Nearly forgotten results in development of physical cosmology

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November 15, 2025

PACS: 01.65.+g, 04.20.Cv, 04.20.Fy, 04.20.-q, 95.30.Sf, 98.80.-k, 98.70.Vc

1 Introduction

General Relativity (GR) was created after intensive conversations between A. Einstein and D. Hilbert in November 1915 [?, ?, ?]. Using his new theory of gravity in November 1915 A. Einstein explained the problem of the anomaly of Mercury's motion, discovered in the middle of the 19th century by Le Verrier and remained unexplained for several decades, and also considered the problem of deflecting a ray of light in a gravitational field, and it turned out that the angle of deviation in general relativity exceeds the angle of deviation in the Newtonian theory of gravity by two times [?] (see, English translation in [?]).

In 1917 A. Einstein found a static cosmological solution assuming that the Universe is homogeneous and isotropic [?] (see English translation in [?]). However, the assumptions adopted in the first cosmological paper were very useful and despite the fact that assumptions about the homogeinity and isotropy of the universe do not look very plausible, such assumptions turn out to be applicable to the theoretical description of astronomical observations and are still used in a large number of works on cosmology and are often called the cosmological principle. To create a static cosmological solution and to compensate gravitational attraction A. Einstein introduced so-called $\Lambda-$ term which corresponds to repulsion. In many textbooks and articles the authors repeated after G. Gamow that "he [A. Einstein] remarked that the introduction of the cosmological term was the biggest blunder he ever made in his life" [?] (see also a similar sentence in a popular article [?])). However, taking into account Gamow's personality, in particular, his predilection

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for jokes and practical jokes, and the different social status of Gamow and Einstein, it seems very strange that Einstein chose Gamow as an interlocutor to whom Einstein would admit to the biggest blunder of his entire life (see also discussions in [?, ?]). More over, in 1998 it was discovered an accelerated expansion of the Universe and in order to explain this phenomenon, it is necessary to introduce a non-zero value of the lambda term (or some generalization of it, which since 1999 has been called dark energy) into the Einstein equations.

When discussing Einstein's static cosmological model, it should be noted that it is hardly applicable to describe the behavior of the universe because as a famous Russian mathematician V. I. Arnold repeated only stable mathematical solutions exist in physical world. Analyzing properties of the static cosmological model in 1930 A. Eddington "working in conjunction with Mr. G. C. McVittie" proved that the Einstein's static cosmological solution is unstable [?].

2 Start of GR studies in Russia

In the early 20th century, despite significant achievements in some areas of physical science development in Russia, world leaders in physics worked in Europe. Young Russians who wanted to acquire scientific skills at the cutting edge came to Europe for training and internship. One of these young people interested in science was a representative of the elite of the Russian empire (his father and grandfather were governors in Russian empire), Vsevolod Konstantinovich Frederiks (13.04.1885 (Warsaw) — 06.01.1944 (Gorky)). He played a key role in initiating research in Russia in the field of GR [?, ?]. In 1903 Vsevolod Frederiks finished gymnasium in Nizhnij Novgorod and decided to go to Switzerland due to its convenient location to visit other European countries. In 1907 he finished Geneva University with specialisation in physics and in 1909 he got PhD degree in physics under supervision professor G. E. Guye (Geneve). Since 1911 Frederiks was an assistant under professor Woldemar Voigt[1] at the Theoretical division of Physics Institute at Göttingen. In 1914 the WWI began and Frederiks started to be a civil prisoner since he was a citizen of an enemy country. In 1910s famous mathematician David Hilbert was very interested in physics he was searching for educated physicist to discuss actual physical issues. Frederiks began working as Hilbert's personal assistant, and Hilbert paid Frederiks a monetary reward from his personal funds. The management of the University of Göttingen did not approve this practice to contact with representative of an ebemt country in University and refused to allow Fredericks to enter the University in response to Hilbert's appeal. In 1918 Frederiks came back in Russia and for a short period he worked in Institute

