Introduction to the Physics of Non-uniform Time

Theory of time beyond the standard model. Part I

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Abstract. Behaviour of a physical entity (mass point, photon) in a frame of non-uniform time is discussed. The principle of time relativity in analogy with Galilean principle of relativity is specified. Equivalence principle to state that the outcome of non-uniform time in an inertial frame and an external fictitious gravity is the same is set. On top of Noether's theorem it is shown that the orthodox energy conservation is not applicable to the frames of non-uniform time. An idea of 'flow of time' is introduced and a generalized energy conservation law which allows flow of time is proposed on the basis of the experiment of Pound and Rebka. It is shown that the inverse-square law is a result of generalized energy conservation under the assumption that the flow of time is a linear function of space. It is shown that momentum conservation is a corollary of generalized energy conservation and that inertial mass is a linear function of flow of time. Mass tends to infinity along the flow of time. A new mechanism of red-shift that involves the difference of the flow of time is proposed. Hubble's law as a linear dependence of red-shift on the distance is deduced analytically.

PREFACE

Science has an undeniable impact on certain traditional religious claims [1]. It is a pity, however, that some dogmatic elements of religion can similarly impact science. Moreover, by sometimes applying a dogmatic stance versus maintaining a focus on basic methodology, some practices of science have turned dogmatic with a number of "evident" dogmas incapable of being independently tested. The "truth" is then established by consensus of the scientific community at ecumenical congresses, and any doubt, say, about energy conservation or the second law of thermodynamics makes a scientist a heretic deserving to be burnt at the stake. Well... Let us see.

Maybe it is nothing more than a deposit of prejudices laid down by the mind to form "the common sense." The "common sense" concept of energy conservation is so deeply rooted in the very foundation of contemporary physics that it seems that nothing, even Noether's theorem that establishes certain conditions for energy conservation, can destroy it. However, "the common sense" is an insecure thing. Prior to Copernicus it was thought that nothing can destroy the commonly accepted concept that the Sun revolves around the unmoving Earth. Similarly, prior to Einstein it was thought that nothing can destroy the common sense concept of absolute time. Yet today, these "common sense" concepts are superseded.

This work sums up the ideas presented briefly in our previous publications [2, 3, 4]. However, we consider it appropriate to repeat a number of our statements.

Einstein's General Relativity is the most excellent phenomenon not only in physics of the 20th century but also in science of all time. However, it is not free of weak points.

Paul Davies even wrote a book subtitled *Einstein's Unfinished Revolution* [5]. Another book with a similar title is announced by Carlo Rovelli [6].

The most conspicuous failure of General Relativity is singularity. In layman's terms singularity denotes a place that does not allow a reasonable physical interpretation. Einstein himself is said to be upset by this. Singularity of General Relativity is a realm of fundamentally unknowable, rather more suitable for theology than physics. However, in a certain coordinate system that we are going to introduce later, a singularity takes up a whole half of the universe, which means that General Relativity can describe only the rest half. This can hardly be considered satisfactory even if the description is perfect.

The problem of the concept of "rest mass" is not so noticeable, yet it is there. According to Galilean principle of relativity a state of absolute rest cannot exist. Rest can be only relative; relative to the Earth, relative to the Sun, etc. I.e., it is permissible to talk about a rest mass of a body relative to the Earth or relative to the Sun. However, relative rest mass invariance is not evident at all. Moreover, *invariance* of a *relative* value, in a sense, is a contradiction in terms. We mean that General Relativity is not sufficiently general.

The weakest argument against General Relativity is its horrendously complex mathematical apparatus. Einstein is said to joke that "Since the mathematicians have invaded the theory of relativity, I do not understand it myself anymore." Yet, there is some truth behind every joke. General Relativity reminds of the Ptolemaic deferent-epicycle-equant model. No one ever dares to say about General Relativity, "It is simple, and therefore it is beautiful" [7]. Quite the reverse, to paraphrase Rutherford's saying, A theory that is hard to explain to a professor is probably not damn good.

We let alone the fact that General Relativity appears completely helpless in the face of such phenomena as the Pioneer anomaly and galaxy rotation.

Finally, General Relativity is a purely classical theory that ignores quantum mechanics entirely. Moreover, General Relativity and quantum mechanics are based on badly self-contradictory assumptions [6].

The flaws are really there in General Relativity, and they bring a number of "alternative relativities" to life. The author would be really upset if this work were branded so. The things below represent an alternative to Einstein's theory just as the Copernican system has been an alternative to the Ptolemaic one.

According to Poincaré, the proposed theory cannot be considered more legitimate or fallacious than General Relativity. A hypothesis like this cannot be true or false; it can only be, to a greater or lesser degree, convenient.

The theory set forth in this article has been prompted by two dicta. A prominent Russian astrophysicist Nikolay Kozyrev said, "In ordinary conditions, space is passive and simply gives place for events. But time is the event *per se*, it can not only possess a passive characteristic of duration, but also represents a phenomenon of Nature" [8]. The other maxim is Paul Davies' belief that, "we are approaching a pivotal moment in history, when our knowledge of time is about to take another great leap forward" [5]. This work is an attempt to undertake such a leap.

However, the inspiration does not mean blind obedience. The latter, together with changing a scientific view into a dogma, is another factor that turns science into religion.

It is superfluous to add that the author does not aspire to finish any revolution. Nor do we intend to announce a discovery of the Holy Grail of quantum gravity. However, the very fundamentals of physics will have to be revised so that physics, as we know it, will be fundamentally changed.

The theory set forth is purely deductive. We will not try to explain how the universe is. We simply build a model. All of the physics is pure modelling. We use just a few postulates and reason alone. Our work can be regarded as a mere speculation, which does not necessarily represent physical reality. As they say, Any similarity to actual physical laws is purely coincidental. However, as our model yields a relevance to the observed phenomena, we extend our model to the real universe, and we make certain predictions.

However, along with reminders of humility, ”we always must make statements about the regions that we have not seen, or the whole business is no use” [7]. ”In order to avoid simply describing experiments that have been done, we have to propose laws beyond their observed range” [7]. We are simply attempting to glance beyond the curtain, called an ”event horizon” of a ”black hole.”

