Memoir on the Theory of Relativity and Unified Field Theory

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Abstract

Lorentz transformations in their originally more general form, i.e. with the scale factor are considered. It is shown, that H. Lorenz, A. Poincare, and A. Einstein put this factor equal to one without proper foundations. It is clarified the physical sense of this factor – he describes the Doppler effect. As the result the paradoxes of the special theory of relativity are removed, grandiose simplifications occur in GR and the natural path to the construction of unified field theory is opening.

FROM THE AUTHOR:

In 2000 I published in Russian a brochure "Memoir on the Theory of Relativity and a Unified Field Theory": http://viXra.org/abs/1801.0305.

Now I present the English translation of version II of the brochure with minor differences from the version 2000 (and with abbreviations not relating to physical content).

INTRODUCTION

In classical mechanics, during the transition from one inertial frame of reference to another, the coordinates change in accordance with the Galilean transformations. In the case of motion of the second system relative to the first along the X axis at a speed v, only this coordinate is recalculated: $x` = x - vt$; The other spatial variables, as well as the time variable, retained their values: $y` = y, z` = z, t` = t$.

But in the late 19th century it was realized that in electrodynamics Galileo's formulas no longer work: Maxwell's equations are not invariant with respect to them, because of which different inertial observers become unequal. Therefore, it was necessary to find other transformations, which received the name of Lorentz; they look (again when moving along the X axis) like this:

$$x' = Q(x - vt),\ y' = y,\ z' = z,\ t' = Q(t - vx/c^2),$$

where

$$Q = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}},$$

and c is the speed of light.

The physical interpretation of the new transformations was given by A. Einstein in his special theory of relativity (STR). It is clear that if on try to change something in Lorentz's transformations -- this is the purpose of our work -- on must be ready for a serious reconstruction of the SRT itself and the theories based on it, first of all the general theory of relativity (GR). And in order to better understand the essence of the proposed innovation, it is useful to trace how the search for new (Lorentz) transformations was underway.

CHAPTER I. SPECIAL THEORY OF RELATIVITY: THE LOST MULTIPLIER

1.1. From Galileo to Lorenz

In 1887, W.Voigt of Göttingen discovered that the wave equation (to which Maxwell's equations are actually reduces) retains its form under such transformations:

$$x' = x - vt,\ y' = y/Q(v),\ z' = z/Q(v),\ t' = t - vx/c^2.$$

As one can see, the radical appeared

$$Q = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}},$$

and time has become relative, that is, depending on the mutual motion of two observers (in general, its formulas differ from the current Lorentz transformations by a constant factor of 1/Q).

The Englishman J. Larmor, the Dutch H. Lorenz and other physicists deduced the transformations, starting, as a rule, from one or another model of the ether -- a hypothetical medium in which electromagnetic waves propagate. In 1898, Lorenz received these expressions:

$$x' = \eta(v)Q(v)(x - vt),\ y' = \eta(v)y,\ z' = \eta(v)z,\ t' = \eta(v)Q(v)(t - vx/c^2).$$

Note that in addition to the Voigt radical, there is also a factor $\eta(v)$ in them, which equally affects all the coordinates (both -- spatial and temporal), that is, it characterizes a general change of scale. Lorentz pointed out that this coefficient should have a definite value that can be established, "... only comprehending the essence of the phenomenon." In 1904, he returned to this issue and came to the conclusion that $\eta(v)$ should be equated to one.

The following year the events developed rapidly: on June 5, Poincare spoke in Paris with a message published in the "Comptes Rendus". He considered the same type of transformations as Lorentz, and he also put $\eta(v)$ equal to one (then the French scientist suggested to call these formulas "Lorentz transformations", and this was confirmed in science).

And on June 30, "Annalen der Physik" received the famous article by Einstein "On the electrodynamics of moving media". A young employee of the patent bureau deduced the transformation of coordinates, basing not on the requirement of invariance of Maxwell's equations, but on the two postulates underlying his theory: 1) all inertial systems are equal; 2) the speed of light is constant, that is, it does not depend on the speed of the light source.

