetic term has the standard sign; ensure the coefficient of $(\nabla\phi)^2$ is positive to avoid scalar ghosts.

Energy positivity of the total stress-energy must be checked case-by-case. Domain walls cost positive energy density $(\sim \int [(\partial_r\phi)^2 + V(\phi)]dr)$.

4. Stability: linearized analysis (summary).

Linearize about a background solution $(g^{(0)}_{\mu\nu}, \phi_0, A^{(0)}_\mu = 0)$:

- Expand $\phi = \phi_0 + \delta\phi$, $A_\mu = \delta A_\mu$.

- The quadratic action for fluctuations has kinetic terms ($\sim -\frac{1}{4}(\delta F)^2$) and ($\frac{1}{2}(\partial\delta\phi)^2$). No sign flips → no immediate ghosts.

- Mass/tachyonic instabilities for $\delta\phi$ occur if $V''(\phi_0) < 0$ (tachyonic), which can be desirable (spontaneous symmetry breaking) or problematic (runaway). Choose $V(\phi)$ accordingly.

- If $h'(\phi_0)$ or $\theta'(\phi_0)$ are large, mixing terms couple $\delta\phi$ to δA; diagonalize to check the positivity of the kinetic matrix. This is a standard stability calculation; the requirement is that the kinetic matrix be positive definite.

5. Domain walls and matching conditions.

If ϕ interpolates between regions where $h(\phi)$ has different signs (e.g. +1 and −1), an interface (domain wall) forms. The wall carries finite surface energy and pressure and produces gravitational effects. Matching requires continuous metric and junction conditions (Israel junction conditions) if the wall is thin. The wall profile is found by solving the static scalar equation with appropriate boundary conditions; its tension is

$$\sigma \simeq \int_{-\infty}^{+\infty} [(\partial_x\phi)^2 + 2V(\phi)]\, dx.$$

Practical choices and example functions:

1. Example coupling: $h(\phi) = \tanh(\phi/\phi_0)$. Smooth, bounded in $(-1,1)$; ϕ_0 sets the transition steepness.
2. Example potential: $V(\phi) = \frac{1}{2}m_\phi^2\phi^2 + \frac{\lambda}{4}\phi^4$ (or a double-well $V(\phi) = \lambda(\phi^2 - v^2)^2$ to allow metastable vacua).
3. Small θ : $\theta(\phi) = \theta_0\frac{\phi}{\Lambda}$ with $|\theta_0| \ll 1$ ensures experimental CP constraints are satisfied.

Observational constraints and phenomenology (brief).

Any spatial region where $h(\phi)$ differs appreciably from 1 would modify Coulomb's law and forces between charges. High-precision experiments on Coulomb's law and the electrostatic constant bound deviations to tiny fractions, so in laboratory/solar-system environments $h(\phi)$ must be extremely close to unity. The model predicts potential signatures in extreme environments (near compact objects, in the early universe) where ϕ may be driven away from its asymptotic value. Domain walls and phase transitions in ϕ-sector would leave cosmological imprints (CMB, structure formation) that currently constrain such possibilities strongly; parameters must be chosen to avoid conflict with observations.

Final boxed summary --- equations deriving from $\delta S = 0$:

From the action $S = \int d^4x\,\sqrt{-g}\,\mathcal{L}$ with

$$\mathcal{L} = \frac{1}{2\kappa}R - \frac{1}{2}(\nabla\phi)^2 - V(\phi) - \frac{1}{4}F^2 - \frac{1}{4}\theta(\phi)F\tilde{F} - qh(\phi)A\cdot J + \mathcal{L}_{\text{matter}}^{\text{rest}}. \quad (30)$$

the Euler--Lagrange field equations are

(a) Modified Maxwell equations:

$$\nabla_\mu F^{\mu\nu} + (\partial_\mu\theta(\phi))\,\tilde{F}^{\mu\nu} = q\,h(\phi)\,J^\nu. \quad (31)$$

(b) Scalar field equation:

$$\Box\phi - V'(\phi) = \frac{1}{4}\theta'(\phi)\, F_{\mu\nu}\tilde{F}^{\mu\nu} + q\, h'(\phi)\, A_\mu J^\mu. \tag{32}$$

(c) Einstein equations:

$$\frac{1}{\kappa} G_{\mu\nu} = T_{\mu\nu}^{(\phi)} + T_{\mu\nu}^{(EM)} + T_{\mu\nu}^{(\theta)} + T_{\mu\nu}^{(\text{int})} + T_{\mu\nu}^{\text{matter(rest)}}. \tag{33}$$

These follow directly from $\delta S = 0$ under standard boundary conditions.

