# On historical aspect of The Big Bang cosmological model appearance

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*We attempt the historical analysis of the reasons of appearance of The Big Bang standard cosmological model that describes the expanding Universe but is built on the metric tensor of the stationary Universe with permanent space curvature.*

*We conclude that at the foundation of the existing paradoxical situation there are two mistakes made by Einstein and Friedmann in 1922-1925.*

## 1. Introduction

Building a cosmological model begins with choosing the coordinates (metrics) that are described by the expression for the infinitely small movement in 4-dimensional space-time (interval). This expression contains the coefficients at every of the spatial variables and variable of time, that are the components of the 4-dimensional metric tensor.

In the basis of cosmological model, describing the homogenous isotropic Universe lies the expression of the metrics, corresponding to the equally curved space. It was first obtained by Einstein in 1917 [1] by introducing the imaginary $4^{th}$ spatial coordinate and its further exclusion, expressing via the radius of space curvature.

This mathematical formalism that allows to describe the curvature of the 3-dimensional space by the gravitational field, was introduced by Einstein when studying the stationary Universe. That is why when deducing the expression for the metrics, the differential of the excluded $4^{th}$ spatial coordinate is expressed in Einstein's article through differentials of other three spatial coordinates but not through the space curvature radius differential da, which in stationary Universe a = const, is equal to zero. At that the component of the metric tensor at time variable (in modern [2] terms $g_{00}$) is a constant value and is accepted as equal to one

$$g_{00} = 1. \qquad (1)$$

In the non-stationary Universe, we cannot consider the differential of the space curvature radius to be equal to zero. It is not difficult to show [3], that in this case the absent in the stationary Universe member with da is added to the expression for the metrics, and the expression for the time component of the metric tensor gets the value

$$g_{00} = (1-a'^2); \qquad (2)$$

where a' = da/cdt.

However the standard cosmological model, describing the expanding Universe, that appeared as a result of a catastrophic event (The Big Bang), is built on the same metric tensor that was obtained by Einstein in 1917 [2] for the stationary Universe with the value of $g_{00}= 1$.

The described situation appears to be paradoxical. In this work, we try to reconstruct the story of its appearance based on the existing literature.

## 2. The choice of the metrics in the initial works of Friedmann

The possibility to describe by Einstein's equations the non-stationary, changing in time world, was first shown in the works of the Russian physicist Alexander Friedmann. In 1922 Friedmann's work "On space curvature" [4] was published, where he, basing on the published in 1916-1917 works by Einstein [1] and de Sitter, analyses the possibility to describe the world with curvature changing in time.

Starting this analysis from metrics definition, Friedmann writes: *"Let us address now to the study of another possible world – the non-stationary one. In this case M is a function only of $x_4$; changing $x_4$ accordingly we can put M = 1 with no limit"* (here M ≡ $g_{00}$; $x_4$ – time coordinate).

More specifically Friedmann points out the reason to choose M = 1 in his next work [5], dedicated to the possibility of non-stationary world with negative curve of the space: *"... assured that in the studied case M is the function only $x_4$; so, it is possible, without violating the entity, put M = 1 (for this we only need to introduce instead of $x_4$ the coordinate $x_4' = \varphi(x_4)$)"*.

This way the value of the time component of the metric tensor equal to 1, was chosen by Friedmann solely for the purpose of comfort with pointing out the possibility to redefine the time coordinate.

## 3. Discussion of Einstein and Friedmann

Friedmann's article "On space curvature" [4] was published in the $10^{th}$ issue of "Zeitschrift fьr Physik" magazine. In the next, $11^{th}$ issue of this magazine a short note by Einstein "Comments on Friedmann's work "On space curvature" [6] was published.

The content of this note is so laconic that we have a chance to publish it fully: *"The results in relation to the non-stationary world that are published in this work seem suspicious to me. In reality, it appears that the solution in this work does not satisfy the field equation (A). As it is known, it follows from these equations that the divergence of the matter tensor $T_{ik}$ converts into zero. In the case characterized by the assumptions (C) and ($D_3$), it leads to the correlation $\partial\rho/\partial x_4 = 0$, which together with equation (8) requires constancy of the world radius in time. Therefore, the meaning of this work is to prove this constancy"*.

