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Einstein, cosmological constant, and gravitational forces

(Updated 23.07.2009)

Until they allowed to change something on the Aristotelian sky, they refuse furiously what they are looking on the Nature's one. Even when they are seeing for something, they do not believe in it.
Galileo Galilei

1. Introduction

At first sight this paper may be seemed to be absolutely "heretic", however, it really is more orthodox than common representations. It do not refuse the axioms and examines by a maximally rigorous way the conclusions that finally become more clear and more corresponding to a spirit of the theory than these above representations (see, for example, **[Chernin, 2008]**). Furthermore, in order to focus on the problem meaning I knowingly avoid here any formulas and calculations[1]. At last, I'm going to discuss several incorrect (in my opinion) conventional statements during the exposition.

2. Einstein's static Universe

In 1917 A. Einstein firstly applied his just created General Relativity to the world as a whole. He considered the Universe as a media enclosed on it-self and consisting in a uniform (in large scale) matter that has a non-zero mean density. He formulated a corresponding system of equations for such Universe that hadn't some external bound. At this time Hubble yet did not open the Universe expansion, because of that Einstein did not consider a possible Universe evolution in time.

However, there was one very regrettable circumstance – this proposed equations system had not a solution! More precisely, it allowed some solution that Einstein refused as well as all his followers. In work "On the cosmological problem" **[Einstein, 1953]** he wrote that such solution should be linked with a *negative* pressure, but there was no any physical reason for it.

He preferred to do something that he later called his "greatest blunder". Instead of a negative pressure (we yet will return to it) he set it equal to *zero*, but in addition he introduced some formal parameter – so called "cosmological constant" Λ. To base this he mentioned a Poincaret's hypothesis. Poincaret suggested that there are several forces in atoms *compensating an electrical repulsion* of their likely charged parts.

So, Einstein says here *clearly* that an *effective* pressure corresponding with the constant Λ should be *negative* in order to compensate some repulsion and provide an *attraction*. However, the author of **[Chernin, 2008]** states: to provide a static character of his model Einstein had to introduce the additional suggestion on the existing in Nature a universal repulsion able to compensate and counterbalance the universal gravitation in the Universe as a whole. This is direct and explicit contradiction with the above Einstein's statement! We will yet return to the origin of this formulation (see also the Appendix).

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[1] All this one can find in my publications on web-site http://www.timeorigin21.narod.ru/eng_time . Meanwhile, I present a pair of formulas in the Appendix.

3. Evident – incredible, or trivial meaning of the *negative* matter pressure in the Universe

We observe that Einstein used somehow or other a *negative* pressure in his model, at least as its "substitute" – cosmological constant Λ. But what indeed the negative pressure means, by what a physical manifestation is it characterized? Let us search for this in the classical textbooks **[Landau et al., 1965, 1976]**:

> At the typical conditions a body pressure is positive, i.e. it is oriented as the body tended to expand. However, it is not necessary, and a body may also be in a state at a negative pressure: in such states the body seems to be "extended", and because of that tends to compress. For example, the superheated liquid can characterize by a negative pressure; such a liquid acts to its bounding surface with a force that is oriented inside the volume of liquid.

And now I call a reader to encircle in his mind some (finite) volume of the Universe space with an external bound, to "forget" the remote matter existence outside of this region (for example, like Solar system). Let us consider the matter at rest that is placed *inside* the region. You may do not believe but the matter will tend to *compress*, i.e. the actual force will be oriented just inside the region! Every schoolboy knows the reason of it: this is the universal Newtonian attraction. So, regardless of the incredible Einstein's delusion, *the matter explicitly manifests the negative pressure existence as its global and necessary attribute.* By the way, it is not connected with a compensation of an electrical force in the atoms.

It is very strange how the Einstein's followers had easily accepted his thesis. For example, author of the known monograph **[Tolman, 1969]** carefully analyzes the *dynamical* pressure contribution (due to stars, galaxies, and clouds velocity presence), but refuses any possibility of a *static* negative matter pressure existence.

This returns us to the cosmological constant introducing expediency. My arguments, as I believe, lead inevitably to the recognition a (really existing) negative pressure in the Einstein's model. Its numerical value is of course equal to this one of the cosmological constant. Some physical motivation of such pressure existence in the Universe will be proposed just at the end of the publication.

4. Friedmann's dynamical Universe

As it is known, in 1922 году A. Friedman proposed a non-stationary generalization of the Einstein's Universe model. He did not discuss a meaning and expediency of the cosmological constant, but showed that in the non-stationary model a solution exists even if one set the constant equal to zero. Einstein was very glad to know this information (after he firstly refused it), he "recalled" his own idea and declared it as "blunder".