[1]In 1887 W. Voigt found transformations which were similar to Lorentz ones [?]. In addition, Voigt described group properties of his transformations as it was noted by H. Minkowski in his famous lecture delivered in 1908 [?] (see also discussions about a relation between Voigt and Lorentz transformations in [?, ?, ?, ?]).

of Physics and Biophysics in Moscow. In 1919 he moved to Petrograd and was a senior physicist at State Optical Institute, a member of Atomic commission, associate professor in Petrograd State University, professor in Pedagogical Institute, in 1920 he was a lecturer at Polytechnic Institute. In 1921 Frederiks published the first review on general relativity (GR) in Soviet Physics Uspekhi which was a leading physical journal in Russia [?]. In 1923 Frederiks was a senior physicist in Institute of Physics and Technology, the Institute was founded by A. F. Ioffe in 1918 and in 1924 it was named the Leningrad Institute of Physics and Technology (LIPT) or shortly the Ioffe Institute. V. K. Frederiks and A. A. Friedmann[2] decided to wrote joint book on foundations of GR but in 1924 it was published only the first chapter of the book where tensor calculus was discussed (this project to write a joint book was not realized due to the untimely death of A. A. Friedmann). In Autumn 1927 Frederiks married Maria Dmitrievna Shostakovich (a sister of composer D. D. Shostakovich). In 1931 Frederiks was appointed as the Head of the Crystallization Laboratory in LPTI and in 1933 started to be the Head of anisotropic liquid Laboratory in LPTI. Frederiks studies in liquid crystal field were rather successful, in particular in 1927 V. Frederiks and A. Repiewa discovered the phase transition in liquid crystals under action of magnetic field. Now this property of liquid crystals is used in operation LC screens in different devices and it is called now the Frederiks transition [?]. In 1934 Frederiks got DSc degree without a formal defense, he was nominated by the LPTI Scientific Council as a candidate for corresponding member of Soviet Academy of Science but he was not elected. Due to very rapid development of contemporary physics in 1920s and 1930s it was necessary to write new books and V. K. Frederiks was the co-editor with A. . Afanasiev of Course on General Physics (I. K. Kikoin, Yu. B. Khariton were among authors of chapters in the book). Later, the textbook was republished where only A. . Afanasiev was indicated since Frederiks was in detention at this time. On October 20, 1936 V. K. Frederiks (among many other Leningrad scientists) was arrested as a defendant in the Pulkovo case. On May 23, 1937 Frederiks sentenced to 10 years in prison camps (Taishetlag). On January 6, 1944 Frederiks died. Only in 1957 his relatives got an official document on his death, where is the dash was written in the place of death. Lydia Chukovskaya (whose

[2]British expert in astronomy and history of science S. Mitton noted [?]: "There are three ways to spell his surname: Fridman, Friedmann, and Friedman... Friedmann is the most common version in use today, largely in connection with cosmology. I [S. Mitton] use Friedman when referring to his publications because that is the version he used as author. A Bolshevik Government Decree issued 1917 December 23 eliminated double letters in Russian orthography. Typographers were required to enforce the reforms. The contemporary Russian literature invariably uses Friedman." I [AZ] basically use Friedmann in the paper since this spelling was used in a majority of articles and books that I read before writing the paper including English translation of the remarkable book [?] written by the best experts in history of Russian cosmology.

husband Matvey Bronstein[3] was an another Pulkovo case defendant) received a similar document concerning a time and a place of the Bronstein death.

