Space-time continuum and Louis de Broglie waves of elementary particles.

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Abstract: Using de Broglie waves of elementary particles it is shown how time is formed in the Universe. The definitions of the concepts "time" and "space" are given. Time is a simple duration of the process of oscillation of microparticles, which is fixed at a certain point in space. Therefore, time is a scalar and there is no "arrow of time". It is also shown how de Broglie waves transfer information between microparticles at a speed exceeding the speed of light in a vacuum.

Keywords: Time, space-time continuum, interval, de Broglie wave, Compton wavelength, information transfer between microparticles.

INTRODUCTION.

What is time? What is the space-time continuum? How are they formed, what are they made of? These questions have been of interest to physics and philosophy since ancient times. With the development of science, the emphasis in understanding these concepts shifts, but complete and reliable knowledge is still far away. Moreover, it is difficult even to give an exhaustive definition of the concepts of "time" and "space" in the physical sense. But, nevertheless, we will try to do it...

For an accurate definition of time, it is necessary to consider how time is formed in our world, and what the concept of "time" is in general. To do this, we turn to quantum mechanics, more precisely to de Broglie waves and to A. Einsheitn's theory of relativity. This will be enough to define time. So let's get started.

RESULTS AND DISCUSSION.

Consider an elementary particle such as an electron. According to Louis de Broglie, for the electron there is a certain periodic process that occurs with a frequency γ [1]:

«In quantum theory, I assumed that there is a periodic process associated with the electron as a whole (the material point). This process for an observer stationary relative to an electron would occur over the whole space with the same phase and would have a frequency γ...».

Moreover, the duration of this periodic process will be equal to:

$$E = h * \gamma = m * c^2$$

$$\gamma = (m * c^2) / h$$

$$\Delta t0 = 1 / \gamma = h / (m * c^2)$$

We especially note that the duration of the oscillation Δt0 is a fundamental characteristic of an elementary particle. It is because of this oscillation, which has a duration Δt0, that we observe and experimentally can register waves of matter, that is, de Broglie waves. Moreover, the de Broglie wavelength will be determined only by the speed of an elementary particle v in the selected frame of reference.

$$\lambda = h / (m * v)$$

Therefore, with a certain set of reference systems, we can fill the entire Universe with de Broglie waves of a particular elementary particle. It is especially important that the de Broglie wave, like any wave, is characterized by the frequency of the wave. That is, for any de Broglie wave, we will always have a certain duration of oscillation (Δt), which will already be greater than Δt0, since the wavelength will always be greater than the Compton wavelength. Namely, the frequency of the Compton wave determines the duration of the periodic process Δt0.

$$\lambda c. = h / (m * c)$$

$$\gamma * \lambda c. = c$$

$$\gamma = c / \lambda c. = (m * c^2) / h$$

$$\Delta t0 = 1 / \gamma = h / (m * c^2)$$

$$\lambda c. = c * \Delta t0$$

Thus, depending on the selected inertial reference system, each observer will see a different length of the periodic process. For the de Broglie wave, the duration of the oscillation (Δt) will be determined by the duration of the time interval during which the light beam will cover the distance equal to λ.

$$\lambda = c * \Delta t$$

$$\Delta t = \lambda / c$$

In fact, in this simple way, we got time slicing. To be more precise, we got a process by which we can mathematically describe the formation of our space-time continuum.

Let's say we have a point elementary particle. Let's place the given elementary particle at the origin. Then any point will be removed from the origin by a certain distance, that is, by the de Broglie wavelength (any point has spatial characteristics). In addition, each such point will also have temporal characteristics, since each point will be "assigned" a certain duration of the periodic process (Δt). It is obvious that time is a scalar, since it is simply the duration of the process of oscillation of a microparticle, which is recorded at a certain point in space. The time gradient that is formed in this scalar field. Therefore, there is no arrow of time with a specific direction. Also, there is no future, no past, only the present exists. It is interesting to note that as the points move away from the elementary particle, the speed of time flow at the points will slow down, since at $\lambda 2 > \lambda 1$, $\Delta t2 > \Delta t1$.