We can note that any theory must be falsifiable (as per Karl Popper), but no theory can be judged how valid it is from the viewpoint of another theory, no matter how glorified it is. Moreover, our theory cannot be contested on the orthodox basis. Ultimately, only objections from the standpoint of experiment can be accepted.

The proposed theory is quite simple. It involves a drawback (as per Poincaré), because it has the greatest chance of passing unnoticed. But as said by Rutherford it should be ”damn good” so that it can be explained to any bartender.

Regarding Einstein, the supreme goal of all theory is to make the irreducible basic elements as simple and as few as possible. He also said, ”Problems cannot be solved by the level of awareness that created them.” Let us follow this advice.

First of all, we have to be aware that humans do not have even the faintest conception of what time is. Time simply seems to be a clear concept. Augustine once said, ”What then is time? If no one asks me, I know: if I wish to explain it to one that asketh, I know not.” Since then, humans have not advanced a tiny bit in their conception of time. Human can even not measure time. Instead humans compare something to the pace of some process, and call a standard a pendular, or a quartz, or even an atomic clock. I.e., humans substitute time with a clock, and believe that the clock slows as time slows. In conceptualizing this way, humans could, in fact, also believe that a weathercock directs the wind where to blow.

We intend to break the reader out of both Newtonian habits of external time and Einsteinian time dilation in which time is sometimes merely spatialized and the dynamics of events or processes is neglected. Process-oriented interpretations of time in modern physics are discussed in detail in Eastman and Keeton [9], and references therein. To do so we intentionally use the idea of rapidity of time or even ’flow of time’ that may suggest some hydrodynamic notion that conflicts with normal usages of ’time’ as a marker of repetitive events.

Let us assume that neither time nor ’flow of time’ is a universal idea. As such, we imply that firstly, there is no ”clock” to measure absolute time, and secondly, that time flows differently in different points of space. Posing the question in such a way should not cause problems for contemporary readers.

Quite the reverse, problems should arise in regard to stories about the first three (five) minutes (seconds) since the big bang [10]. What tool they have been measured with?

Certainly, not an absolute one. And what about the pace of time, where the tool was situated? After all, this might greatly affect the duration of the minutes.

That is, there is no universal time for all inertial frames to share. In other words, time dilation, which in General Relativity is an *effect* of gravity, is *postulated* in this work.

1. AXIOMS AND CONVENTIONS

Axiom 1: The flow of time is not an invariant of space. In other words, time is non-uniform, i.e., every point of space (inertial frame) features its specific flow of time.

We borrow only one postulate from Einstein:

Axiom 2: The speed of light (c) is an absolute invariant, i.e. it does not depend on any variables and conditions. In other words, $c = const$.

The domain of velocity: $\forall u \in (0, c]$. That is, no physical entity can move faster than light, and no physical entity can be in the state of absolute rest.

Definition 1: By inertial frame of reference, we mean a frame not affected by any external influence.

Definition 2: The idea of physical entity encompasses an electromagnetic wave, a light quantum (photon), a physical body, a mass point m, a neutrino-like elementary particle, i.e., anything featuring at least one of the following apparent physical characteristics: mass (m), energy (E), momentum (P).

Let us note that zero velocity $u = 0$ is excluded from the domain. This means that it is impermissible to use a notion of rest and its derivatives (e.g., *rest mass*).

However, we note that according to Definition 2, neither a frame of reference nor an observer attached to it are physical entities (and so they can be at rest).

In order to avoid impractical nitpicking we introduce **Axiom 3: The rapidity of time in a frame of reference affects the (relative) rapidity of the processes in the frame.** We do so regardless of (or due to) [9].

We do not make any other assumptions. We do not start with the premises of Special Relativity. Specifically, being that we consider inertial reference frames stationary in relation to each other, we consider it inappropriate to involve an idea of Lorentz transformation. Let alone exotic non-physical hypotheses such as anthropic principle.

From Axiom 1, it follows that we have very little to borrow from the Classical Mechanics. Regarding Einstein's Relativity…

Henri Poincaré wrote a century ago (in 1905), "Time and space… It is not nature which imposes them upon us, it is we who impose them upon nature…" Therefore, we will not try to discuss the problem in terms of space-time. Such an approach is equal to an attempt to construct heliocentric cosmology while assuming that the Earth is flat. Nobel laureate David Gross expresses hope for a scientific revolution that "will likely change the way we think about space and time, maybe even eliminate them completely as a basis for our description of reality" [6]. In other words, we let space time go. However, "to let the background space-time go is perhaps as difficult as letting go of the unmovable background Earth. The world may not be the way it appears in the tiny garden of our daily experience" [6]. Anyway, a description of a sunrise in terms of space-time intervals is a preposterous idea.

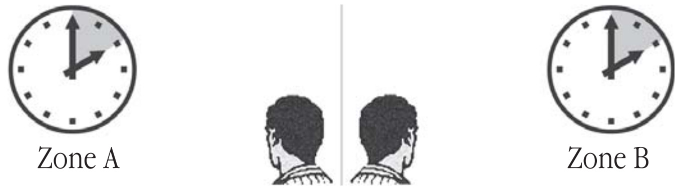

FIGURE 1. Time flow anomalies cannot be detected by internal observations.

Since we eliminate space-time as a fundamental variable we have to suggest an alternative. It is velocity (or rather the rapidity of a process). In terms of space-time, velocity is a time derivative of space. However, an observer never calculates a time derivative of space to figure out that a car is faster than a cyclist and a cyclist is faster than a pedestrian. To fine a driver for speeding, a police officer never calculates a time derivative. He even does not have to know what a derivative is. Instead, a police officer uses a radar gun to calculate the velocity immediately. Of course, a radar gun needs to be calibrated, but a timepiece needs it too.

So, a discussion of space-time metric goes beyond the scope of our work. Besides, each time we calculate a derivative of the coordinate of a (possibly) non-uniform space with respect to *a priori* non-uniform time while calculating velocity, we take the risk if not of a calculating mistake, then of the loss of the physical sense of the calculation.

Moreover, eliminating time (variable t) from the consideration makes the concept of simultaneity pointless, and thus lets us get rid of a number of paradoxes typical for Special Relativity.

Time (t) will appear in no further expressions. So the objection that thought experiment completion may require infinite time is incorrect. Excluding time (t) from our considerations is another reason to let the background space-time go.

