Limiting the speed of light, gravitational potential, and the removal and acceleration of galaxies in the Universe.

Bezverkhniy Volodymyr Dmytrovych, Bezverkhniy Vitaliy Volodymyrovich.
Ukraine, e-mail: bezvold@ukr.net

Abstract: Space and time form a single 4-dimensional space-time continuum of our Universe, based on this, it can be shown that the speed of a body cannot be greater than the speed of light in a vacuum. Also, taking into account the limit of the speed of light, the removal and acceleration of galaxies in our Universe can be explained using only the law of universal gravitation of I. Newton.

Keywords: The speed of light, space-time continuum, interval, gravitational potential, the removal and acceleration of galaxies, Newton's law of universal gravitation.

INTRODUCTION.

The main reason the speed of light is the maximum speed of light in the Universe is that our Universe exists in a 4-dimensional space-time continuum. Proceeding from this, or rather from the interval S, it can be strictly shown that the speed of a material body cannot be greater than the speed of light. To explain the removal and acceleration of galaxies in our Universe, the law of gravity of I. Newton is sufficient. More precisely, with the elements of Einstein's STR, since the limit of the speed of light will be taken into account.

The average speed of a body is the ratio of the distance traveled to the time it takes a given distance:

$$v = \Delta L / \Delta t$$

It is from this formula that the illusion arises that the speed can be arbitrarily large, since the distance and time, based on the formula, can be any. But, this is a mistake. Since distance and time in a 4-dimensional space-time continuum are related according to the formula for the interval.

Space and time form a single space-time continuum. The fundamental concept is the "interval" S, 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). But, the length and time will change consistently, which is why the speed of a body in our Universe will always be less than the speed of light. Let's present the proof.

RESULTS AND DISCUSSION.

We write the interval for an infinitesimal displacement in space-time:

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

or

$$dS^2 = c^2 * dt^2 – dL^2$$

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, the same expression can be written for finite difference coordinates:

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

or

$$S^2 = c^2 * \Delta t^2 – L^2$$

If we do some transformation, we get the expression [1]:

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

From here it is easy to get the expression:

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

Let's do some elementary transformations.

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

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

At the end of elementary transformations, we get the expression:

$$v^2 = (c^2 * L^2) / (L^2 + S^2)$$

With the last formula we get the final formula for the speed in the space-time continuum:

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

From the last formula it is clearly seen that the speed of light cannot be overcome. Never!

Let's explain in more detail. Let's say we have a timelike interval ($S^2 \geq 0$) between two points. The time-like interval between events means that they can be causally related. Between these two points, we will move the test body with a certain speed v, from point 1 to point 2 (therefore, and causally related events). Recall that the interval between these points is constant ($S = const$)! Depending on the speed, the length of the segment (in 3-dimensional space), and the time, will change. But, the length and time, will change according to each other. And therefore, the speed of the test body between these two points will always be determined by the formula:

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

This means that the speed of the test body will always be less than the speed of light. Naturally, the formula also implies that if $S = 0$, then the speed will be equal to the speed of light, which is quite understandable, since this is a zero interval.

Let us recall that the limit of the speed of light is also strictly deduced from the curpuscular-wave duality of microparticles [2].

Next, we will consider the question of why galaxies in the Universe are receding and accelerating. Let's take it in order and by example.

1. A ball with a spherically symmetrically distributed mass attracts in the same way as a material point with a mass equal to the mass of the ball and placed in its center. This is clear and there is no objection.

2. A material point placed inside a hollow sphere is not attracted by this sphere. Likewise, everything is extremely clear and intuitive. Mathematically rigorously shown that the shell does not attract the material point even in the case when this shell has an ellipsoidal shape. We remember the movement of planets around the Sun along an ellipse and are surprised...

3. In general, the gravitational potential created by an arbitrary mass distribution satisfies the Poisson equation [3, 4].

4. Now comes the fun part. In potential theory, mathematically rigorously proved that the gravitational potential in the center of a homogeneous ball is one and a half times greater than on its surface. We give formulas for the potential, they are very illustrative and speak for themselves [5].

$$V(R) = G\tfrac{M}{R}$$

$$F = \frac{\partial V}{\partial r} = -\frac{4}{3}\pi G r$$

$$\Delta V(P) = \tfrac{\partial^2 V}{\partial x^2} + \tfrac{\partial^2 V}{\partial y^2} + \tfrac{\partial^2 V}{\partial z^2} = -4\pi G\sigma$$

$$\Delta V(P) = -4\pi G\sigma$$

$$V(0) = 4\pi G\sigma\frac{R^2}{2} = \frac{4}{3}\pi R^3\sigma G\frac{3}{2R} = \frac{3}{2}\frac{MG}{R} = \frac{3}{2}V(R)\,.$$

Consider our visible Universe as a cosmological ball, in the center of which our planet Earth is located with us. The distribution of matter in this ball is isotropic and uniform. With distance from the center, that is, from the Earth, the speed of galaxies increases. At the border of this sphere (R), the speed of galaxies will be equal to the speed of light in a vacuum.