$$\lambda 1 = c * \Delta t1$$

$$\lambda 2 = c * \Delta t2$$

But, since we are in a fixed position (at the origin of coordinates), we will observe that at these points the bodies will have a certain speed (if the frames of reference move relative to each other, then the flow of time in these frames of reference is different). This effect is the theoretical basis for the Hubble-Lemaitre law [2, 3]. Moreover, we see the movement of bodies from us (removal of galaxies), since the duration of the periodic process $\Delta t0$ can only increase. This is quite understandable, since the duration of the oscillations in the Compton wavelength is minimal ("zero oscillation"). Therefore, the duration of the time interval (Δt) can only increase as the wavelength increases (as the microparticle moves away from the observer, the duration of the oscillations that the observer fixes always increases).

You may ask: what about the uniformity of the passage of time?

Answer: the flow of time at all points is homogeneous, since all reference frames are equivalent, which means that any point in space can be taken as the origin (that is, any elementary particle can be taken as the origin).

All of the above is well demonstrated and calculated using the theory of relativity, the concept of "interval", and de Broglie waves.

As previously shown, de Broglie waves are interval waves [4]:

“We will analyze the concepts of “interval”, “length” and “time”. Space and time form a single space-time continuum. Therefore, the fundamental concept is "interval" S, and not the concept of "length", or the concept of "time". An interval is a “distance” between two events in space-time (a generalization of the Euclidean distance between two points). The length and time in different inertial systems can vary, but the interval will always be constant (according to Einstein's STR). We write the interval for an infinitesimal displacement in space-time:

$$dS^2 = c^2*dt^2 – dx^2 – dy^2 – dz^2$$

or

$$dS^2 = c^2 \cdot dt^2 – dL^2$$

where S - is the interval,

L - is the distance between two points,

c - is the speed of light, t - is time.

In the case of flat space-time, that is, space-time without curvature (absence of gravity), the same expression can be written for finite difference coordinates:

$$S^2 = c^2 \cdot \Delta t^2 – \Delta x^2 – \Delta y^2 – \Delta z^2$$

or

$$S^2 = c^2 \cdot \Delta t^2 – L^2$$

Note that in the microworld, gravity is virtually absent (due to smallness). Therefore, in the microworld, space-time can be considered flat.

Let's do some transformations...

$$S = L \cdot (1 – v^2/c^2)^{0.5} \cdot c/v$$

This is the dependence of the interval on the length and time (for a flat, Euclidean space). Instead of time, speed is taken here. This follows from the fact that two coordinate systems in which time flows in different ways will move one relative to the other with a certain speed v. Therefore, speed as a physical concept displays the speed of time in a given frame of reference relative to another frame of reference.

In the microworld, space-time is flat, therefore, in the mathematical apparatus, it is necessary to use the fundamental concept of “interval” rather than length, etc. In fact, there is no longer a separate “length” in the microworld, but there is an interval. Therefore, in the formula of Louis de Broglie for the wavelength, you need to replace the "wavelength" with the "interval" of the wave:

$$\lambda = h/(m \cdot v) \quad \rightarrow \quad S = h/(m \cdot v)$$

Where S — is interval,

$$S = L \cdot (1 – v^2/c^2)^{0.5} \cdot c/v”.$$

Thus, the de Broglie wave is an interval wave.

$$S = h / (m \cdot v)$$

Let's write the interval through the length between two points:

$$S = L * (1 - v^2 / c^2)^{0.5} * c / v$$

Let's define what is the length between two points:

$$h / (m * v) = L * (1 - v^2 / c^2)^{0.5} * c / v$$

$$h / (m * c) = L * (1 - v^2 / c^2)^{0.5}$$

$$L = \lambda c. / (1 - v^2 / c^2)^{0.5}$$

The resulting formula clearly demonstrates that the distance between two points, that is, the de Broglie wavelength, is an increased Compton wavelength. Moreover, it is quite obvious that the increase in the wavelength occurs precisely due to the increase in the duration of the oscillation time.