Closing remarks (interpretation)

- The Lagrangian above does satisfy the variational principle $\delta S = 0$ and yields the proposed modified Maxwell, scalar and Einstein equations in a mathematically standard way.
- The construction is physically meaningful as an effective field theory: it implements a local control field ϕ (your α) that modulates electromagnetic coupling and allows the "reverse Maxwell" regime in regions where $h(\phi) < 0$.
- The principal physical and mathematical challenges are: preserving gauge consistency in a full microscopic model, avoiding ghost regimes, and satisfying observational constraints. These are manageable: the safest route is to keep the EM kinetic term standard, interpret the theory as an EFT, carefully choose $V(\phi)$ and $h(\phi)$, and check stability.

§ 9. The hypothesis of the general picture of the universe and baryon asymmetries

We might begin by contemplating the nature of time at the very origin of existence. According to the prevailing cosmological model, our universe originated from a singularity—an event known as the Big Bang. This model implies that all matter, energy, and the fabric of spacetime itself emerged from an extremely hot, dense, and singular state.

Let us consider the hypothetical properties of this primordial entity. To facilitate a structured thought experiment, we may initially postulate its form to be spherically symmetrical. The choice of a sphere is motivated by its prevalence among large celestial bodies and its property of perfect isotropy, which implies no preferred direction or inherent differentiation between any of its parts. This assumption of homogeneity and isotropy is a foundational principle in modern cosmology (e.g., the Cosmological Principle).

Furthermore, we must define the environment of this entity. It is postulated to exist in a state of absolute isolation, not merely a classical vacuum but a complete absence of any external spacetime, matter, energy, or fields. This includes the absence of phenomena associated with dark matter or dark energy, as these are properties of the evolving universe that came into existence after the initial expansion.

Given this isolation, we can interrogate its properties:

1. Location: The question of its spatial position is rendered meaningless. Spatial coordinates require a pre-existing framework or other reference points for definition. Since this entity constitutes the entirety of existence, the concept of "where" does not apply.

2. Size and Scale: Similarly, without a reference frame or an external metric, attributing a classical size (e.g., that of an apple or a galaxy) is not physically definable.

3. State of Motion: Questions regarding its translational or rotational motion are also unanswerable within this framework. Motion is only defined relative to something else, which, by postulate, does not exist.

Despite these indeterminacies, we can infer that this state must have possessed an immense energy density. To be the origin of all observable universe, it must have contained the totality of energy in an ultra-compact form. Consequently, one can hypothesize that it would be characterized by intense radiation, including high-energy photons (gamma rays) and particle-antiparticle pairs, all confined by extreme gravitational forces.

This description bears a resemblance to the characteristics of a black hole singularity or the hyper-massive accretion disks of quasars, which also exhibit regions of extreme density and energy. However, a critical distinction must be made: black holes and quasars exist within a pre-existing spacetime continuum and are bound by an event horizon. They are known to slowly lose mass over astronomical timescales via Hawking radiation, not to explode.

This leads to the central and unresolved questions of cosmology:

- What mechanism triggered the transition from a stable singularity to a rapid, inflationary expansion? The nature of this "initiation event" remains the foremost inquiry in physics.

-What was the state of the universe during and before the Planck epoch? Our current theories of general relativity and quantum mechanics break down at this scale, and a theory of quantum gravity is required to probe this domain. The very origin of this "primordial kernel" itself constitutes the ultimate boundary of our scientific understanding.

To address these questions, we must first grapple with the fundamental issue of how time manifested its essence at that primordial moment. How did time "flow" at the beginning of everything?

A common intuition, drawn from the physics of black holes, might suggest that since this entity was a singularity, time at its "center" must have been "frozen" or dilated infinitely. Conversely, one might erroneously presume that in the surrounding "absolute vacuum," time would flow infinitely fast or instantaneously. However, these analogies are fundamentally flawed, as they implicitly rely on the existence of an external spacetime framework and an observer to make such measurements—conditions that are absent by definition in the pre-Big Bang state.