3 A. A. Friedmann and dawn of physical cosmology

There's no doubt that Friedmann's cosmological work laid the foundations of physical cosmology and is a source of pride for Russian and international science [?, ?]. For Friedmann's centenary, which was celebrated in June 1988, a scientific biography was written [?] (this remarkable book was translated into English in 1993). In the book the authors wrote, "He [Friedmann] discards a centuries-old tradition, which a priori, prior to all experience, considered the Universe eternal and forever motionless. He is making a real scientific revolution. Just as Copernicus forced the Earth to revolve around the Sun, so Friedmann forced the Universe to expand". In the days of the Baldin seminar we celebrated a memory of this remarkable scientist. Alexander Alexandrovich Friedmann (Friedman) was born on 4(16).06.1888 in Sankt-Peterburg (SPb) and died on 16.09.1925 in Leningrad (Sankt-Peterburg (1703 – 1914), Petrograd (1914 – 1924), Leningrad (1924 – 1991), Sankt-Peterburg (1991 – till now)). In 1897 - 1906 Alexander Friedmann was a student at the Second SPb gymnasium, in 1905 he wrote the first mathematical paper (published in 1907). In 1906 - 1910 he was student at mathematical division of the faculty of physics and mathematics. In 1910 - 1913 he left in SPb University for a preparation for a professor position. In 1914 – 1916 Friedmann joined the Russian army as a volunteer, he served in aviation units. In 1918 – 1920 he was a professor of mechanics department of Perm University. In 1920 – 1924 he was a researcher at Atomic Commission in State Optical Institute. In 1920 – 1924 he was a professor at the Faculty of Physics and Mechanics of Petrograd Polytechnic Institute In 1920 – 1925 Friedmann was a senior physicist, head of mathematical bureau, scientific secretary and since February 1925 director of Main Geophysical Observatory In 1922 Friedmann published his first cosmological paper [?] (English translation of the paper was published in [?]). Soon after that Einstein published a short comment [?] (consisting a few sentences and one expression) where he claimed:"The results of the work on the non-stationary world contained in the mentioned work seem suspicious to me. In fact, it turns out that the solution indicated in it does not satisfy the field equations."[4] Friedmann was extremely disappointed by this

[3] M. Bronstein was one of the leaders of Soviet theoretical physics [?] and he was among the pioneers in quantum gravity research [?] (in the quoted paper C. Rovelli noted that an introduction of the graviton concept proposed by D. I. Blokhintsev and F. M. Galperin in 1934 was an important initial step in development of quantum gravity).

[4] A Russian translation of the comment published in the special issue of Soviet Physics – Uspekhi dedicated to the 75th anniversary of Friedmann `https://ufn.ru/ufn63/ufn63_7/Russian/r637g.pdf`.

opinion of the GR creator. Friedmann consulted with Petrograd mathematicians and sent a lengthy letter to Einstein where Friedmann presented formulas confirming his conclusions. At the end of his letter Friedmann requested Einstein [?] "...Should you find the calculations presented in my letter correct, please be so kind as to inform the editors of the Zeitschrift fur Physik about it; perhaps in this case you will publish a correction to your statement or provide an opportunity for a portion of this letter to be printed." In 1923, Petrograd theorist Yuri Krutkov was going to Germany on a scientific visit. Friedmann discussed the essence of his arguments with Krutkov in the letter to Einstein and requested Krutkov to meet with Einstein and convince him that Friedmann was right. Krutkov met Einstein at Paul Ehrenfest house (both Krutkov and Einstein were Ehrenfest's good friends) and Krutkov convinced Einstein that Friedmann was right. After that Einstein wrote a short note where he mentioned that "My criticism, as I saw from Friedmann's letter, communicated to me by Mr. Krutkov, was based on an error in calculations. I consider Friedman's results to be correct and shed new light..." [?][5] In 1923 Friedmann published his book "World as space and time" (it was the first popular presentation of GR in Russia). The cover page of the book is presented in Fig. 1.

Figure 1: Cover page of the first Russian book on GR.

In 1924 Friedmann published his second cosmological paper, where the negative curvature case for the cosmological solution was considered [?] (English traslation of the paper was published in General Relativity and Gravitation [?]).[6] Friedmann and Frederiks planned to write voluminous book "Foundations of relativity

[5]Russian translation of the Einstein note published in `https://ufn.ru/ufn63/ufn63_7/Russian/r637h.pdf`.