Einstein also at first gets the same general form of transformations as Lorentz with Poincaré, and then finds out what the coefficient $\eta(v)$ should be. Primo: the application of direct and inverse transformations leaves everything unchanged, that is, $\eta(v)\,\eta(-v) = 1$. Secundo: the change in the sign of the velocity should not influence (the isotropy of space), therefore $\eta(v) = \eta(-v)$. From these two statements he immediately gets that $\eta(v) \equiv 1$.

In July Poincaré finished his work (published in 1906), where he considered in detail the question of the coefficient $\eta(v)$. He argued that the transformations would be a mathematical group (and this is an absolutely necessary requirement) only if $\eta(v) \equiv 1$.

So, all three founding fathers of relativistic physics agreed that the speed-dependent coefficient $\eta(v)$ must be identically equal to one, that is, it actually disappears from the formulas. In such a private, truncated form the Lorentz transformation entered into thousands of books and textbooks; so it is not surprising that now few people remember the initially more general form of them -- with a scale factor $\eta(v)$.

1.2. Gedankenexperiment

The reader has probably already guessed that further reasoning will be somehow connected with this multiplier. We unexpectedly meet again with it and understand its possible physical meaning, considering from a new angle the same thought experiment from which Einstein repelled when creating the STR.

As already mentioned, Einstein proceeded from two postulates. The first of them (on the equality of inertial systems) is completely understandable, but the second (on the constancy of the speed of light) looks strange -- indeed, it contradicts our intuitive ideas based on the usual mechanics.

In fact, let us imagine that there are two fixed observers *A* and *B*, the distance between them is *L* (Fig. 1). If at the moment when the rocket, on which the observer *N* is moving with velocity *V*, is compared with *A*, both of them (that is, *A* and *N*) will shoot from the same guns to the side *B*, then a bullet from *N* will arrive to it earlier, because the speed of the rocket will be added to the speed of a bullet.

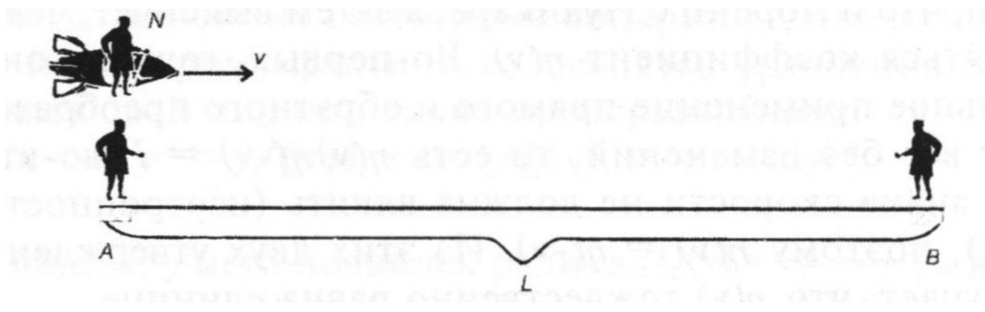

Fig. 1

If, instead of shots from rifles, observers *A* and *N* produce flashes of light from identical lanterns, then, according to Einstein's postulate, the light signals will come from them to *B* simultaneously. This is the principle of the constancy of the speed of light -- the movement of the rocket does not affect it in any way. At the beginning of the century, this was an experimentally established, albeit paradoxical fact (it was pointed out by the experiments of Michelson-Morley). And as someone advised, "if you have a paradox, make it an axiom." This is exactly what Einstein has made.

But after accepting these two postulates, you immediately come to a contradiction between them: according to the second of them, the rays from *A* and *N* must reach *B* simultaneously. However, during this time the rocket will have shifted and will be at point *P* at a distance *(L - vL/c)* from B (Fig. 2). But then the speed of the light released by *N* will be less *c*.