This leads to a natural and profound problem: how can one define the passage of time in a universe containing only a single, isolated entity? Just as the concepts of spatial position and scale become meaningless without a reference frame, the concept of temporal flow loses its definition without change or interaction. Without a second entity or an internal process to serve as a clock, there is no operational way to distinguish between a state where time is "stopped," "flows infinitely fast," or does not exist at all.

To explain this conceptual impasse, I advance the following hypothesis: for time to possess operational meaning, the universe must contain at least two distinct entities or degrees of freedom capable of interaction. Time is not an absolute background entity that exists independently; rather, it is an emergent property that derives its meaning from change and causal relationships between physical systems.

Consider a universe with two bodies. Let the distance between them periodically increase and decrease—in other words, let them oscillate relative to one another. For these two bodies, time exists and has a clear meaning. Their relative motion provides a clock; the oscillation period defines a unit of time. Even if the bodies were perfectly stationary relative to each other, we could still hypothesize the passage of time if they were moving together through a hypothetical space. The absolute state of rest is undetectable.

Now, consider a universe containing only one solitary body and nothing else. In this scenario, we cannot ascertain any properties of time—not its direction (forward or backward), not its rate of flow, and not even whether it flows at all or is halted. Without a second reference point or an internal dynamic process, the very question of temporal flow becomes unanswerable and physically undefined. In such a perfectly static and isolated state, the concept of time may not merely be "stopped"—it may be entirely absent, as there is no physical process to give it substance.

This perspective suggests that the initial singularity may not have been a state within time, but rather the event that gave rise to time itself along with space and matter. The transition from a timeless, undifferentiated state to a universe with multiple degrees of freedom (through the process of inflation and the Big Bang) may have been the moment when time, as we understand it, began to flow.

Here you can object that since we have found the "fields of time" in equation (23), then regardless of whether there is another body nearby or not, this field must exist. And if there is a field, then the space of time itself exists. You can also refer to the gravitational field as an example. Let's say there is a formula for gravitational interaction:

$$F = G\frac{m_1 m_2}{r^2}$$

You will say that in this case, gravitational attraction does not exist because there is no second body (m_2). But you will also say that there is a gravitational field that is not determined by whether there is a second body or not according to this formula:

$$\varphi(\vec{r}) = -G\frac{M}{r}$$

Like the formula we've already found:

$$\varphi(r) = \pm\frac{3c^2}{2}\left[\frac{1}{r}\int_0^r f(s)\,ds + \int_r^\infty \frac{f(s)}{s}\,ds\right] + C$$

But there are two main problems here. First, we don't know if the constant constants (G,c) were still valid during the Planck epoch or even before it. Second, and most importantly, as we mentioned earlier, the distance r loses its meaning. Furthermore, if we adhere to the principle that everything which exists must have a beginning, then it is logically consistent to propose that time itself must have had a moment of inception—a point at which it began to act. This would intrinsically mean that prior to this moment, time, as a physical property, did not exist.

Building upon this logic and the previous hypothesis, I am inclined to speculate a step further: that it was precisely this state of timelessness that served as the fundamental cause of the Big Bang and the subsequent emergence of all known physical reality. One might venture a theoretical proposition: the very impossibility of a sustained state of non-existence—a timeless, static nullity—created an unstable ontological condition. A profound metaphysical contradiction between the potential for existence and the act of non-existence, necessitated a resolution. The Big Bang, in this view, was not an explosion within space and time but rather the cataclysmic event that marked the violent birth of space and time from this untenable pre-existential state. This "explosion" was the mechanism through which this contradiction was resolved, giving rise to the temporal continuum and the evolving universe we inhabit.

This line of reasoning implies that the immense concentration of energy associated with the Big Bang was not a pre-existing cause but a consequence of the initiation of the expansion. Initiation was itself catalyzed by the fundamental instability of a timeless state—a state of "non-existence" where the very concept of a "disagreement" or tension is metaphorical, representing an ontological instability that required resolution.

Therefore, we must extend the properties of this primordial entity: not only did it lack definable size, position, or motion, but it also lacked energy in any of its forms—be it mass, gluon field energy, or radiation. Reiterating that there was no reference frame, we conclude that its characteristics were not just unknown but fundamentally undefined. It could be described as infinitesimally small, or more accurately, the concepts of "size" and "volume" were inapplicable.