[6]According to Fock's memoirs, he suggested Friedmann to consider this case when Fock translated the first cosmological Friedmann's paper into German.

theory" for Russian readers but the authors wrote only the first chapter "Tensor calculus" which was published in 1924 and the project was not finished due to Friedmann's untimely death. Investigations of atmosphere turbulence were among main Friedmann's interests and in July 1925 he and P. F. Fedoseenko[7] made a record-breaking balloon ascent (flight at 7400 m) where the flyers did medical experiments and measurements of atmosphere properties at different heights. After the flight Fedoseenko and Friedmann wrote their reports on the flight. In July – August 1925 Alexander Friedmann and his wife (N. E. Malinina – Friedmann) relaxed at the Crimea cost. On August 17, 1925 Alexander Friedmann came back to Leningrad, while his wife went to another town where she was supposed to work at the geomagnetic station. Perhaps, in his last train trip Friedmann was infected by a typhus since he ate dirty fruits. According to Friedmann himself, he probably got infected by eating an unwashed pear bought at one of the railway stations on the way from Crimea to Leningrad. Suddenly (on September 2) he felt sick. On September 16, 1925 Friedmann died in hospital (in days of the Baldin Seminar scientific community the gravitational community remembered this remarkable man and his works on cosmology, in which it was firstly discovered that the universe can expand). He was buried at the Smolensk Orthodox Cemetery in Leningrad (his tomb is presented in Fig. 2). As we discuss below models of evolving Universe were practically banned in USSR in 1933 – 1963 since the birth of the Universe may be easily associated with the Genesis in Bible text (we will discuss the issue below in the Chapter on Lemaître studies). In connection with the 75th anniversary of the birth of A. Friedmann, the Soviet authorities lifted the tacit ban on mentioning Friedmann's cosmological works, and in June 1963, the physical-mathematical division of the Academy of Sciences organized a special session dedicated to his memory. At his introductory speech P. L. Kapitsa said at the session in June 1963 [?]:"Friedmann's name has so far been undeservedly forgotten. This is unfair and it needs to be fixed. We must perpetuate this name. After all, Friedmann is one of the pioneers of Soviet physics, a scientist who made a great contribution to domestic and world science." Soon after the session in July 1963 Soviet Physics Uspekhi published a special issue with articles of outstanding scientists on subjects which were connected with Friedman's scientific interests. In his short note about a genesis of GR studies in Russia V.A. Fock wrote [?]: "Alexander Alexandrovich Friedmann and Vsevolod Konstantinovich Frederiks were professors of Petrograd University (now Leningrad University) and they were the first scientists who started to teach Russian physicists (working in Petrograd) GR...Main speakers were V.K. Frederiks and A.A. Friedmann. Styles of their talks were rather different. Frederiks clearly understood physical aspects of theory and disliked to show mathematical calculations, while Friedmann placed emphasis on mathematics but not on physics. He aimed at mathematical rigor and paid attention to complete and precise formulations of initial assumptions. Dis-

[7]Pavel Fedoseenko was the Osoaviakhim-1 captain and died in the balloon crash on January 30, 1934.

Figure 2: The Friedmann's tomb at the Smolensky Cemetery in St. Petersburg. The photo was taken in October 2025.

cussions between Frederiks and Friedmann were very interesting." At the session in 1963 it was decided to publish selected works of Friedmann as an academic publication edition [?] (it was very convenient for Soviet researchers and students to read Russian translations of fundamental Friedmann's papers instead of difficult-to-access original articles written in German). In June 1988 Soviet Academy of Sciences organized a big international Friedmann seminar in Leningrad to celebrate the 100th anniversary of his birth.