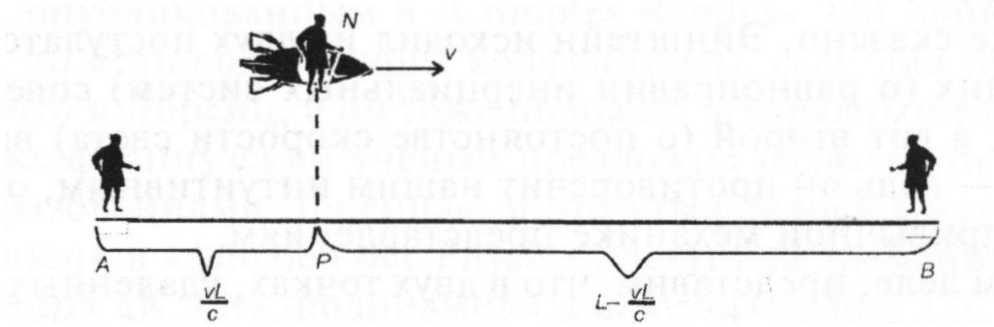

Fig. 2

In other words, for both observers, the velocities of light cannot be the same. Let's call this reasoning "the main contradiction". The desire to solve it led Einstein to construct the STR, and he saw the key to the problem in the analysis of the concept of simultaneity.

1.3. The decisive step

But this mental experience can be interpreted in a different way. Note that although light pulses from *A* and *N* will come to *B* simultaneously, the wavelengths of the two signals perceived by them will be different -- light from *N* will experience a violet shift, that is, its wavelength will decrease. This is a well-known Doppler effect, which STO does not pay much attention to -- it treats it as external, not affecting the geometry of space-time. In STO, the Doppler shift of the wavelength of light describes a simple formula:

$$D=\sqrt{\frac{c+v}{c-v}}.$$

But the Doppler effect will change the scales used in the measurements, namely the wavelength and the period of the oscillations of the light signals, which, unlike the rigid rulers and abstract clocks, should be considered genuine physical scales. It is easy to imagine that if we approach to the source of light signals, then all the scales (according to Doppler) are compressed, and if we move away from it, they are stretched.

Therefore, it is logical to assume that the coefficient *D*, which quantitatively describes this effect, must somehow figure in the coordinate transformations when transferring to a moving frame of reference and, therefore, contribute to the very geometry of space-time. Namely, it will make scales variables.

Now we are ready to offer another way out of the basic contradiction. Let's just assume that -- taking into account the scale change -- the paths traversed by light in the same time interval from the observers *A* and *N* to observer *B*, that is, the lengths of the segments *AB* and *PB* (Figure 2) will be the same.

But then the question immediately arises: how can a part of a segment equal the whole? Of course, this is not possible in terms of the familiar Euclidean geometry, however, the length and duration are dimensional quantities, so their numerical values depend not only on them, but also on the scales used in their measurement. Since the scales have become variables, the lengths of the segments *AB* and *PB* can in principle be expressed by the same numerical values.

So, if we equate them, we immediately will know how the scales should change in order for this requirement to be fulfilled: $L = K(L - vL/c)$, where *K* is the desired scale factor; $K = c/(c - v)$, and it is easy to see (school algebra) that

$$\frac{c}{c-v}=\sqrt{\frac{c+v}{c-v}}\,\frac{1}{\sqrt{1-\frac{v^2}{c^2}}}=D(v)Q(v). \qquad (1.1)$$

What happened? In addition to the well-known radical $Q(v)$, as the devil from the snuffbox, an additional factor $D(v)$ appeared, which describes the Doppler effect! But after all, in the expressions that at first were received by Lorentz, Poincaré and Einstein, as we recall, there was a scale factor $\eta(v)$, and they unanimously equated it to unity. So, maybe he does not have to be so?

1.4. Return of the lost multiplier

Poincare said that $\eta(v)$ should be equal to one, so that the transformations were a group. Their group properties describe the law of addition of velocities of SRT: if the system K_2 moves with speed v_1 relative to K_1, and K_3 - with speed v_2 relative to K_2, the system K_3 moves relative to K_1 with speed

$$v_3 = \frac{v_1 + v_2}{1 + \frac{v_1 v_2}{c^2}} \cdot \qquad (1.2)$$

Let us check whether this dependence breaks the Doppler factor. In the successive application of two transformations, the two original coefficients $\eta(v)$ are simply multiplied:

$$\eta(v_3) = \eta(v_1)\eta(v_2) = \sqrt{\frac{c+v_1}{c-v_1}}\sqrt{\frac{c+v_2}{c-v_2}} = \sqrt{\frac{c + \frac{v_1+v_2}{1+\frac{v_1 v_2}{c^2}}}{c - \frac{v_1+v_2}{1+\frac{v_1 v_2}{c^2}}}} = \eta\left(\frac{v_1+v_2}{1+\frac{v_1 \cdot v_2}{c^2}}\right). \qquad (1.3)$$

We see that the law of addition of velocities remained in its original form. It turns out that the great mathematician Poincare was wrong.