2. PRINCIPLE OF TIME RELATIVITY

In order to clarify Axiom 3, let us set the principle of time relativity in analogy to the Galilean principle of relativity. As a matter of fact, the principle of time relativity is a generalisation of Galilean relativity to time.

An observer attached to an inertial reference frame cannot detect any time flow variance within its own reference frame by the mean of any internal observation.

Let us adduce necessary clarifications. Fig. 1 represents two zones (reference frames) featuring different flows of time. Each observer perceives the course of events in his own zone at a standard pace.

Each observer perceives the flow of time in his own zone as expected. That is, from the viewpoint of each one, all apparent physical processes occur with natural speed in each respective zone. As a result, the observers are unable to find any anomalies of time flow within their own zone.

However, if the observer in zone B looks at the events occurring in zone A, he finds out that they go slower than he is used to seeing in his own zone (Fig. 2). E.g., the ”slow” observer B registers a longer half-life of a radioactive isotope in zone A.

FIGURE 2. The ”slow” observer sees the processes in zone A as slowed down.

FIGURE 3. The ”rapid” observer A sees the processes in zone B as speeded up.

On the contrary, the observer in zone A notices that all processes in zone B go faster than he expects (Fig. 3). Accordingly, for the ”rapid” observer A, it seems that the same radioactive isotope decays faster in zone B than in his own zone A.

If observer A sends his clock to zone B and after that it returns to him, then he notices that the clock has been fast as compared with the standard clock that has remained in zone A for the same period. If observer B does the same, it turns out that his clock after arrival from the zone A, has been slow. *Roughly speaking*, the latter trial with clocks is reminiscent of the Hafele–Keating experiment [11].

We can comment that an observer is unable to know what happens ”in reality.” He is only able to register things that he can perceive and measure. His perception and measurement are the only facts he can rely on. Therefore it is natural that he takes all speed variations in the other zone as real.

We note that we have called the observer A ”rapid” for the sole reason that he sees the processes in zone B faster than in zone A. On the opposite, the ”slow” observer B sees that the clock of the ”rapid” observer moves slowly.

We chose clocks exclusively as an illustration of a process, not an illustration of how time is to be interpreted. The clock situated in the zone of rapid time goes slower from the viewpoint of the slow observer; and the clock situated in the zone of slow time goes faster from the viewpoint of the fast observer respectively. We conclude that time is not at all what a clock displays.

As a final remark in this section, we must warn the reader against attempts to convert the above illustrations into a thought experiment where mirrors connected to the hands of the clocks reflect light from zone to zone. Moreover, we object to the idea of attaching an electric charge to the hands of the clocks. The sole purpose of the above descriptions is to provide a concept of non-uniform time. A discussion of a behaviour of an electrically charged particle is premature. Let us start with simple things.

FIGURE 4. The ”rapid” observer sees sudden acceleration.

3. A MASS POINT IN THE FIELD OF NON-UNIFORM TIME

Let us discuss a mass point (*m*) moving uniformly, i.e., in a straight line and at constant speed from zone A (rapid time) toward zone B (slow time) along a normal to the zone border. In the beginning, for the sake of simplicity, let us restrict our discussion to a one-dimensional model. Both zones are considered inertial, i.e., they are not affected by any external influence.

It is easy to see that after the mass point crosses the border between zones A and B the observer in zone A will perceive the motion of the mass point in zone B in a rapid pace. Accordingly, he records a sudden increment of velocity, i.e., acceleration (Fig. 4).

Similar observations will be registered by the ”slow” observer in zone B. As the mass point enters zone A the observer will detect a sudden acceleration as well.

Thus, both observers detect sudden acceleration. It is easy to show that a mass point moving in the reverse direction, from zone B to zone A, will be slowed down, which will be noticed by both observers as well.

Both observers naturally suppose that the mass point was affected by some unknown force.

We draw attention to the fact that, although we have introduced mass *m*, accelerations detected by the observers in no way depend on mass point *m*, for they are completely conditioned by the rate of the flows of time in corresponding zones. Therefore, we have to refine the latter statement: the mass point is affected by some *fictitious* force (or *pseudo-force*).

It is much more appropriate to assume that time conditions vary continuously from point to point, rather than in discrete steps. Therefore it is possible to calculate both apparent acceleration (which will not be sudden), and time conditions to emulate a law of any fictitious force.

Now, let us consider a line segment $\alpha\omega$ travelling uniformly from zone A to Zone B along a normal to the border. It is easy to see that point α moves faster in zone B for both observers, while point ω moves slower as it remains in zone A. In the time between crossing the border by point α and by point ω the line segment $\alpha\omega$ becomes distinctly longer (Fig. 5). This makes the association with the tidal force pertaining to gravity almost obtrusive.

It is superfluous to repeat that ”tidal strains” do not depend on the mass of the entity travelling between zones with a different flow of time.

In other words, the fictitious force described is so close to resulting gravity that it is permissible to pose an equivalence principle.

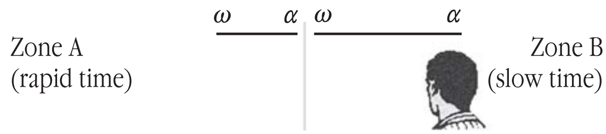

FIGURE 5. The line segment becomes longer.

4. EQUIVALENCE PRINCIPLE

The outcome of non-uniform time in an inertial frame of reference is equivalent to the outcome of a fictitious gravity force external to the frame of reference.

The zone with a slower time works as a ”centre of attraction” for the entities residing in zones of a faster flow of time. Respectively, the zone of a rapid time ”extrudes” entities into the slower time zone.

From geometrical (or more accurately, it is possible to use the term *chrononomical*) reasoning we can conclude that if time conditions vary continuously and monotonically, then the velocity of a mass point m will increase continuously and monotonically as well.

A mass point behaviour invariance under mass m also means that the point behaviour would change in no way, even if in the final analysis it turns out that mass itself depends on the flow of time (or on velocity, as it is in Special Relativity). This is a very important point. Let us stress once more: As much as the motion of the mass point in time conditions described above is defined solely by geometry (or *chrononomy*), then the behaviour of the mass point remains the same, independent of whether m increases infinitely, or decreases to zero, or even varies periodically.