4 G. Lemaître , the Hubble law and the Big Bang concept

Georges Henri Joseph Édouard Lemaître (17 July 1894 – 20 June 1966) was a Belgian Catholic priest who made major contributions to cosmology.[8] G. Lemaître

[8] Lemaître was born in Charleroi, Belgium approximately 20 year before WWI. In 1911, Lemaître started to study engineering at the Catholic University of Louvain. In 1914, after the outbreak of World War I, Lemaître interrupted his studies and he entered the Belgian army as a volunteer. After the war, Lemaître abandoned engineering for the study of physics and mathematics. In the 1920s, Lemaître got scholarship and spent a few years in the USA, studied in Harvard and worked at the Harvard Observatory. In 1925 he came back to Belgium became a part-time lecturer at the Catholic University of Louvain. After a defence of his PhD thesis in MIT in 1927 he got a ordinary professor position in Louvain. Lemaître personally knew Vesto Slipher (for instance, it is known that he visited Slipher in Arizona and Hubble at Mount Wilson in the summer of 1925 [?]). Slipher analyzed Doppler spectral shifts and found that distant nebulae are preferably moving from us [?]. E. Hubble used Slipher's data on velocities of distant nebulae, and now some historians of science proposed to rename the Hubble constant [?]. Interesting details on Lemaître's life

played an exclusive role in a development of cosmological studies. As a recognition of his achievements at the Symposium devoted to 50 years since the introduction of the *Primeval Atom* concept an outstanding cosmologist James Peebles (he got Nobel prize in physics in 2019) wrote [?]: "Physical scientists have a healthy attitude toward the history of their subject: by and large we ignore it. But it is good to pause now and then and consider the careers of those who through a combination of the right talent at the propitious time have had an exceptional influence on the progress of science. As I have noted on several occasions it seems to me that Georges Lemaître played a unique and remarkable role in setting out the program of research we now call physical cosmology". Similar Friedmann's results were obtained independently by Belgian Abbe George Lemaître, where a derivation of the law which describes velocities of distant objects as dependence on distances toward them was observationally discovered by E. Hubble, and later this law began to bear his name. While Friedmann was a skillful mathematician and he did not speculate about astronomical applications of his results, Lemaître had a deep knowledge in astronomy and always think about an opportunity to test theoretical laws with astronomical observations. So, in 1927 Lemaître published paper [?] in obscure Belgium journal where the expanding Universe solution of the Einstein equations and he analytically derived a relation between distance and velocity of distant galaxies (now it is called Hubble – Lemaître law). He obtained about 575 km/sec/Mpc [?, ?], not very different from Hubble's ultimate value. From 24 to 29 October 1927, the 5th Solvay Congress on physics in Brussels was organized and Einstein participated at this activity. The main topic was "Electrons and Photons" or in other words, discussion of main quantum mechanics laws which were discovered in 1925. H. Lorentz was the chair of the Congress (he was also the chair at the four previous Solvay Congresses on physics). Lemaître was not invited to those discussions since he was not famous as other participants of the Congress,[9] however, Louvain is only 20 km from the Belgium capital. Lemaître went to the Congress venue and during the Congress breaks Lemaître had conversations with Einstein about his cosmological solutions published in 1927. Einstein commented favourably the Lemaître's mathematical skills but he rejected an expanding Universe concept. "Your calculations are correct, but your physical insight is abominable," concluded Einstein [?]. Einstein also directed Lemaître's attention at the Friedmann's cosmological studies. In spite of Einstein's skepticism in respect to models of expanding Universe, Lemaître continued to work on interpretation since he knew Slipher's results that majority of distant galaxies have redshifts [?, ?], it means that most galaxies are moving away from us. Using Cepheid variable stars (who are giant stars where there is dependence between their luminosities and

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and scientific investigations are given in [?].

[9]Participants of the Vth Solvay Congress in physics are presented in `https://en.wikipedia.org/wiki/Solvay_Conference#/media/File:Solvay_conference_1927.jpg`. As the History Insider noted it is "The Most Intelligent Photo Ever Taken" since 17 Nobel Prize Winners are presented at this photo.

periods) E. Hubble found a linear dependence between velocities of extragalactic sources and distances toward them [?], or in other words, $V = HR$, where V is a velocity of extragalactic source, R is a distance toward a chosen galaxy, H is a constant, which is called now the Hubble constant (in this paper Hubble estimated the constant as 500 (km/s)/Mpc.[10] Currently, astronomers estimate this constant and get a value about an order of magnitude smaller, which is very unusual for physical constants, and the main problem and inaccuracies are related to measuring distances.