Recall that the gravitational potential in the center of a homogeneous ball is one and a half times greater than on its surface:

V(0) = 1.5 * V(R) = (3 * M * G) / (2 * R)

In a gravitational field, the body tries to occupy the position with the lowest potential energy. It is for this reason that when you drop your laptop, it falls to the floor (note, with acceleration g), while its potential energy decreases. It is the same with galaxies: they "fall" over the entire visible Universe, but their acceleration increases.

For the calculation, we will take into account that the visible Universe is a cosmological ball of a certain radius (R). In the center of such a ball, the gravitational potential will be 1.5 times greater than on its surface. With distance from the center of the ball, the gravitational potential decreases. Therefore, galaxies will "fall" with a certain acceleration in order to take the position with the lowest potential energy.

So, the gravitational potential at the center of the cosmological ball will be equal to:

$$V(0) = (3 * M * G) / (2 * R)$$

where M - is the mass of the cosmological ball,

R - is the radius of the cosmological ball,

G - is the gravitational constant.

The gravitational potential on the surface of the cosmological ball will be equal to:

$$V(R) = (M * G) / R$$

In order to reduce its potential energy (relative to the entire Universe), the galaxy must move in the direction from the center of the ball to its surface, with a certain acceleration (since the galaxy falls into the Universe). Let's define this acceleration. To do this, take into account that the mass of the cosmological ball is:

$$M = (4 * \pi * R^3 * \rho) / 3$$

where ρ - is the density of the cosmological ball.

Then, the potential difference (in the center and on the surface) can be written:

$$\Delta V = V(0) - V(R) = (2 * \pi * \rho * G * R^2) / 3$$

Naturally, the potential difference between the center and an arbitrary position will be equal to:

$$\Delta V = V(0) - V(R) = (2 * \pi * \rho * G * r^2) / 3$$

where r - is the distance from the center of the ball to some arbitrary position.

The work of moving a galaxy of mass m, from the center of the ball to a position remote from the center by r, will be equal to:

$$A(1) = \Delta V * m = (2 * \pi * \rho * G * r^2 * m) / 3$$

But, if we take into account Newton's second law, then the work can be written like this:

$$A(2) = F * r = m * a * r$$

Equating these two works, we can easily obtain a formula for the acceleration of galaxies, which will not depend on the mass of galaxies, since this is a free fall of galaxies onto the cosmological ball.

$$A(1) = A(2)$$

$$(2 * \pi * \rho * G * r^2 * m) / 3 = m * a * r$$

From here, we get the final formula for the acceleration of galaxies in the Universe:

$$a = (2 * \pi * \rho * G * r) / 3$$

In an abbreviated form, you can write:

$$a = K * r$$

where K - is a constant, $K = (2 * \pi * \rho * G) / 3$

r - is the distance from the center of the ball to the position of the galaxy.

CONCLUSION.

Thus, galaxies will accelerate all the time, since their acceleration is directly proportional to the distance from the center of the cosmological ball. That is, the movement of galaxies away from us and their acceleration is the usual work of Newton's gravity, and in order to derive the formula for the acceleration of galaxies, we need to take into account additionally only the limit of the speed of light. In fact, galaxies fall on the entire visible Universe (cosmological ball), with a certain acceleration, but this acceleration increases.

Amazing! Apples are falling to the Earth, and galaxies are falling on the Universe!

REFERENCES.

1. Bezverkhniy V. D., Bezverkhniy V. V. De Broglie Interval Wave and Heisenberg's Uncertainty Principle. SSRN Electronic Journal (2019). P. 3. DOI: 10.2139/ssrn.3435852, https://vixra.org/pdf/1908.0255v1.pdf
2. Bezverkhniy V. D., Bezverkhniy V. V. Limiting the Speed of Light in a Vacuum and Cosmological Paradoxes. SSRN Electronic Journal (2020). P. 2-4. DOI: 10.2139/ssrn.3679311, https://vixra.org/pdf/2008.0169v1.pdf

3. Gravitational potential. Wikipedia. https://en.wikipedia.org/wiki/Gravitational_potential
4. Poisson's equation. Wikipedia. https://en.wikipedia.org/wiki/Poisson%27s_equation
5. The gravitational potential of the ball. Astronet. http://www.astronet.ru/db/msg/1169697/node16.html