This permits the assumption that when accelerating continuously and monotonically, a mass point reaches the speed of light c. They are exclusively the axiom limitations, which do not allow a mass point to continue accelerating. As soon as the velocity of a mass point is defined only geometrically (or *chrononomically*), there are no factors to prevent its velocity from reaching c. The latter means that it is not altogether necessary that the velocity of a mass point will approach c asymptotically (as in Special Relativity).

As the concept of an inertial frame becomes in a sense pointless, it becomes more convenient to talk in terms of zones.

5. A PHOTON IN THE FIELD OF NON-UNIFORM TIME

Let us consider the behaviour of a light quantum (photon) as it travels from zone A (rapid time) to zone B (slow time). The velocity of a photon is c. According to Axiom 2, any reasoning as to the kinematical acceleration of a photon is senseless. Let us consider the frequency of an electromagnetic wave (ν) instead.

Observer B registers light coming from zone A as ”faster,” having higher frequency ($\nu_B > \nu_A$). I.e., observer B notices a *blue-shift* as compared to a standard source in his zone (Fig. 6). Observer A, on the contrary, registers light coming from zone B as ”slower,” with lower frequency ($\nu_A < \nu_B$). I.e., observer A notices a *red-shift* compared to a standard source in his zone (Fig. 7).

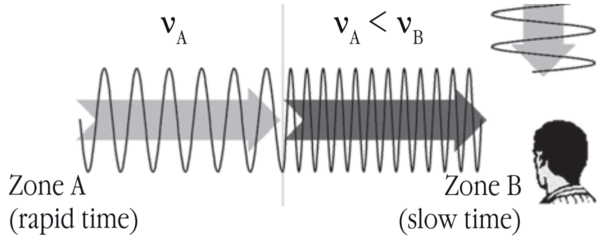

FIGURE 6. The ”slow” observer sees blue shift.

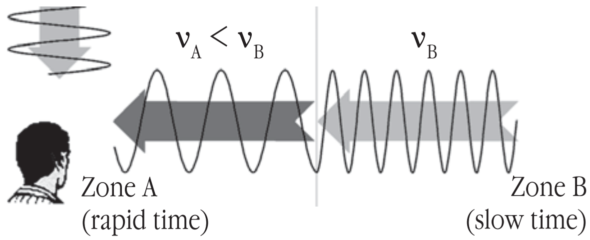

FIGURE 7. The ”rapid” observer sees red-shift.

We point out that the blue-shift is seen only by observer B, while the red-shift is seen only by observer A. However, $\nu_A < \nu_B$ anyway.

The phenomenon described above is not solely our mental experiment, but it is a result of a number of researches, of which the foundation is Pound and Rebka's experiment [12]. The question is the interpretation of the outcome of the experiment.

We can note that the described red-shift mechanism is a better explanation of cosmological red-shift than a hypothesis of tired light that has no experimental proof, and is a much better explanation than a literal interpretation of the Doppler effect which necessitates the idea of an expanding universe, thereby bringing up numerous objections.

6. STATEMENT OF PROBLEM

We will consider the behaviour of a physical entity in the field of non-uniform time. We assume that the flow of time varies continuously and monotonically. We consider the frame of reference to be empty and exclusive of any external force.

We will consider a physical entity with initial conditions $E \rightarrow 0$, situated infinitely far ($r \rightarrow \infty$) and travelling in the direction of a decreasing flow of time according to the equivalence principle.

The initial condition $E \rightarrow 0$ (at $r \rightarrow \infty$) means an infinitely large red-shift for a light quantum ($\nu \rightarrow 0$), and an infinitesimal velocity for a physical body ($u \rightarrow 0$).

The coordinate r variation (travelling) for a physical entity in this frame of reference will, due to geometry, be unambiguously accompanied by continuous and monotonic increase of energy, i.e., frequency (ν) for a light quantum and velocity (u) for a physical body: $E = f(r)$.

Let us point out that as we introduce velocity u we imply a velocity, which the body acquires in point r under the action of non-uniform time occurring with the initial

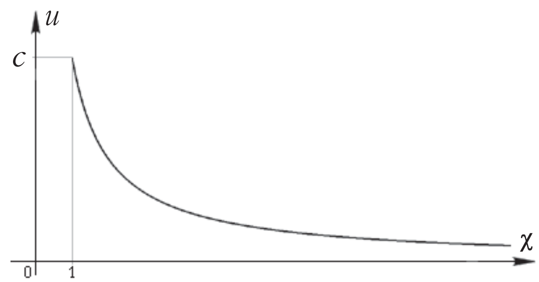

FIGURE 8. The mass point reaches the speed of light at $\chi = 1$.

conditions set above. The physical sense of this value is the straight-line escape velocity from point r to infinity.

Let us introduce the dimensionless scalar variable χ so that

$$u_A \chi_A = u_B \chi_B \ \ or \ \ u\chi = const. \tag{1}$$

Special attention has to be drawn to the case of a mass point reaching the speed of light c. According to Axiom 2, $c = \chi c$. In other words, the mass point reaches the speed of light at $\chi = 1$. That is,

$$u\chi = c, \tag{2}$$

where $\chi \geq 1$ (Fig. 8).

In the quantum case (Fig. 6,7)

$$\chi_A \Delta t_B = \chi_B \Delta t_A \ \ or \ \ \frac{\Delta t}{\chi} = const. \tag{3}$$

Therefore, let us call variable χ rapidity of flow of time, or simply *flow of time*.

Such a posing of the problem, firstly, provides the possibility to establish unambiguous conformity between E (or u for a physical body) and χ; and, secondly, allows us to avoid the concept of potential energy, which essentially involves the idea of force that we escape by the equivalence principle.

That is, in all the pictures above the zone of ”rapid” time A features the higher *flow of time* χ_A, and the zone of ”slow” time B features the lower *flow of time* χ_B.

Recently, we have pointed out that the force mentioned in the equivalence principle is *fictitious*. Accordingly, potential energy and gravitational potential which is linked to force should be called *fictitious* as well. For some reason, the *fictitious* nature of energy of gravitation is never noted as if nothing were wrong.

According to the introduced equivalence principle, the further reasoning does not need an idea of ”gravitational” radiation, be it either in corpuscular or in wave form, nor does it need an idea of ”propagation” of gravity in space. The velocity of gravity calculated by Tom Van Flandern [13] makes more than $2 \times 10^{10}c$, i.e., much faster than light. Thus, we have either to reject the major postulate of Special Relativity or to accept that gravity is transmitted instantaneously.