As it was noted earlier, in 1930 Eddington proved that static cosmological solution proposed by Einstein is unstable and at the Meeting of Royal Astronomical Society on January 10, de Sitter expressed doubts in respect to Einstein's model of static Universe taking into account Hubble's results and at Meeting it was declared that it is necessary to search for non-stationary cosmological solutions and it was published about these ideas in February Issue of Observatory Journal. Usually Lemaître read the journal (in particular, this February issue) and sent a letter to Eddington [?] where he informed that he solved the problem 3 years ago: "Dear Professor Eddington, I just read the February n° of the Observatory and your suggestion of investigating a nonstatistical intermediary solution between those of Einstein and de Sitter. I made these investigations two years ago. I consider a universe of curvature constant in space but increasing with time. And I emphasize the existence of a solution in which the motion of the nebulae is always a receding one..." Lemaître also attached copies of his paper [?] to the letter to Eddington. After reading the Lemaître's letter Eddington understood that the problem to find a suitable cosmological solution which is consistent with astronomical observations has been solved and he started immediately to promote this breakthrough [?]. In particular, in a review [?] on a Silberstein's book Eddington wrote "Three years ago a very substantial advance in this subject was made by Abbé G. Lemaître...it renders obsolete the contest between Einstein's and de Sitter's cosmogonies... We can now prove that Einstein's universe is unstable. The equilibrium having been disturbed, the universe will progress through a continuous series of intermediate states towards the limit represented by de Sitter's universe. By Lemaître's analysis the history of this progress can be studied; and the intermediate stages (one of which must represent the present state of the world) can be treated in detail." Eddington was sure that is was found the solution that described a behavior of the Universe and he wrote [?]: "We have recently

[10] It should be noted that the law of the linear dependence of velocity (or redshift) on distance was discovered by Hubble based on the motion of nearby galaxies that are not uniformly and isotropically located, as Lemaître assumed after Einstein, and before Hubble, he obtained an estimate of the proportionality parameter in this linear relationship, which is close in value to Hubble's estimates. Many years after the discovery of the Hubble-Lemaître law (since it was proposed and accepted to call this dependence in such a way at the IAU congress in 2018 in Vienna), J. Peebles wrote "This nearly homogeneous expansion is in striking contrast to the extremely clumpy space distribution" [?].

learnt mainly through the work of the that this spherical space is expanding rather rapidly." Eddington recommended to publish an English translation of Lemaître's paper [?] in Monthly Notices of the Royal Astronomical Society (MNRAS) and after that William Smart, the Editor of MNRAS and RAS Secretary sent a letter to Lemaître requesting him to submit an English translation of his 1927 paper and to propose to him to become a member of this Society [?]. In Smart's letter it was written that the translation should have not more than 72 paragraphs, and following Smart's recommendations Lemaître reduced an article length and deleted the piece of text where the quantity (which called now the Hubble constant) was evaluated from available observational data on redshifts of moving galaxies. Some authors declared that it was a free Lemaître's choice do not indicate in 1931 that in 1927 Lemaître discovered the law now named after Hubble [?] (since 2018 it is called the Hubble – Lemaître law) but other authors claimed that this decision was made under pressure from Smart [?] and for English speaking people Hubble had the absolute priority in discovering this law. In 1931 Lemaître translated his paper written in French [?] and published the English translation in MNRAS [?]. Also in 1931 Lemaître considered the birth of the Universe as a quantum physics phenomenon [?]. It was the first introduction of a hot cosmological model (which were called Big Bang following Hoyle's ironical cliche). Later, these Lemaître's ideas were transformed in the Primeval Atom hypothesis. It would interesting to note that Lemaître predicted a background radiation with a temperature around a few kelvins in his cosmological model of hot Universe. more precisely, in 1934 Lemaître wrote [?] "...if all the atoms of the stars were equally distributed through space there would be about one atom per cubic yard, or the total energy would be that of an equilibrium radiation at the temperature of liquid hydrogen.." (see also comments in [?]) Lemaître hoped that his cosmological approach may explain an origin of cosmic rays (at this time Robert Millikan was interested in the subject and he proposed cosmic rays as a term for high enrgy particles from space). At the end of 1932, Millikan invited Lemaître to visit Caltech. On January 11, 1933, Lemaître was invited to deliver a lecture at the Mount Wilson Observatory, where E. Hubble worked. A. Einstein followed this Lemaître's lecture. When journalists asked Einstein about his impression of Lemaître's cosmological model, Einstein replied, "This is the most beautiful and satisfactory explanation of creation to which I have ever listened!"[11]. After that journalist Dunkan Aikman published interview with Lemaître with the title "Lemaître follows two paths to truth: The famous scientist, who is also a priest, tells why he finds no conflict between science and religion". This article was extremely popular over the world. Because the theses that religion can open the way to truth, and that religion does not contradict science, were unacceptable to Soviet ideologists. They found a way out of this situation, just as it was later done for genetics and cybernetics. Soviet ideologists came to the conclusion that the approach to constructing cosmological