However, we saw that the mistake did not consist in what Einstein did think about. And what about the Friedmann's model? Before all I would like to pay a reader's attention to the follow note in the review **[Bousso, 2007]**:

> "Today's cosmological constant was dynamically irrelevant in the early universe. This is one of the greatest difficulties in solving the cosmological constant problem, and it is frequently overlooked".

Indeed, the commonly accepted cosmological model that the parameters are essentially fitting (in order to coincide with astrophysical observations and measurements data) just ignore this fact. I believe, it is infeasible circumstance at all.

The main (but not unique) observable fact used to fit the common model is the low luminosity of Supernovae **Ia**. On this effect base one can calculate the quantitative value of Λ that seems to led the Universe expands with an acceleration in modern epoch. It is commonly accepted to believe that some "dark energy" (about 70% of total matter density) creates an "anti-gravitation" (see **[Chernin, 2008]**).

Here one again talks about anti-gravitational force that I considers as delusion (see the Appendix). Seemingly, it origins from a hypothesis that modern epoch is "specific" one and based on the existing a non-zero cosmological constant, in spite of a possibility to completely explain the low Supernovae luminosity without this suggestion (see the paper "On the Supernovae low luminosity problem" on my web-site http://www.timeorigin21.narod.ru/eng_time).

I believe, one should keep the principle "*Pluralitas non est ponenda sine necessitate*"(Occam's edge). If one *recognizes* the *negative* pressure existence, then he can get the remarkable results that avoid a number of insuperable difficulties which appear in front of the modern cosmology. However, the way lies through one more fundamental "heresy" (of course it seems to be a such one at first sight only).

Is it well known that many commonly accepted statements are only consequences deduced from the source axioms – for example, the Euclidean geometry may be replaced by the non-Euclidean one if one refuses the Euclid's parallel lines axiom. Remember, this fact recognition was not easy for human community. Is also well known that energy conservation law is not axiom, it presents a consequence deduced from the time uniformity (the Nœther's theorem). However, as well as I know nobody debated accomplishment of this presupposition.

Meanwhile, the early Universe and the modern one present two very different configurations in which the physical laws correctness is very different too. It is enough to say here that the components of the fundamental metric tensor depend directly on the current Universe curvature. Because of that the motion laws in the early Universe (having an extreme curvature) and in the modern one (nearly flat) dramatically differ, hence, *time is not uniform*. The same conclusion follows from the common model with non-zero cosmological constant: the solution depends on time, however, the model does not provide any *external* entities.

So, the promised "heresy" consists in refusing to solve the Friedmann's equations using the energy conservation law as an additional condition, because the necessary premises of the Nœther's theorem are not explicitly accomplished. However, in order to solve these equations (where a pressure is not now a priori setting to zero, but is searching as a solution result) we need something in exchange for it. This will allow us to determine a Universe energy *evolution* law in time.

A remarkable new solution providing such evolution corresponds with a case when the Universe age is always *proportional* to its curvature radius (the velocity of light in vacuum presents an empirical coefficient of proportionality). This solution practically determines time itself as a general phenomenon due to the Universe expansion (or *any* another evolution type). The more, just this solution lead many consequences that perfectly correspond with actual astrophysical observations without any fitting a models having unnecessary free parameters. In addition, this solution is in very natural (logical) correspondence with known Schwarzschild's solution **[Tolman, 1969]** for a material uniform sphere and for its generalization for a finite (not infinitely small) collapsing material object.

5. What does proposed model give?

The new approach was formulated departing from purely theoretical base. However, it turned out very fruitful in order to solve a number of cosmological problems. Let me here list them very briefly.

The "cosmological constant" problem. Of course, this problem is eliminated by definition. Moreover, a connection between the Universe current size and the current (negative) matter pressure (i.e., mean gravitational force as such) becomes evident. Additionally, any ideas about vacuum energy zero-oscillations are avoided. This energy not only turns out 122 orders more than a needed one, but generally cannot be used for the Universe gravitational expansion or for anything, because of correspondence to the state with the minimal possible energy.

The Universe "horizon" problem. This problem in the commonly accepted cosmological model is linked with explanation of the Universe global spatial uniformity (the horizon moves away faster than the Universe expands). One usually explains the observable uniformity using the inflation hypothesis. Meanwhile, in our model the horizon moving away speed is exactly equal to the Universe expanding rate, so this problem is absent.

The problem of a variable rate of the Universe expansion. It is commonly accepted last years to think that observations point out to accelerated expansion of the Universe. Meanwhile, in the frame of the approach it is easy to get a wholly satisfactory quantitative explanation of the low Supernovae luminosity based on the *linear* in time model of the Universe expansion without any model fitting. Of course, any accelerated or decelerated expansion is impossible by definition.