Fictitious gravity has a nature pertaining to time, and has nothing to do with interaction whether short-range or long-range one, because time is the necessary condition for a

TABLE 1. Meter reading [14] comparisons with the increase of g under the inverse-square law.

Depth (m)	Δg theory ($0.001 m/s^2$)	Δg test ($0.001 m/s^2$)	Deviation (%)
267.23	0.824049	0.8252	0.14
487.11	1.502164	1.5038	0.109
599.94	1.850162	1.8522	0.11
720.13	2.22088	2.2233	0.109
834.14	2.572555	2.5753	0.107
935.29	2.884579	2.8877	0.108
948.16	2.924281	2.9274	0.107

process, rather than simply an influencing factor. ”Time does not propagate but appears in the whole universe at once. Therefore communication through time should be instantaneous... This does not contradict Special Relativity because in instant communication through time there is no material motion” [8].

On the other hand, according to orthodox views, behaviour of a particle in a gravitation field is defined purely geometrically and does not depend on particle mass m. However, geometry itself is defined by the mass of the source of gravity M. Hence, it turns out that the mass still affects geometry, and here we face a philosophical problem of symmetry: one mass (M) generates geometry, while another one (m) does not affect geometry at all.

Every time we talk about mass m, we imply the *inertial* mass, because the proposed principle does not require the idea of ”gravitational” mass, for according to the equivalence principle, the cause of gravity is not the mass of an attracting body, but a decrease of flow of time, invariant to both masses.

7. EXPERIMENTAL VERIFICATION

The latter proposition could be easily tested even in earthly conditions: according to the existent standpoint, acceleration due to gravity should (almost) linearly decrease from standard gravity g at the Earth’s surface to zero in the centre of the Earth (because gravity increases in inverse proportion to the square of r, and the gravitational mass M decreases in direct proportion to the cube of r). The proposed theory, on the contrary, predicts monotonous increase of acceleration g along with the depth due to the decrease of the time flow toward the centre of the Earth that is what really causes gravity.

Function $g(r)$ should obey the inverse square law both above the Earth and at its core. Such an increase of observable g along with depth is in strong agreement with experimental data (Table 1), although Stacey *et al.* interpret this outcome as ”the possible (but not probable) systematic error arising from density inhomogenity” [14] and even ”possible violations of Newton’s inverse-square law” [15].

It is worth noticing that the deviation is not only systematic, but also nearly fixed, which even further improves the inverse-square law compliance. An appropriate correction for the systematic bias (a decrement of $R_\oplus$ by only 1 m) results in a scandalous precision: 0.0003%.

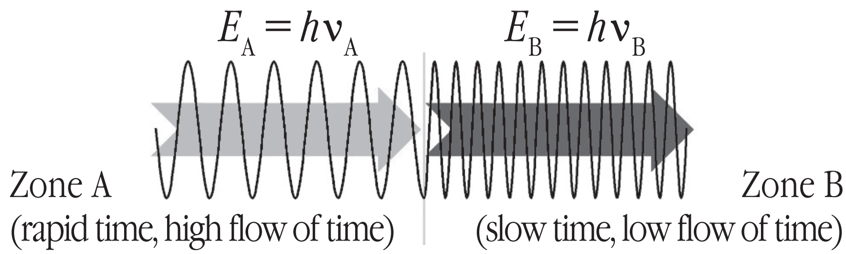

FIGURE 9. Energy increases in the zone of low flow of time.

Similar results regarding the observable g at the Earth's core can be deduced from the work by Ander *et al.* [15], although with bigger systematic error. And there is no experimental evidence that g decreases with depth.

Accepting gravity dependence on the mass (of attracting body M) inevitably leads to postulating a defect in Newton's law of gravity [16]. Holding *et al.* explicitly state discrepancies between planetary and laboratory measurements of G and use value G_∞ [14] [16]. However, if laboratory $G_{lab} \neq G_\infty$, i.e., if G is not a fundamental constant, then the inverse-square law looses its sense. And if Newton's law of gravity has a defect, then the defect correction has no physical justification, and the correction itself turns into a deceptive adjustment. Although even if Newton's law has no defect, its physical justification leaves much to be desired. In the final analysis, as per Richard Feynman, ”Up to today, from the time of Newton, no one has invented another theoretical description of the mathematical machinery behind this law which does not either say the same thing over again, or make the mathematics harder, or predict some wrong phenomena. So there is no model of the theory of gravitation today, other than the mathematical form” [7]. Furthermore, ”it may well turn out that some of the laws which we see today may not be exactly perfect” [7].

8. ENERGY CONSERVATION

As we return to the case in Fig. 6, it is easy to see that according to Planck's quantum postulate ($E = h\nu$), along with the increased frequency in zone B ($\nu_B > \nu_A$), energy increases ($E_B > E_A$) as well (Fig. 9).

Let us repeat that energy incrementation is in no way connected with external influences. Energy increase is solely a result of different time conditions (flow of time) and in our consideration is free of the necessity to introduce an artificial idea of ”gravitational mass of light.”

It follows from the above that the law of energy conservation is neither universal nor fundamental. Classical energy conservation is applicable only in the frames of reference featuring constant flow of time, or *uniform* time.

The above is not new, for it simply repeats a special case of Noether's theorem, according to which, energy conservation is effective only in the frames of uniform time. But we have *a priori* assumed non-uniformity of time; hence the classical energy conservation law is no longer applicable.

A tendency to retain (or to reanimate) the classical energy conservation law at all costs on the assumption of dilated time cannot lead to the true representation of the universe. A plausible physical theory is difficult to frame even starting with plausible premises. As for the *a priori* false assumptions, however ”evident” they may seem, and however solid the scientific consensus about them may be, they cannot help but lead only to false conclusions. However, let us not digress into philosophy.

It is the **generalized energy conservation** law that should apply to the frames of non-uniform time:

$$E\chi = const. \tag{4}$$

This law is *evidently* fulfilled for a light quantum. Moreover, physically this expression can be noticed as absolutely equivalent to Max Planck's $E = h\nu$.

$$E\chi = const \Rightarrow E = const\,\chi^{-1} \Rightarrow E = const\,\nu. \tag{5}$$

Thus, from the viewpoint of philosophy, the most instrumentalist[1] formula in the history of physics acquires reasonable grounds that turn it into a self-evident truth.