The arguments of Einstein based on considerations of symmetry of motions in opposite directions turn out to be lightweight, since approximation and removal are not equivalent from the point of the Doppler-effect. Therefore, his condition $\eta(v) = \eta(-v)$ must be discarded, and then $\eta(v)$ is no longer required to be a unit.

Thus, we assume that $\eta(v) = D(v)$. The transformations of coordinates, taking into account the scale factor will be written as follows (we will call them the "New Lorentz transformations"):

$$x' = \left(\sqrt{\frac{c+v}{c-v}}\right)^r \frac{x-vt}{\sqrt{1-\frac{v^2}{c^2}}};\ y' = \left(\sqrt{\frac{c+v}{c-v}}\right)^r y;\ z' = \left(\sqrt{\frac{c+v}{c-v}}\right)^r z;\ t' = \left(\sqrt{\frac{c+v}{c-v}}\right)^r \frac{t-\frac{vx}{c^2}}{\sqrt{1-\frac{v^2}{c^2}}}. \qquad (1.4)$$

{The exponent *r* is required because the Doppler factor change its value to the inverse on transition from approach to removing and vice versa: $r = sgn\ (x - vt)$; $r = 0$ if $x = vt$, that is, when the observer crosses the point, the coordinate of which he determines. It is the change in the parameter *r* that ensures the equality $\eta(v) = \eta(-v)$ in the particular case that Einstein considered when $\eta(v)$ characterizes the change in the length of the rod when it moves in one direction or another from the observer. Now together with the sign of *v*, the value of *r* will also change: at first the rod was on one side of the observer, and then on the other, that is, crosses it. As a result, $\eta(v)$ remains unchanged.}

The physical meaning of our innovation is simple: if an object is at rest in some reference frame, then measurements are carried out by some standard scales (rest scales). Approaching the object leads to Doppler reduction of scales, and the movement from it leads to their stretching; in the general case, when the velocity has an arbitrary direction, the scales change is given by the formula describing the Doppler effect as a function of the angle at which the light travels from the moving source O_1 to the observer *O*. In particular, if it is equal to 90°, there will be the so-called transverse Doppler-effect; in this case

$$D = \sqrt{1 - \frac{v^2}{c^2}} = 1/Q \,. \tag{1.5}$$

1.5. Kinematics without sophisms

In SRT, that is, under the Old Lorentz transformations, all the main dependencies determined the coefficient

$$Q = \frac{1}{\sqrt{1 - \frac{v^2}{c^2}}},$$

which includes only the square of the velocity. Therefore, the change in the sign of the velocity did not affect*: Q(v)* is always greater than one, because of which the lengths in moving frames of reference are always shortened, and the clocks are slowed down.

Now the transformation includes the product of two coefficients -- the previous Q and D

$$D = \sqrt{\frac{c+v}{c-v}} \,.$$

For one direction of motion (when $V > 0$), the second coefficient is greater than 1, for the other ($V < 0$) -- less. Moreover, the new factor determines the result, that is, if $D > 1$, then the product is the same, if $D < 1$, then the product also. Hence, the Doppler effect will determine the asymmetry of the two opposite directions -- depending on it, lengths and times will increase or decrease, as well as other physical characteristics. (Of course, such an asymmetry is associated only with measurement procedures and in no way breaks the isotropy of space-time itself.)

The laws of the new relativistic kinematics are obtained directly from the new transformation formulas. I will cite some of them.

1. Moving clocks are accelerated or slowed (from the point of view of the stationary observer). The motion of the moving clock now determines the formula $T` = T\,(1 + v/c)$, where $T`$ is the time interval over the moving clock in the reference frame where they are at rest. The notorious "paradox of twins" (a favorite subject of science fiction writers) will not be anymore -- by the time of the meeting they will both grow old the same way.

It is possible to imagine it so. Let's the rocket is removing from us and a telecast is broadcast from it. In our resting frame of reference everything that we see on the TV screen takes place at a slower pace, so for us, the clock on the rocket lags behind. But when the rocket turns back, everything seems to us already accelerated, and by the time of arrival, the readings of both clocks will equalize.