Consequently, possessing no energy density, mass, radiation (making it perfectly black in a non-existent space), or electromagnetic properties (due to the absence of charge and motion), this "entity" would be utterly indistinguishable from its surrounding "non-environment." This presents a profound philosophical and physical question: does such an "entity" actually exist?

Indeed, it is logically parsimonious to conclude that an entity devoid of mass, charge, size, velocity, spin, and energy does not exist in any meaningful physical sense. This reasoning leads to a radical yet compelling interpretation: the universe, in its entirety, emerged from a state that can be equated with nothingness or a pure vacuum fluctuation on a cosmic scale.

However, the cause of this emergence was not a pre-existing "thing" but the spontaneous genesis of the first fundamental property: spacetime. The initiation of time (the beginning of its "flow") and the expansion of space were the primordial events. They were not the result of a cause within time but the first cause themselves. Once spacetime came into existence, it provided the framework—the arena—within which energy could spontaneously manifest (in accordance with the uncertainty principle of quantum field theory), precipitating the hot, dense state we call the Big Bang and giving rise to all subsequent physical phenomena.

Now let's continue our discussion and consider the case when the universe has already appeared. Since the Big Bang, a fundamental asymmetry has been evident in the universe. One of its manifestations is baryon asymmetry—the observed predominance of particles over antiparticles. In modern cosmology, we practically never encounter antiparticles, except for those created artificially in accelerators or in certain high-energy processes. This naturally raises the question: what is the cause of this asymmetry?

In theoretical physics, as we have shown, antiparticles are often interpreted as states associated with the reverse flow of time. All quantum processes in which they participate can be viewed as mirror images of similar processes involving particles. In other words, their properties are largely equivalent to those of particles, but with a changed direction of evolution. For example, the spin of a particle and an antiparticle has the same magnitude but opposite orientation. In a metaphorical sense, this can be interpreted as “moving backward in time.”

It follows that the observed predominance of particles over antiparticles is related to the direction of time in our universe. On a macroscopic scale, we observe only one direction of time flow — conventionally speaking, forward — and processes going “backward” are practically not observed. This limitation also applies to other interactions: for example, electromagnetic interaction exhibits clear asymmetry. Thus, the right-hand rule is used to determine the direction of magnetic induction. The question arises: why the right hand and not the left? The answer lies in the fundamental connection between the charge, magnetic moment, and spin of a particle. We have already written down the “reverse” equations of electrodynamics, where all processes would be described by time reversal, but in the observable physical reality, such solutions are not realized.

A similar situation is observed in gravity. Masses attract each other, but we do not observe similar stable processes with repulsion. This raises a similar question: if there are black holes that absorb matter and distort space-time, why are there no white holes that eject matter outward? Why do we not encounter negative mass or negative energy?

Thus, fundamental asymmetry manifests itself at different levels of the physical picture of the world: from baryon excess and electromagnetic rules to the properties of gravity and the structure of cosmological objects. This asymmetry indicates that the arrow of time and fundamental interactions cannot be considered completely symmetrical, and this is probably the reason why the universe is structured the way we observe it.

It seems possible to consider the existence of a so-called “anti-world” — a hypothetical symmetrical reality in which the fundamental properties of matter and interactions are inverted relative to our universe. Within this concept, time in the antimatter universe flows in the opposite direction: processes evolve not forward, but “backward” compared to our cosmological arrow of time.

In the antimatter universe, particles are replaced by antiparticles, which entails the inversion of electric charges and a number of quantum characteristics. The only exceptions are those objects that coincide with their antiparticles — for example, photons or hypothetical Majorana neutrinos. Thus, the structure of matter and fields in the antimatter universe would reflect all the laws known to us, but in reverse configuration.

A key consequence of this hypothesis is related to baryon asymmetry. In our universe, particles consistently prevail over antiparticles. In the antimatter universe, however, antiparticles must be the dominant objects, which would restore the global balance of matter and antimatter within a broader cosmological picture. Along with this, a difference in energy states is assumed: positive energy prevails in our world, while in the antimatter world there could be a sphere in which negative energy is the main manifestation.

Mirror analogues can also be expected in the field of astrophysical objects. Where black holes exist in our universe, absorbing matter and deforming space-time, white holes should arise in the antimatter universe — objects that eject matter and radiation outward. Galaxies in such a reality would rotate in the opposite direction to ours, and the universal force of gravity would have an inverted analogue — «antigravity», manifested as the repulsion of masses.