Since it is absurd to suggest a specific energy conservation for material bodies, we extend it onto all physical entities.

For a start, we can make a trivial remark that if χ =const, then time is uniform and the classical energy conservation turns out to be correct.

Since neither the red nor the blue-shift have any physical limitations, so initially we can accept the domain of flow of time as $\forall\chi \in [0,\infty)$.

In the case of the blue-shift considered above (Fig. 9) we get:

$$E_A\chi_A = E_B\chi_B \Leftrightarrow \nu_A\chi_A = \nu_B\chi_B \Rightarrow \chi_A\Delta t_B = \chi_B\Delta t_A. \tag{6}$$

We stress that the last expression is invalid for the physical entities with finite mass in ”real” initial conditions. This remark is essential for the physical comprehension of the introduced generalized energy conservation law as applied to *corpuscular kinematics*.

We remark also that $E \to \infty$ at $\chi \to 0$, and $E \to 0$ at $\chi \to \infty$. These cases are worthy of special consideration in the future.

The energy (E) (or the rapidity) versus the flow of time (χ) is exactly the coordinate system we have mentioned in the very outset, to which we turn from the conventional space-time. A logarithmic graph of the generalized energy conservation (Eq. 4) yields a straight line (Fig. 10), and General Relativity describes only the right part ($log\chi > 0$). The entire left part of the graph ($log\chi < 0$) is singularity in Einsteinian terms.

We point out that in the corpuscular case, the generalized energy conservation (Eq. 4) is valid only at the above initial conditions.

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[1] Instrumentalism is the view of the philosophy of science that concepts and theories are merely useful tools, instruments and their worth for a human is measured not by whether they are true or false or whether they depict reality plausibly, but by how effective they are in explaining and predicting phenomena. Hitherto, Planck's formula $E = h\nu$ has been instrumentalist: it has not contained any distinct sense; it works and that's all there is to it.

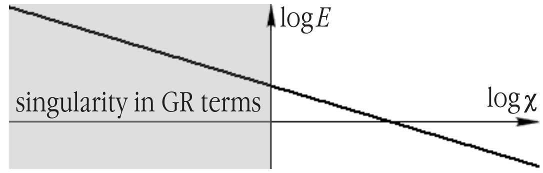

FIGURE 10. Generalized energy conservation in log scale.

9. CONSERVATION OF MOMENTUM

Let us write down the generalized energy conservation law for the case in Fig. 4:

$$E_A\chi_A = E_B\chi_B. \tag{7}$$

We point out that although geometry of Fig. 4 is invariant under mass, we by no means can insist on mass invariance under geometry. In other words, a ”natural” supposition that $m_A = m_B$ ($m = const$), is as natural as the ”fact” that the Sun revolves around the flat (which also seems natural) Earth. In the general case we ought to state: $m = f(\chi)$.

Having divided Eq. 7 into Eq. 1 we get:

$$E_A u_A^{-1} = E_B u_B^{-1}. \tag{8}$$

On the sure ”non-relativistic” side ($u_A, u_B \ll c$) accepting $E \sim mu^2$, we get:

$$m_A u_A = m_B u_B. \tag{9}$$

In other words,

$$P_A \equiv P_B. \tag{10}$$

Thus, the conservation of momentum automatically follows from the generalized energy conservation. From the philosophical viewpoint, conservation of *quantitas motus*, ”quantity of motion,” is natural in a closed system regardless of non-uniformity of time.

Here it is worth noticing that according to the previously mentioned Noether's theorem, conservation of momentum conforms to the uniformity of space. However, *a posteriori* we cannot consider space to be uniform since time is non-uniform. On the other hand, as long as momentum is conserved, such a space can be considered *pseudo-uniform*.

In the case under consideration, this means that the flow of time can be defined as $\chi = f(r)$. I.e., expressions like ”the flow of time in zone…” turn out to be justified, although somewhat late.

It is superfluous to note that momentum is conserved only at the initial conditions described above.

10. INVERSE-SQUARE LAW OF UNIVERSAL GRAVITATION

The pseudo-uniformity of space also justifies an idea of the gradient of the flow of time ($\nabla\chi$). To calculate the gravity force we differentiate Eq. 4 with respect to spatial coordinate and get:

$$\chi\nabla E + E\nabla\chi = 0. \tag{11}$$

Since $\nabla E = F$, we derive:

$$F = -C\frac{\nabla\chi}{\chi^2}. \tag{12}$$

where C is a constant that is formally mass-dependent.

Equation 12 is valid for each (individual) body.

It is easy to see that if time is uniform ($\chi = \text{const}$), $\nabla\chi = 0$ reduces the force to zero; and if the flow of time depends on spatial coordinate linearly,

$$\chi = \beth r + X, \tag{13}$$

where $\beth = \nabla\chi$ (hebrew beth or beit) and "basic" flow of time X (chi) at $r = 0$ are constants, we get:

$$F = -C\frac{\beth}{(\beth r + X)^2}. \tag{14}$$

It is evident that at $\beth r \ll X$ (or, which is the same, at $X = 0$) Eq. 14 becomes $F \sim r^{-2}$, i.e. Newton's inverse-square law of universal gravitation. Although we discuss an abstract model the rest distributions of the flow of time in space become superfluous.

Although we consider gravity a fictitious force, the inverse-square law of universal gravitation is not fictitious at all. Since the law of universal gravitation is beyond doubt, **our assumption that the flow of time depends linearly on spatial coordinate, becomes a fact**, which needs no experimental proof, just as the inverse-square law of universal gravitation does not.

We can note that the inverse-square law results regardless of the number of spatial dimensions.

Also, let us notice that, strictly, we can neglect X only with respect to $\beth$, for if both $\beth$ and X are equal to zero then the fictitious force becomes uncertain. This means that if $\beth$ is small then $X > 0$.