2. Similarly, a rod oriented along the direction of movement is lengthened or shortened depending on the sign of the speed: $l = l` (1 - v/c)$, where $l`$ is the length of the rod in the reference frame where it is at rest.

3. In SRT, the geometry of a rapidly rotating disk turns out to be non-Euclidean: there is no change of length along the radii, but there are along tangent directions (coefficient Q), that is, the usual dependence of the length of the circle on the radius becomes incorrect (this is the so-called Ehrenfest paradox). Now, taking into account the transverse Doppler-effect (D, in this case, is $1/Q$, and the product of our two coefficients gives unity), there will be no tangential changes. Therefore, the geometry of the disk remains Euclidean, which agrees with the principle of the relativity of rotational motion (otherwise this effect would allow us to reveal the rotation of a single body in the universe -- such a movement would become absolute).

The laws of dynamics will now change too. For example, in the formula expressing the dependence of mass on velocity, a Doppler factor is added, that is, it will no longer be $m' = Qm$, but

$$m' = DQm = \frac{cm}{c-v}. \quad (1.6)$$

Hence, the mass will grow or decrease depending on the sign of v.

1.6. The scales in nature

In SRT, the geometric quantity called the four-dimensional interval: $s^2 = x^2 + y^2 + z^2 - c^2t^2$ turned out to be equal in all inertial frames of reference (invariant). Now the interval will stretch or shrink by $\eta(v)$ times (along with the length and time scales, only the condition $s = 0$ is invariant). By the way, Einstein, while discussing in 1921 the theory of H. Weyl, wrote that it would be worth trying to change the theory of relativity in this way.

But all inertial systems are equal, so we immediately come to a very important conclusion about scale invariance (scaling) in the physical world. This means that a change in the space-time scales automatically leads to such a consistent adjustment of the values of masses and other physical quantities that no experimentally detected violations in the laws of nature occur. In other words, there are no fixed scales in the surrounding reality (such a possibility was discussed already in the 18th century by the Croatian thinker R. Boshkovich, later by G. Helmholtz and other scientists).

In the early twentieth century, this issue attracted close attention. From a mathematical point of view, the Old Lorentz transformations (when the interval does not change) give a linear orthogonal transformation (with 10 parameters). But in 1910 the British G. Bateman and E. Cunningham discovered that Maxwell's equations (more precisely, the wave equation) are invariant with respect to wider, so-called conformal transformations, which include stretching and contraction of the interval (these are similarity transformations, given by 11 parameters), and also "inversion", when the interval varies from s to $1/s$ (it is characterized by 15 parameters).

It would seem that the basis symmetry of all physics should be as broad as possible, that is, the conformal symmetry, and there have been many attempts to implement this idea, but they have not been crowned with success. As our historian of physics V.P. Vizgin wrote in the 1970s, "... the diverse, sometimes mysterious connections of conformal symmetry with physics continue to excite the imagination of theorists to the present day."

Interval in STR was constant. At new transformations it became variable: $s` = \eta(v)\, s$, that is actually we already passed to the similarity group, when the interval can be compressed and stretched. In addition, an approach with a velocity v gives a change in the interval in $\eta(v)$ times, and the removal with the same velocity is $1/\eta(v)$ times. Inversion is associated with the so-called «general Lorentz transformation» (when the determinant is negative), in which, besides the turns, the reflection is included (it will change the direction of time).

(By the way, inversion transformation plays an important role in biology, for example, describes the process of shape formation in flowers.)

Apparently, under the New Lorentz transformations, the 15-parameter conformal group is realized. On these representations *de Spatio et Tempore*, physics must be based.

CHAPTER II. GRAVITATION AND OTHER FORCES

2.1. Geometry and gravity

After the creation of the STR, Einstein took ten years to build a general theory of relativity (GRT), which also encompassed non-inertial frames of reference. A guiding star for him was the analogy between gravity and accelerated motion.

Under the New Lorentz transformations, this transition from uniform motion to an accelerated one becomes almost obvious. In fact, for uniform motion, the interval is multiplied by a constant number: $s` = \eta(v)\, s$, where $\eta(v) = const$. Therefore, the principle of equal rights for all inertial observers can be formulated as follows: the laws of nature proceed in the same way in frames of reference connected by transformations, in which the interval changes a fixed number of times.