$$\Delta t = \Delta t0 / (1 - v^2 / c^2)^{0.5}$$

Thus, our space-time continuum is formed according to A. Einstein's STR from the Compton wavelength of a microparticle. At distances smaller than Compton's, it makes no sense to talk about lengths, time, dimensions, etc., since we have a boiling vacuum. Also, an elementary particle has no dimensions, its radius literally tends to zero $r \to 0$. But, nevertheless, its radius is not equal to zero, since an elementary particle exists in the real material world, and has certain energy characteristics. If its radius were equal to zero, then such a particle would not exist in our Universe.

At distances greater than the Compton wavelength of an elementary particle, our space-time continuum is already forming. Moreover, an increase in the Compton length "gives rise" to the length itself, that is, the space itself (x, y, z). And the increase in the oscillation time "gives birth" to our time (t). From the foregoing, it is obvious that time is only just the duration of the oscillation, which we fix in different frames of reference. Therefore, time is a scalar. The time gradient that is formed in space is a simple scalar field that we can observe with our own eyes at a macroscale using the example of the recession of galaxies. Hubble-Lemaitre's law is a direct embodiment of this time gradient. It is obvious that the movement of a person in this gradient creates in our consciousness the “arrow of time”, that is, the illusion of movement from the past to the future.

It is also quite obvious that the space-time continuum is simply an experimental fixation of the spatial and temporal characteristics of oscillations, from a certain frame of reference (according to A. Einstein's STR). Consequently, the space-time continuum does not consist of the material environment. In fact, it does not exist, it is just a kind of mathematical averaging of the process of oscillation of elementary particles. From here, by the way, follows the definition of time and space.

Definition of time: Time is a mathematical averaging of the duration of the process of oscillation of elementary particles.

Definition of space: Space is a mathematical averaging of de Broglie wavelengths that correspond to the oscillations of elementary particles.

CONCLUSION.

Note that de Broglie waves are quantum mechanics at its best! Above, we have shown how de Broglie waves form time in our world. But, it is also easy to show how de Broglie waves transmit information at a speed greater than the speed of light in a vacuum, between the corresponding microparticles. Everything is very simple. Let's do a thought experiment as A. Einstein did. Let's learn from him.

So, let's say the electron moves with a speed v relative to the frame of reference 1. Moreover, the electron is in one galaxy A, and the frame of reference 1 is in galaxy B. And the distance between them is quite large (millions or billions of light years). When an electron moves at a speed v, a wave of matter, that is, a de Broglie wave, will be associated with the electron. The length of this wave will be:

$$\lambda = h / (m * v)$$

where λ - de Broglie wavelength,

v - electron speed,

m - is the electron mass.

The de Broglie wave speed will be:

$$Vf = c^2 / v$$

where c - is the speed of light in vacuum,

v - is the speed of the electron as a corpuscle,

Vf - is the phase velocity of the de Broglie waves.

Thus, the speed of de Broglie waves in general form will be equal to:

$$Vf = c^2/v = (c^2/h) * m * \lambda$$

That is, the greater the distance from the electron to the frame of reference 1, the larger the de Broglie wave itself, and the greater its phase velocity. And this speed will always be greater than the speed of light in a vacuum. At large distances between galaxies, this speed will be truly enormous. But, the propagation time of de Broglie waves will be negligible. Remember the quantum entanglement?

Another thing is interesting here: since the phase velocity of the de Broglie waves is determined by the speed of the electron (Vf = c^2 / v), the experimental fixation of the velocity of the de Broglie wave in the reference frame 1 (in galaxy B) will make it possible to unambiguously determine the speed of the electron in galaxy A. This means that the de Broglie wave carries information about the motion of a real microparticle. Moreover, the transfer of information is carried out with lightning speed even between galaxies at different ends of our Universe (due to the speed of de Broglie waves). Here is the explanation for the "eerie long-range action": distant particles exchange de Broglie waves. This is enough for instant interaction between particles. Even on the scale of the visible Universe.

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