The problem of the relict anisotropy. A background microwave radiation dipole anisotropy was discovered and surely confirmed in the second half of the 20^{th} century. Any common this phenomenon explanation is absent, however, it contradicts to the Relativity postulate on a selected reference frame absence.

Our model of the time physical origin that is due to the Universe expansion phenomena directly points out to the necessity of the Einstein representations generalization and to the just such "selected" reference frame existence. Moreover, the model predicts that the anisotropy exists for each (not only relict) electromagnetic radiation. For example, and it may be tested experimentally, such anisotropy has to exist for the Sun light coming to Earth at the different phases of its orbital moving around Sun, or for any radiation from the monochrome source wich should be differently oriented relative to the anisotropy "axis".

Additionally, the anisotropy is also specified by higher-order multipole values. If the Universe was infinite, then we reached the significantly large values than the real quadrupole and octupole values that WMAP found. Remember, that in our model the Universe is suggested being finite, although the matter density is equal to the critical value.

Also, there is an interesting peak at the multipole number 4 as well on the temperature correlation spectrum as on the cross-correlation specrum between the temperature and the so called polarization E-mode of CMBR. The typical models cannot explain satisfactory this phenomenon. However, my approach just predicts such peak and explains it using the oldest photons existence which made a full world tour around the Universe. Now they arrive at the angle near 40°.

The Universe origin problem. The Friedmann's cosmology could not say something about the Universe origin. Contrary, our approach allows examine this problem. Briefly, our Universe expansion can be interpreted as an process in a *black hole* of some "mother Universe". The daughter Universe expansion (extension) just generates the negative pressure effect and can be considered as a matter "retraction" from the "mother Universe". So, we can suggest that if the Universe *compressed*, then the Newtonian attraction was replaced by the anti-gravitation.

On the Universe "flatness" problem. The observations say that the total mean Universe density is practically equal to the *critical* density value. From this using Friedmann's model one deduce that in our epoch the Universe is *flat*. However, the new approach leads to the differ conclusion: the Universe metrics has always the positive curvature that is always equal to the critical density *multiplied by two*. Such discrepancy of astrophysical data is bad for our model, but may be explained by someway in future.

Appendix

On a common delusion

The following fact may seem to be paradoxical. As it is known, since 1930's a classical version of the relativistic motion equation is in use in the scientific literature. It can be deduced for the *external* bound layer of a spherical cloud having a radius $\boldsymbol{R}$, if the particles of that cloud fly away with the velocities corresponding to the Hubble law, and a relativity amendment is added "by hands" to the density $\boldsymbol{\rho}$ (one says, the pressure $\boldsymbol{P}$ has a "weight"):

$$(d^2\boldsymbol{R}/dt^2) = - (4\pi G\boldsymbol{R}/3)(\boldsymbol{\rho} + 3\boldsymbol{P}/c^2)$$

In this case the equation left side just presents an external layer particle acceleration. So, *an attraction* gravitational force (due to $\boldsymbol{\rho}$) and a repulsion *positive pressure* ($\boldsymbol{P}$) should act in the same direction, but it is *impossible*. In practice one tries to overcome the appearing difficulty by *setting* a pressure to zero and introducing the positive cosmological constant. But this one is equivalent to a negative pressure, so it is like "scavenging under a carpet", as Feynman said. Also we have got the unsolvable vacuum energy problem; the calculated energy value is 120 orders more than the observable one!

In fact, this classical model is as well contradictory as unequal to realm. Particularly, "the Hubble velocity" in it has to be different for a particle of a different internal layer of the sphere, while at the real Universe expansion the Hubble phenomenon is the same anywhere. This model leads also other paradoxes.

The true General Relativity evolution equation having fictive similarity only with above motion equation is (the cosmological constant is omitted):

$$(d^2\boldsymbol{a}/dt^2) = - (4\pi G\boldsymbol{a}/3)(\boldsymbol{\rho} + 3\boldsymbol{P}/c^2)$$

Here $\boldsymbol{a}$ is not an arbitrary radius $\boldsymbol{R}$ of a sphere in one's mind, it is a *global* scale factor (the curvature radius) for the Universe *as a whole*. Because of that the left side of the relativistic motion equation should be considered not as *3D* acceleration of a particle, but as a derivative of the Universe 4D evolution rate. So, there is no any reason to refuse a possibility that positive $\boldsymbol{\rho}$'s and $\boldsymbol{P}$'s influence can have the same sign. Additionally, in this case the Hubble law is a *sequence* of that equation, not its premise.

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