In the case of non-uniform motion, the factor $\eta(v)$ will already be variable, depending on the coordinates: $ds` = \eta[v(x,y, z,t)]ds$. However, if in this case the space-time scales at each point are changed in a certain way, then the interval can again be multiplied by a constant number (that is, the condition $ds` = a ds$, where a is a constant) is fulfilled. To do this, simply enter the variable coefficient for ds, and put $F(x,y, z, t) = a/\eta[v(x,y,z,t)]$.

This factor *F(x,y,z,t),* affecting the scale and so compensating for the change in speed, that the accelerated motion becomes indistinguishable from the inertial one, it is naturally to consider as a gravitational potential.

2.2. The gravitational equation

The value of *F(x,y,z,t)* will be scalar, and following Poincaré, M. Abraham, G. Nordström, and other scientists of the beginning of the last century, it can be assumed that it satisfies an equation that is a natural extension of the Poisson equation

$$\frac{\partial^2 \phi}{\partial x^2}+\frac{\partial^2 \phi}{\partial y^2}+\frac{\partial^2 \phi}{\partial z^2}=4\pi\rho\,, \tag{2.1}$$

expressing Newton's law of gravitation, to d'Alembert's equation:

$$\frac{\partial^2 \phi}{\partial x^2}+\frac{\partial^2 \phi}{\partial y^2}+\frac{\partial^2 \phi}{\partial z^2}-\frac{1}{c^2}\frac{\partial^2 \phi}{\partial t^2}=4\pi\rho\,. \tag{2.2}$$

Here, the fourth coordinate -- time is added, because of which the equation became invariant with respect to the Lorentz transformations (in the old and new sense). Such a transition from a mathematically very complicated tensor general relativity to a scalar theory of gravitation will be a huge simplification. In fact, the entire general relativity has been reduced to a simple equation.

In classical physics, the constant gravitational potential did not manifest itself in the experience. Now we see that it alters at all points the length and time scales (as well as the interval *s*). And there are no visible changes because the masses and other physical quantities, as we have already said, because the laws of nature are scale invariant. Hence, the relationship between the principle of scale invariance and gravity became clear.

(Incidentally, from the point of view of changing the scales, there is no difference between the straight and uniform motion and the introduction of a constant gravitational field: $s` = \eta(v)\, s$ and $s` = Fs$. As already mentioned, the body mass depends on η, therefore it will depend on *F*. Such dependence was supposed by E. Mach -- the Mach principle.)

Einstein used curved (Riemannian) geometry in general relativity, and in this geometry, there are difficulties associated with conservation laws which have not yet been eliminated; so there were attempts to construct a theory of gravitation in flat space-time. We have obtained that the potential *F(x,y,z,t)* serves as a coefficient showing the change in scales at each point, that is, it determines the so-called "conformal factor". As a result, a known conformally flat space arises in which the conservation laws are satisfied as well as in the planar space.

2.3. Three whales on which stands GRT

As we read in textbooks, the experimental confirmations of general relativity are reduced to the three main predicted effects: the curvature of light rays in the gravitational field, the displacement of the perihelion of Mercury, and the gravitational shift of the spectral lines. What can we say about them now?

1. Light travels along the shortest paths, and in a space with a variable length scale, a straight line, generally speaking, will no longer be the shortest line (geodesic) connecting two points (in much the same way as in a transparent material with a variable refractive index). Near the gravitating mass, say, the planet, the scale of the length (meter) will be less than far from it, and the length (the number of meters that fit into a certain line segment) is correspondingly larger. Therefore, it is more advantageous for a light beam to stay away from the planet and it will bend, what is observed.

2. The problem of Mercury. In the middle of the 19th century. U. Le Verrier revealed an anomaly in the motion of this planet: the point of its perihelion is slowly shifting (only 43 arc seconds per century; for other planets this effect is even less). To explain it on the basis of classical mechanics was not possible, therefore astronomers began to try somehow to modify the Newtonian law of gravitation. For example, when the force depended not only on the distance but also on the speed of mutual motion of the Sun and the planet.