Electromagnetic laws would also undergo mirror changes. In our physics, the direction of magnetic lines is determined by the right-hand rule; in the antimatter universe, the left-hand rule would play this role. If the cosmological evolution of our universe is characterized by the expansion of space and time, then in the antimatter universe, the opposite process — contraction — would naturally occur.

Thus, the antimatter hypothesis allows us to view the observed asymmetry not as a fundamental violation, but as a manifestation of the divided structure of existence. In this interpretation, our universe is only one half of a unified picture, while antimatter is its mirror complement. Together, they form a holistic system in which the directions of time, energy, and interactions are opposite but mutually balance each other, creating a deeper and more universal symmetry of the universe. The proposed shape of the entire universe is similar to Figure 12.

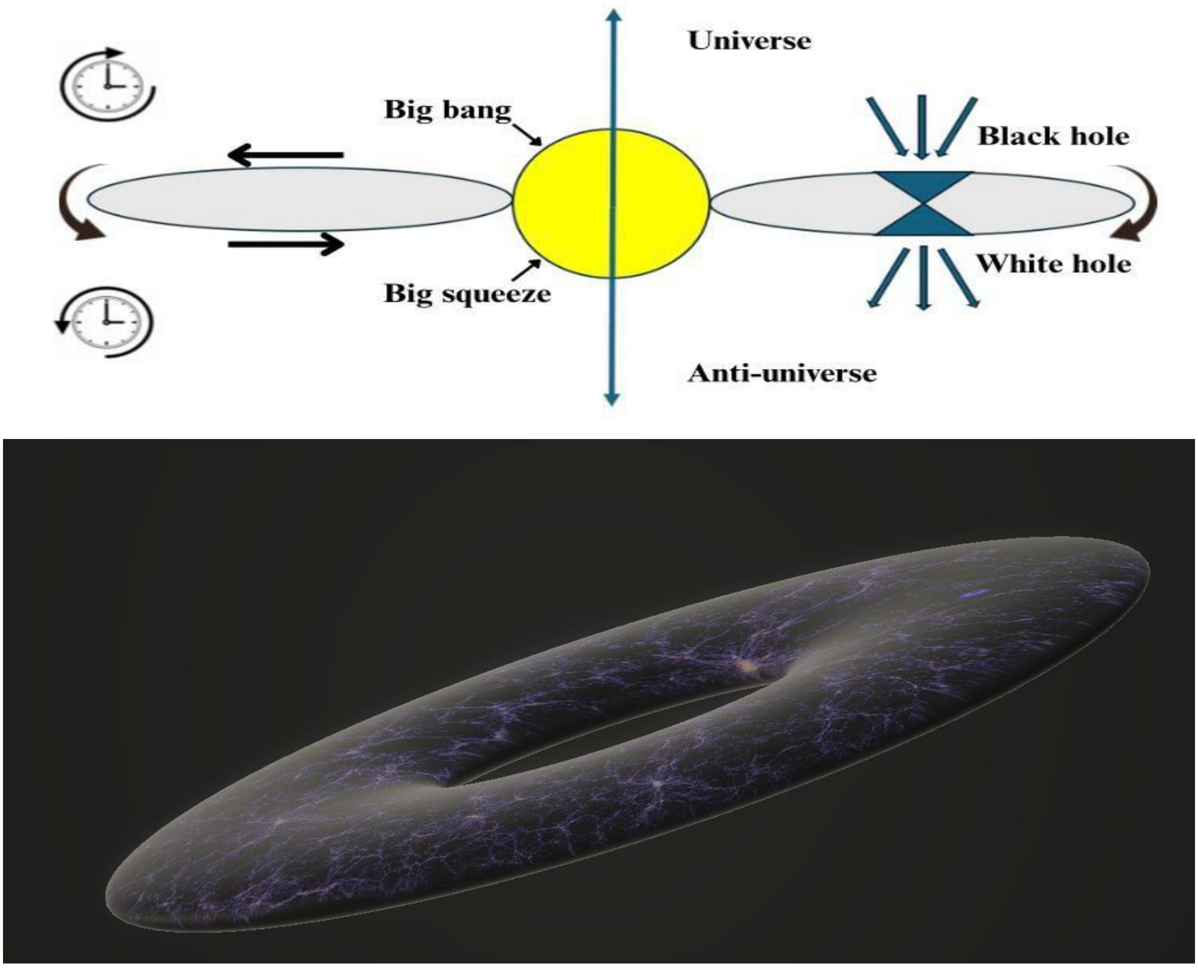

Figure 12

Here, our universe is represented as a torus, with the upper side being the current world we live in. The lower side is the antimatter world, where time flows in reverse. The entire universe expands from the center, eventually transforming into the antimatter world and returning to its initial point, where everything begins anew. Therefore, in the antimatter world, all bodies should contract with an energy equal to the dark energy, but with a negative sign, which should eventually lead to a large contraction. Consequently, all the positive energy that exists in our normal world should have the same magnitude, but with the opposite sign, in the hypothetical anti-univers. Taken together, this should result in a net energy of zero. This is why we observe the asymmetry effect, as we are only experiencing one side of the universe.

It is appropriate to ask here when our world will turn into an anti-world. One could answer this question by saying that it will happen in an almost infinite amount of time.

Modern physics considers the question of the “eternity” of particles not as a philosophical abstraction, but as a very concrete problem related to the stability of matter, conservation laws, and the statistical properties of the quantum vacuum. According to current theories, no known particle is absolutely eternal. Even those that appear stable—such as protons or electrons—may have a finite lifetime from the point of view of fundamental physics, albeit an astronomically long one.

The matter that makes up the observable universe is subject to the laws of quantum electrodynamics, strong and weak interactions, and gravity. All these forces allow for the possibility of elementary particles decaying over sufficiently long periods of time. According to the standard model, the electron is stable, but extended grand unified theories (GUT) suggest that even the proton, the basis of the atomic nucleus, can decay with a lifetime of about 10^{34} years. This means that if the universe exists long enough, even matter as we know it will disappear, leaving only a stream of light particles and radiation.