In December 1922, Friedmann wrote to Einstein [7] a letter that pointed out the mistake he made when obtaining the expression given in the note. We will quote several fragments:

*"Dearest professor! From the letter of one of my friends who's being abroad right now, I had an honor to learn that you added to the $11^{th}$ volume of "Zeitschrift fьr Physik" a small note where it says that if we accept the assumption ($D_3$) and (C) in my article "On space curvature", then from the universal equations obtained by you it should have followed that the curvature radius of the world is the value that does not depend on the time. ... If we put Q4 equal to zero, as it follows from your universal equations, we will obtain not the expression that given by you in your article, but another expression $\partial\sqrt{g}\,\rho/\partial x_4 = 0$. ... In case if you consider my calculations correct I ask you to do me a favor and inform the editorial office of "Zeitschrift fьr Physik" about it ... Sincerely respecting you,*

*Yours A. Friedmann. December 6, 1922, Petrograd"*.

In May 1923 the editorial office of «Zeitschrift fьr Physik» magazine received Einstein's note "On A. Friedmann's work "On space curvature" [8], that we publish fully as it is quite laconic:

*"In the previous note I criticized the work mentioned above. But my critique as I was convinced by Friedmann's letter, translated to me by Mister Krutkov, was based on a calculation mistake. I consider Mister Friedmann's results correct and shedding fresh light. It appears that the field equations allow, along with static, also the dynamic (i.e. variable in relation to time) centrally symmetric solutions for the structure of space".*

### 4. Einstein on cosmology after Friedmann

In 1925 Friedmann, after getting back from his honeymoon in Crimea, died in Leningrad of typhoid. He himself supposed that he got typhoid when ate an unwashed pear bought on one of the railroad stations on the way from Crimea to Leningrad [9].

In 1927–1929 in the works of G. Lemaitre and E. Hubble, the astronomic data on red shifts of the galaxies appeared which confirmed the expansion of the Universe.

Because of this astronomic data that brings the discussion about the Universe history to the new level, Einstein wrote in his work "On the cosmological problem of the general relativity theory", published in 1931 [10]:

*"But after it was clear from Hubble's results that extragalactic nebulae are spread in the space equally and that they disperse (at least if their systematic red shifts are explained by the Doppler Effect), the assumption (2) about the static nature of the space is not justified and a question appears – if the general relativity theory can explain these results.*

*Different researchers tried to relate new facts to the spherical space which radius P depends on time. The first one on this path, with no dependence on the observed facts, was Friedmann, in the following argument I will use the results of his calculations".*

Further Einstein addresses to the Friedmann's results again. In his work "On cosmological problem" [11], when describing the attempt to introduce the cosmological constant Λ to his cosmological equations, he writes:

*"Introduction of this additional member complicated the theory and, thus, harmed its logical simplicity. ... Russian mathematician Friedmann found the solution of this dilemma. His result then received the unexpected confirmation in the celestial system expansion discovered by Hubble (red shift of the spectral lines that grows linearly with the distance). The following narrative is nothing else then the narrative of Friedmann's ideas".*

### 5. Metrics influencing the history of the Universe

As we know, the general relativity theory that lies in the basis of all the cosmological models has in its heart the principle: *"The common laws of nature must be expressed via the equations that are true in all the coordinates"* [12]. However, it does not mean that the sense and the values of the variables within them are the same in all the coordinates.

The metric tensors that outstand by the re-definition of the time coordinate can be considered equivalent only until the moment when we want to show the dynamics of the Universe development and define the steps of its development in specific time units, which is what cosmology does. The existence of the metrics with time re-definition immediately raises a question – in which of them the "t" symbol is time and in which it is the function of time?

In Friedmann's articles, when there was no data on the expansion of the Universe, the question about value of $g_{00}$ (in Friedmann's terms M) had purely academic meaning. It was comfortable and natural to accept it as equal to one, as in the initial work of Einstein (mentioning the possibility of redefinition at that!).

But when the task came to the next level, when the numeric data about Universe expansion appeared and the necessity of numeric calculations came up, Friedmann, unfortunately, could not do it anymore.

### 6. Conclusion

As a result of the retrospective journey we made into the works that lie in the basis of The Big Bang cosmological model, we can make a conclusion that there are two mistakes in the very foundation of this theoretical model made by Einstein and Friedmann in 1922-1925.

First of them – the mathematical mistake of Einstein at first reading of Friedmann's work, that, after the correction thanks to Friedmann's letter, allowed Einstein to fully rely on Friedmann's conclusions when exploring the cosmology problems further.