In 1898, the teacher of one of the German gymnasiums P. Gerber, based on ideas that are not completely clear to historians of science, but considering the finiteness of the speed of propagation of the gravitational field (considering it equal to the speed of light), proposed such an expression for the gravitational potential:

$$U = \frac{m}{r\left(1 - \frac{1}{c}\frac{dr}{dt}\right)^2}. \qquad (2.4)$$

From it, he received a formula expressing the displacement of the perihelion of Mercury that gave a numerical value, exactly coinciding with the actual. When later Einstein derived his formula from The General Theory of Relativity it was the same as Gerber's.

From the New Lorentz transformations, as already mentioned, the dependence of mass on velocity (in the direction of the action of force) is:

$$m' = \frac{cm}{c - v}$$

and of distance on velocity:

$$r' = \frac{c - v}{c} r.$$

Substituting them into Newton's formula for the gravitational potential $U = m/r$, we see that the Gerber expression is correct:

$$U = \frac{m}{r\left(1-\frac{v}{c}\right)^2}, \tag{2.6}$$

where $v = dr/dt$. Thus, the problem of Mercury is immediately solved on the basis of the New Lorentz transformations.

2.4. Are the photons reddening?

According to Einstein, light coming to us from the star experiences a red shift -- the photons seem to lose some of their energy, overcoming the force of attraction (if the light goes in the opposite direction, then, respectively, the violet shift). And such a wavelength change should in principle be observable for the radiation of the Sun and other stars, although due to the chaotic motion of atoms there the effect is difficult to detect.

In the 1960s R. Pound and his colleagues experimentally tested this prediction of general relativity in terrestrial conditions. They started a beam of light along a tower 23 meters high and used the Mossbauer-effect to fix the wavelength shift. But the relative change of this quantity in this case should be extremely small -- on the order of 10^{-15}. Nevertheless, the authors of the work claimed that they managed to observe just such a shift.

With a new interpretation of gravitation, this effect should not exist: the gravitational potential, as we have established, calibrates the scale, that is, determines the wavelength and the period of oscillations at each point. Therefore, identical atoms located in places with different potentials (for example, hydrogen atoms on the Sun and on Earth) will emit light of different wavelengths (on the Sun with smaller, on the Earth with larger).

And when the light emitted on the Sun reaches our planet, its wavelength will equal that which radiates the hydrogen atom on Earth -- in accordance with the local value of the gravitational potential. Hence, to notice the displacement of the wavelength of light to the earth observer in any way will be impossible.

What affects the gravitational potential? Everything: on the scales of length and time, mass, charges, but it influences so that no visible changes in the laws of nature occur. Therefore, for a hypothetical observer on the Sun and for a person on Earth, the wavelength and period of oscillations of light emitted by atoms of the same type will appear the same in both places.

We can say that in the region of a higher potential, all processes are accelerated, but such effects cannot be noticed in principle. Any clock sent from one area to another, upon return, will show the same time as those that remained in rest -- there will be no paradox of the clock (or twins) in this case.

Another imaginary experience. Let the spacecraft moves away from us -- it moves inertially in a region with zero gravitational potential. The light source on the ship emits light with a certain wavelength, and we receive it with a greater wavelength (Doppler-effect). Then the ship enters the area of gravity of the massive body (planet) and begins to accelerate (fall into the gravitational field). What will we observe? No change: the wavelength of light should increase (Doppler-effect), but also decrease, as the light source moves towards the growth of the gravitational potential -- both effects compensate each other.

As for Pound's experiments, they were not widely cross-checked, so we can assume that their results are erroneous.

2.5. Symmetries and fields

Einstein devoted the last 30 years of his life to the search for a unified field theory, and in our time this task remains central in theoretical physics. In the 1970s, on succeeded in combining electromagnetic and weak interactions (Salam--Weinberg theory), and now physicists are trying to attach a strong one to them.

The key to solving this grandiose problem is the principle of "gauge invariance" (and the physical fields themselves are called gauge, or compensating). Briefly speaking the presence of a field allows us to move away from a weak, global symmetry (when some parameter varies equally throughout space) to a stronger, local (when its change depends on the point). In other words, the introduction of the field extends the symmetry of equations describing the laws of nature.