If we consider the question more deeply, it should be noted that the concept of a “particle” is not absolute in itself. In quantum field theory, a particle is an excitation of the corresponding field, localized and finite in time. Any excitation of a field, interacting with others, loses energy, annihilates, or turns into other excitations. Therefore, the statement that particles are finite reflects the very nature of the quantum vacuum: stable states in it are not eternal, but only metastable.

In the distant future, from a cosmological perspective, the process of matter degradation will become total. Stars will burn out, black holes will evaporate through the Hawking effect, and residual particles will decay or be absorbed by vacuum fluctuations. The universe will enter the so-called heat death era — a state in which energy is distributed as evenly as possible and no processes occur anymore. This is a natural consequence of the second law of thermodynamics, which states that the entropy of a closed system always increases. Even if we consider quantum fluctuations, which can locally disturb the equilibrium, they will not lead to the return of ordered matter. At best, they will lead to rare, random formations of short-lived structures that will immediately disappear. From a philosophical point of view, it can be said that the infinite existence of a particle is impossible because it contradicts the very nature of time and interactions. Everything that has energy and mass must eventually exchange them with the environment, losing its individuality.

Some hypotheses of quantum cosmology suggest that the field underlying particles can transition to other states, creating new forms of matter in the future. However, this does not negate the finiteness of current forms — it only transfers evolution to another level. Thus, we can conclude that particles do not disappear "into thin air" but are transformed into other states of energy and vacuum, following the law of conservation but losing their individual form.

Ultimately, all structures, from elementary particles to galaxies, are subject to destruction over time. But disappearance here does not mean destruction — it means transformation. Matter does not die, it simply ceases to be what it was. And in this sense, infinity is not a property of particles, but a property of the very process of existence, which never completely ceases, but only changes forms.

If we continue to speculate about the future of matter and energy, then after an infinitely long time we will encounter a limiting state—not simply the "end" of the universe, but its transition to a stage of eternal rarefaction and the disappearance of differences. According to modern cosmological models (ΛCDM), the expansion of space not only continues but is accelerating under the influence of dark energy. This means that the distances between galaxies will grow exponentially, and the energy density contained in ordinary matter and radiation will rapidly decrease.

Over time, all forms of bound matter will cease to exist. Stars will stop thermonuclear reactions, leaving behind white dwarfs, neutron stars, and black holes. But even these remnants are not eternal: white dwarfs will cool down, turning into "black" ones, neutron stars will gradually lose energy, and black holes will evaporate through the Hawking effect, turning into soft radiation. This will be followed by a "dark age" — a period when space is filled only with an extremely sparse background of low-energy photons, neutrinos, and possibly rare traces of decayed particles.