The latter conclusion allows us to get rid of an infinity of gravity at the extremely small χ. In the final analysis, the physics of the real world cannot tolerate infinities. Infinity is an abstraction suitable in mathematics, but "there is an unwritten rule in physics that when anything potentially observable is predicted to become infinite it is a sure sign that the theory is breaking down somehow" [5]. I.e., if X were equal to zero, it would threaten with a singularity at $\chi = 0$ (an infinite gravitation and an infinite curvature of space-time in the terms of General Relativity); in the final analysis, that might denote a possibility of a "black hole" in each centre of gravity including the centre of the Earth.

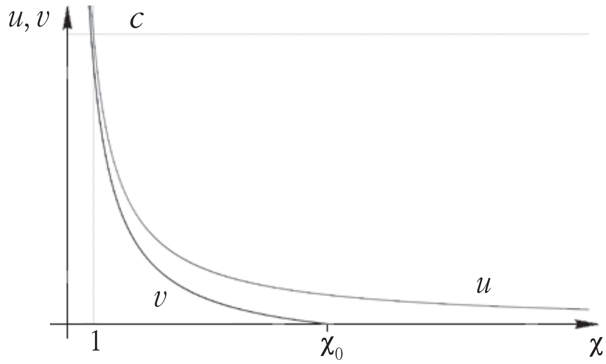

FIGURE 11. Velocity dependence on the flow of time at initial conditions $v = 0$ at $\chi = \chi_0$.

At the outset, we have stipulated that we won't try to explain how the universe is. Nevertheless, our model is valid to a certain extent for the universe.

Although the linearity of the flow of time *per se* needs no experimental proof, a stationary version of Hafele–Keating [11] atomic clock experiment in a deep mine (up to 3 km) can be conducted to measure values $\daleth_\oplus$ and $X_\oplus$ characteristic for the gravity of the Earth. The inverse value of the upper clock time delay relative to the lower one ought to lay on a straight line, whose slope defines $\daleth_\oplus$, and extrapolation to the centre of the Earth defines $X_\oplus$. The same results should be expected from the experiment of Stacey [14] and Ander [15], which is also worth re-conducting at greater depths.

11. REAL INITIAL CONDITIONS

Let us exaggerate the problem. Let us consider the kinematics of a point with arbitrary initial conditions: $v = 0$, at a finite distance $r = r_0$, or at $\chi = \chi_0$, (which is the same) and travelling in the direction of a decreasing flow of time according to the equivalence principle.

Such a point is situated in the selfsame (scalar) field of flow of time as in the case of initial conditions $u \to 0$ at $r \to \infty$. The distinction is that v is not an escape velocity (to infinity).

$$(v + u_0)\chi = c, \tag{15}$$

where $u_0\chi_0 = c$, or

$$v = c(\frac{1}{\chi} - \frac{1}{\chi_0}) \tag{16}$$

(Fig. 11).

It is no effort to conduct the same reasoning in regard to energy ε:

$$\varepsilon = \mathfrak{M}c^2(\frac{1}{\chi} - \frac{1}{\chi_0}) \tag{17}$$

For rigor's sake, let us note that the domain of functions $v(\chi)$ and $\varepsilon(\chi)$ differs from the domain of functions $u(\chi)$ and $E(\chi)$. Within the joint domain functions $v(\chi)$ and $\varepsilon(\chi)$ differ from $u(\chi)$ and $E(\chi)$ only by a constant ($\frac{c}{\chi_0}$ and $\frac{\mathfrak{M}c^2}{\chi_0}$ respectively). It is evident that any derivatives of these functions are equivalent ($v' = u'$). Accordingly, any concepts attached to the derivatives are also equal. I.e., **fictitious gravity does not depend on initial conditions**.

12. RELATIVITY OF MASS

What is most important, is that keeping in mind Eq. 1, it follows from the conservation of momentum that

$$m_A \chi_A^{-1} = m_B \chi_B^{-1}. \tag{18}$$

That is, mass m is directly proportional to χ:

$$m = \mathfrak{M}\chi. \tag{19}$$

(where $\mathfrak{M}$ is reduced or "basic" mass), while both energy and velocity are inversely proportional to χ. In fact, this means that mass m is inversely proportional to velocity u.

It is true that we have made the reservation that $u_A, u_B \ll c$, but with the current statement of the problem, there are no physical (let alone mathematical) substantiations for such circumspection. The only thing that demands a discussion of the limits of velocity u is the domain of u. However, our reasoning has been free of even asymptotic motifs, especially in a purely geometrical (or *chrononomical*) presentation. That is, the conservation of momentum should be extrapolated to the entire domain of u.

In other words, from Eq. 19 it follows that $m \to 0$ at $\chi \to 0$. Although this conclusion contradicts "common sense," it bids fair to get rid of the singularities of General Relativity, which are its most evident shortcoming.

However, let us not be too hasty. As we claim that $m \to 0$ at $\chi \to 0$ we can not forget the domain u. The velocity of a physical body cannot exceed the speed of light c, hence mass m has a bottom limit.

Again, if $\chi \to \infty$, then mass tends to infinity ($m \to \infty$) too, which in a physical sense provokes questions. Specifically, questions arise if one takes mass as a measure of the quantity of matter of the Lomonosov–Lavoisier law. However, as we recall a primitive definition of mass as a measure of the inertia of matter, relativity of mass becomes more evident. The slower the pace of processes, the higher the inertia of the matter involved in the processes. Or, in other words, the higher the flow of time, the higher the mass. As the flow of time varies, it is nearly obvious that inertia cannot remain constant. That is, relativity of mass is almost a Platonic *innate idea*.

As a matter of fact, if a body is situated in the zone of infinitesimal flow of time (i.e., a finite displacement takes an infinitesimal slice of time) then even an infinitesimal force makes the body move at an infinite velocity (faster than light). This represents infinitesimal inertia of the body. Again, if a body is situated in a zone of infinite flow of time (i.e., a finite displacement takes an infinitely long time) then even an infinite force makes the body move infinitesimally slow, which denotes infinite inertia (mass) of the body.