This is particularly clearly seen in the example of how we introduced gravity. If, under uniform motion, there was a global scale transformation in the entire Minkowski space $s' = \eta(v)s$, then for nonuniform motion it will already be local: $ds` = \eta(v,x,y,z,t)\, ds$. But the introduction of the gravitational field allows to compensate the change in speed so that the accelerated motion becomes a free fall. Therefore, such a field ensures equality of uniform and accelerated movements.

In addition to gravitation in nature there are other fields (Einstein did not even know about the existence of some of them). Is it possible likewise to "summon them out of nothingness"? (Now we take on the functions of the Creator of the Universe -- we decide which fields should be in it.) Now, when the interval ceased to be permanent (as it was in SRT -- there was nothing to compensate for), it seems to be possible.

In fact, gravity, as a scalar field, turned out to be compensating for the transition from a global scale transformation to a local one. However, there are mathematically more general transformations -- affine, projective (F. Klein considered this sequence of geometries in his "Erlangen program"). It would be logically if the hierarchy of fields corresponded to this hierarchy of geometries.

Hence, by analogy, one can demand the invariance of the laws of nature relative to local affine coordinate transformations, that is, independent changes in scales for each coordinate separately. Then, to compensate for such changes, we must introduce not a scalar field, but a vector field (of four components), which is naturally we should consider as a four-dimensional electromagnetic potential.

2.6. Mathematical Interlude

We have come to the fact that both the gravitational and electromagnetic (electroweak) fields cause a change in scales at each point of space-time, but the first of them is characterized by a scalar function and the second by four such functions. And such a 4-vector can no be considered as a gradient of a scalar function (the scalar field reduces to a vector field, but not vice versa). This is due to the nonsmoothness, the especial points of the electromagnetic field (as we know, electromagnetism is closely related to topological facts, such that "a spherical hedgehog cannot be combed without cuts or crochets").

In fact, such a geometric interpretation of the electromagnetic field was proposed in 1918 by G. Weyl. But his theory was not accepted, since a change in the interval when passing through a closed contour due to the presence of singular points could become non-integrable and ambiguity arose. However, in quantum mechanics, as E. Schrodinger showed for the simplest cases, for example, for the Bohr quantum conditions, the total change in the phase of the wave turns out to be equal to an integer number of waves, that is, not observable.

Apparently, this is a general principle, in other words, in quantum mechanics, the contradiction is removed, and the wave properties of matter themselves as if specifically exist for this purpose (so that non-integrability does not lead to ambiguity). As a result, everything turns out to be logically linked to the overall picture.

The geometric meaning of the very important principle of gauge invariance of the electromagnetic field becomes clear. It says that the gradient of any scalar function can be added to its vector potential, and this does not affect the intensity of the field, which alone manifests itself in the experiment. It is obvious that such an arbitrary function is a gravitational potential, that is, electromagnetism does not seem to notice gravity because there the functions are smooth.

Now it's time to remember the last of the known physical interactions -- strong, intranuclear. How do we can enter it?

Acting by analogy, we can require the invariance of the condition $s' = const$ with respect to even more general -- local projective coordinate transformations. Then, to compensate for them, we need to introduce an already eight-components field, which, apparently, can be identified with what appears in the modern theory of strong interaction (quantum chromodynamics).

CONCLUSION

Many scientists felt that the theory of relativity is not all right -- no other physical concepts have caused such fierce controversy for many decades. But if an acceptable alternative cannot be found, then, as the well-known methodology scientist T. Kuhn noted, "rejection of any paradigm means a rejection of science in general".

So it happened with the theory of Einstein. Of course, it has been tested in various experiments, particle accelerators are designed on its basis, that is, already has the status of engineering science. But even the wrong theory can in many cases give correct results. On the other hand, in modern physics, there are enormous difficulties connected, first of all, with the divergences in quantum field theory, which connects relativism and quantum mechanics. It is known how to artificially overcome it (the renormalization method), but according to P. Dirac and many other theorists, the basic equations are incorrect.

It can be assumed that correcting the old error in the Lorentz transformations will remove these difficulties. In general, it will affect and even transform all physics -- from the theory of elementary particles to cosmology. There is a hope that the way to "beautiful clarity" which was lost in the course of the quantum-relativistic revolution will be open.