However, over an infinitely long period of time, even these residual forms of energy lose their physical meaning. Due to the constant expansion of the universe, the wavelength of any radiation stretches, the frequency tends to zero, and the energy density tends to an infinitely small value. Energy does not disappear in an absolute sense, but becomes so sparse that in each finite region of space, the average energy is practically zero. From the observer's point of view, the universe turns into an empty, cold, and motionless space without structure, events, or differences.

Over an infinitely long time, the distances between any points in space will become so great that the causal connection between them will disappear: no particle or quantum of radiation will be able to overcome this abyss. Thus, even the concept of the "universe" loses its meaning, because all that remains is an infinite and homogeneous expanding field in which there are no observers and no processes.

It can be said that everything that exists dissolves into space itself, and the universe asymptotically strives for a state of complete thermodynamic equilibrium. Entropy reaches its maximum, and energy becomes evenly distributed over an infinite volume. At this limit, there is nothing left that could be called a "thing," a "particle," or a "motion." Time as a sequence of changes loses its physical meaning because there is nothing left to change.

This is not an end in the usual sense, but an eternal fading away — a process stretched out to infinity, where each subsequent stage is characterized by less and less dynamics. One can imagine that as we approach this limit, space itself becomes an increasingly abstract concept — energetically empty, but formally continuing to expand.

Philosophically, this state can be called the “silence of being”: everything that once existed is not destroyed, but simply distributed across infinite space with zero density. In this sense, disappearance is not the opposite of existence, but its limit. Energy is preserved, but the meaning of its existence disappears along with the possibility of differences. And perhaps this is where true infinity lies — not in the eternity of matter, but in the eternal striving of everything toward peace, where there is not even time to notice that everything has ended.

This infinitely small density of energy arising from the infinite expansion of the universe is very similar to what existed at the very beginning of the universe. And these two states, which have identical conditions, determine the boundaries of the entire universe. That is, Figure 12 is not entirely correct for our hypothesis. The picture of the entire universe will apparently be correct if the width or radius of the torus itself is infinite. In this case, many processes must occur as on an infinite plane, which is in fact only one surface of the torus itself. At the same time, this infinite nature of the universe's form does not prevent the expansion of space in our world and the compression in the anti-world. To explain this, let's consider a rope that has a finite length. Now let's pull one end of the rope, and the other end of the rope will immediately stretch. Now imagine that this rope has infinite length. When we pull the rope again by one end, the other end will apparently also stretch. Intuitively, it may seem strange that an infinitely long rope can have two ends. But here we have mentally placed one end of the rope in our world and the other end in the anti-world. Between these ends, the length of the rope, strange as it may seem, must be infinitely long. The same principle applies throughout the entire fabric of the universe, which is constantly and continuously contracting, creating more and more universes, while at the same time absorbing already inverted worlds where time flows in reverse and the world consists of antimatter. But at the same time, it is interesting that each universe that has appeared and disappeared does not follow one after another, that is, it is not chained. The reason for this apparently lies in the fact that between these processes of time, as we understand it, does not exist, and therefore it cannot be said that one universe appeared earlier or later than another.

It is crucial to emphasize that these statements are not assertions of established physical truth. Rather, they are philosophical deductions and theoretical predictions intended to probe the boundaries of our understanding. They form a speculative framework aimed at addressing the ultimate question of why there is something rather than nothing, a question that currently lies at the frontier between theoretical cosmology and metaphysics.

References

[1] Feynman, R. P., Leighton, R. B., & Sands, M. (2022). *Feynman's Lectures on Physics. Vol. 1: Mechanics, Radiation, and Heat* (Russian edition, p. 87). Moscow: AST Publishers.

[2] Oxford University Press. (2012, July 4). *Time*. In *Oxford Dictionaries*. Archived from the original on July 4, 2012. Retrieved May 18, 2017, from https://www.oxfordlearnersdictionaries.com/definition/english/time

[3] Wikipedia contributors. (n.d.). *Antiparticle*. In *Wikipedia, The Free Encyclopedia*. https://en.wikipedia.org/wiki/Antiparticle

[4] Wikipedia contributors. (n.d.). *Dirac equation*. In *Wikipedia, The Free Encyclopedia*. https://en.wikipedia.org/wiki/Dirac_equation