13. REFINING GENERALIZED ENERGY CONSERVATION

Dependence of mass on the flow of time forces us to reconsider Einstein's formula $E = mc^2$ immortalised in stone, for it is evident that it can only be valid in the case of uniform time. Above (Eq. 4) we stated: $E\chi = const$. However, it is possible to express more certainly. In order to do so we take a gradient of Eq. 1:

$$\chi \nabla u + u \nabla \chi = 0. \tag{20}$$

Expressing ∇u as $\frac{dudt}{drdt} = \frac{a}{u}$ and keeping in mind Eq. 1 and $\nabla \chi = \beth$ (Eq. 13), we get:

$$a = -\frac{\beth c^2}{\chi^3}. \tag{21}$$

We point out that this equation does not correspond to the observed acceleration because relativity of mass is ignored. Multiplying expression 21 by Eq. 19 and keeping in mind that Newton's second law also ignores relativity of mass, we obtain:

$$F = ma = -\beth \frac{\mathfrak{M} c^2}{\chi^2}. \tag{22}$$

An integration of this expression yields:

$$E\chi = \mathfrak{M} c^2, \tag{23}$$

which becomes Einstein's well known formula when $\chi = 1$.

Dividing Eq. 23 by Eq. 1 we refine momentum conservation:

$$P = \mathfrak{M} c. \tag{24}$$

14. HUBBLE'S LAW

Above, we proposed a new mechanism for cosmological red-shift that does not involve the Doppler effect together with a so-called "undeniable evidence" of the universe expansion. Recently, we have reached the conclusion that the flow of time depends linearly on the spatial coordinate r. Thus, we can deduce that the red-shift (z) of a distant object should also grow linearly with distance:

$$z = \frac{r}{R_0} - 1. \tag{25}$$

where R_0 is the radius of the radiating surface of a remote star.

Furthermore, in the case $r \ll R_0$, the red-shift becomes simply proportional to the object's distance:

$$z = \frac{r}{R_0}. \tag{26}$$

Substitution of R_0 with $\frac{c}{H_0}$, yields:

$$r = \frac{c}{H_0} z. \tag{27}$$

where H_0 is ”Hubble’s constant,” and c is the speed of light.

In other words, we have *deduced* nothing but Hubble’s law as follows: the red-shift in light from a distant object is proportional to its distance, which until recently should have been regarded as an empirical rule at best. We have put the term ”Hubble’s constant” in quotes. The ”panoply of radically different measurements in modern times of an alleged ’constant,’ which is in the foundation of the Big Bang theory, is troubling” [17].

From our reasoning it follows that the red-shift of the red dwarfs should be greater, and of the giants and supernovae it should be smaller than that of the main sequence stars (because of different R_0 in Eq. 26). The corresponding ”Hubble’s constant” should vary accordingly.

From the above law, it does not at all follow that the more distant from the Earth an object is the faster it is receding. Such an interpretation occurs only as a result of the ”natural” involvement of Doppler recession as the first explanation of cosmological red-shift that comes to mind under the uniform time circumstances.

By mistakenly interpreting Hubble’s law, failing to make a distinction between observations and conclusions we can decide that ”the universe is expanding with time, and that means that the gravitational constant is changing with time, and although that is a possibility there is no evidence to indicate that it is a fact. There are several partial indications that the gravitational constant has not changed in that way” [7].

15. CRUCIAL EXPERIMENTS

We consider it appropriate to recapitulate the experiments discussed in the previous pages in order to verify (or falsify) the theory of time in our discussion.

The most crucial test is a stationary version of Hafele–Keating [11] atomic clock experiment in a deep mine (up to 3 km). If all of the clocks are timed against each other, the theory of time is utterly falsified and we can concern ourselves with theology. Again, if an upper clock exhibits a delay relative to a lower one, then the delay permits metering values $\beth_{\oplus}$ and $X_{\oplus}$ to be accomplished.

The second test is re-conducting the experiment of Stacey [14] and Ander [15] in a deep mine (up to 3 km) in order to verify monotonous increase of acceleration g along with the depth.

The most pressing (although never noted) problem ringing in our ears is the Cavendish experiment to measure the force of gravity between masses in a laboratory. It seems to prove that the cause of gravity is the mass rather than the flow of time. However, the Cavendish experiment was done in 1798, i.e., 40 years before the discovery of the Coriolis effect. That is, Cavendish was unable to make allowance for the Coriolis force, which would have been essential in his tests. Moreover, we could not find a reference to the Coriolis effect in the books on Cavendish experiment. Further questions in regard to the Cavendish experiment arise in the discrepancy between G_{lab} and G_∞ [16]. A full stop in this question can be made by the experiments we have proposed. In any case, the Cavendish experiment does not falsify our considerations.

SUMMARY

The proposed theory almost completely eliminates the notion of space-time as a basis for our description of reality. Instead it introduces a concept of the flow of time χ.

It is shown that mass, however large it be, is not a cause for gravity. Gravity has a nature pertaining to the flow of time. Gravitational radiation does not exist neither in the form of gravitons, nor in the form of a wave. Fictitious gravity does not spread in space but appears as a result of time conditions [8].

Because according to Noether's theorem, classical energy conservation is not applicable to the frames featuring non-uniform time, a generalized energy conservation that allows the flow of time is introduced being evidently valid in the quantum case. The most instrumentalist formula of the modern physics, Max Planck's quantum concept ($E = h\nu$), is made "damn good", for it is given a physical sense, "that you can explain to a bartender" (Ernest Rutherford).

The inverse-square law of universal gravitation, which has up to the present time has had no physical sense [7], is deduced analytically. Since the law of universal gravitation follows from the generalised energy conservation under the assumption that the flow of time depends linearly on a spatial coordinate, this assumption becomes a fact.

A new cosmological red-shift mechanism that neither implies a hypothesis of tired light, nor involves the idea of expanding universe is described. The linear flow of time's dependence on a spatial coordinate allows the theoretical validation of Hubble's law regarding the red-shift of remote cosmic objects. However, Hubble's red-shifts have nothing to do with the expanding universe.

Mass (as a measure of inertia of a body) is shown to be a function of the flow of time. Mass of an uncharged point linearly grows with the flow of time from zero to infinity.

Einstein's mass-energy equivalence is refined.

In brief, **all of physics, as we know it, is just a rather narrow, specific case of a physics of non-uniform time.**

The experiments to prove the theory of time in discussion are proposed.

According to the principle of Occam's razor, we had no need of quite a few hypotheses involved *ad hoc* in a variety of theories or the theories themselves:

1) gravitational mass in general and gravitational mass of light in particular,

2) gravitational radiation in any form,

3) gravitational red-shift, including that stipulated by the Doppler effect, tired light, and intrinsic red-shift,

4) expanding universe.

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