The second – the hygienic mistake of Friedmann who ate a pear infected with typhoid and died before the actual expansion of the Universe was discovered, so he could not apply practically the possibility (and the necessity) to re-define the variable of time.

It lead to the paradoxical situation – a cosmological model of the expanding Universe built on the metrics that corresponds to the zero value of the space curvature radius differential da = 0, i.e. stationary Universe.

Taking into account the non-zero value of da and building the Universe model on the basis of the metrics with $g_{00}$ = (1-a'[2]) leads to the cosmological model describing the Universe closed at any matter density, not requiring introduction of the additional non-observatory substances (cosmological constant or dark energy), infinite in time and expanding in accelerated manner at the current development stage [3]. The slower expansion dynamics solves a range of problems of the standard cosmological model and opens the possibility to describe the observed astronomic phenomena [13],[14], not described by The Big Bang model.

### References:

1. Albert Einstein. Cosmology issues and general relativity theory. Russian edition. *(Kosmologishe Betrachungen zur allgemeinen Relativitatstheorie. Sutzungsher preuss. Akad. Wiss., 1917, 1, 142-152).*

2. Landau L.D., Lifshitz E.M. Course of Theoretical Physics: The Classical Theory of Fields. Vol.2.

3. Iurii Kudriavtcev. On inner contradiction in the metric tensor of the standard cosmological model. / Physical Interpretation of Relativity Theory: Proceedings of International Meeting. Moscow,4-7 July 2011 / Ed. By M.C. Duffy, V.O. Gladyshev, A.N. Morozov, P. Rowlands. - Moscow: BMSTU, 2012. p.178-185.

4. Friedmann A.A. On space curvature. Russian edition. (*A. Friedmann. Ьber die Krьmmung des Raumes. Z. Phys., 1922, 10, 377-386.).*

5. Friedmann A.A. On the possibility of the world with constant negative curvature. Russian edition. *(A. Friedmann. Ьber mцglichkeit einer Welt mit konstanter negativer Kгьmmung des Raumes. Z. Phys., 1924, 21, 326-332.)*
6. Albert Einstein. A note to Friedmann's work "On space curvature". Russian edition. *(A. Einstein. Bemerkung zu der Arbeit von A. Friedmannn. «Ьber die Kгьmmung des Raumes». Z. Phys., 1922, 11, 326. )*
7. Frenkel V.Y. New materials on the discussion of Einstein and Friedmann on relativistic cosmology. Einstein collection, 1973.
8. Albert Einstein. On Friedmann's work "On space curvature" Russian edition. *(A. Einstein. Notis zu der Bemerkung zu der Arbeit von A. Friedmannn. «Ьber die Kгьmmung des Raumes». Z. Phys., 1923, 16, 228. )*
9. Frenkel V.Y. Alexander Friedmann: biographic essay. 1988.
10. Albert Einstein. On cosmologic problem of the general relativity theory. Russian edition. *(A. Einstein. Zum kosmologischen Problem der allgemeinen Relativitдtstheorie. Sitzungsber. preuss. Akad. Wiss., phys.-math. KL., 1931, 235-237. )*
11. Albert Einstein. On the «Cosmologic Problem». The Meaning of Relativity, 2 nd Edition, Princeton, 1945.
12. Albert Einstein. Basics of the general relativity theory. Russian edition. *(Die Grundlage der allgemeinen Relativitдtstheorie. Ann. Phys., 1916, 49, 769-822).*
13. Iurii Kudriavtcev. Some elementary questions on consistency or inconsistency of the standard cosmological model / Physical Interpretation of Relativity Theory: Proceedings of International Meeting. Moscow,1-4 July, 2013 / Ed. By M.C. Duffy, V.O. Gladyshev, A.N. Morozov, V. Pustovoit, P. Rowlands. - Moscow: BMSTU, 2013. p.189-197.
(http://www.space-lab.ru/files/news/contents_PIRT_13/text/contents_PIRT_13.pdf ).
14. Kudriavtcev Iu. Correlation of the angular distributions of the antisymmetrical component of the microwave backgrounds temperature deviation and the redshifts of quasars // Physical Interpretation of Relativity Theory: Proceedings of International Meeting. Bauman Moscow State Technical University, Moscow, 29 June–02 July, 2015. – Moscow : BMSTU, 2015. Pp 248-265.
(http://www.pirt.info/scopus/all-issues/2015/articles/Kudriavtcev1.pdf ).