[11] D. Lambert, Einstein and Lemaître : Two friends, two cosmologies..., `https://inters.org/einstein-lemaitre`

models based on general relativity should be declared pseudoscientific, and the Soviet scientists who worked on this topic should be declared pseudoscientists and admirers of Western bourgeois science. Thus, a division occurred in cosmology: Western cosmology, which considered realistic dynamic models of the Universe, and Soviet cosmology, which asserted that the Universe is infinite in time and space. It was done in contradiction to a famous Chekhov's statement that there is no national science as there is no national table and Soviet ideologists declared that the Universe must be infinite in space and in time in contrast Friedmann – Lemaître point of view on the subject. Even if famous Soviet scientists considered non-stationary cosmological models describing expanding Universe in this case, they were rather strongly criticized by representatives of the Communist Party apparatus, and, unfortunately, some of the critics were quite good professionals in mathematics and physics and in spite of that they participated in actions on pressure on genuine science and its representatives. Let us consider one interesting case when Soviet scientific community decided to celebrate half-century since the creation of special relativity and the Division of Physics and Mathematics decided to organize a Session devoted to this event on November 30 – December 1, 1955. After the Session, on January 16, 1956 instructor of the Central Committee of the Communist Party of the Soviet Union (CC CPSU) A. S. Monin and the head of the Science Department of CC CPSU V. A. Kirillin sent a letter to the Presidium of the Soviet Academy of Sciences where they strongly criticized the Session where achievements of relativistic cosmology were discussed. The authors of the letter thought that the talks of E. M. Lifshits, Ya. B. Zeldovich, L. D. Landau and V. L. Ginzburg had significant disadvantages and were not criticized properly by the audience [**?**]. At the beginning of the letter, it was written, "...The program of the session, prepared by the Organizing Committee, which included Academicians Tamm and Landau, Corresponding Member of the USSR Academy of Sciences Ginzburg and Professor Lifshitz, was unsatisfactory, as it included reports by Academician Landau, Corresponding Member of the USSR Academy of Sciences Ginzburg and Professor Lifshitz, who do not work in the field of relativity theory and are known for their nihilistic attitude to the development of methodological issues of this theory". Time has passed, and now we know the importance of the criticized scientists for Soviet theoretical physics, and it is hard to believe that their colleagues criticized them genuinely, since both Monin and Kirillin later became great Soviet organizers of science and full academicians in the field of physics and its applications. Concerning E. M. Lifshits report at the session the letter authors wrote "This report is devoted to a review of research on relativistic cosmology. He was a significant advocate of the idealistic "theory of the expanding universe." *This "theory", which is an illegal extension of non-stationary solutions of Einstein's gravitational equations to the universe as a whole, was built by Abbé Lemaître on the direct order of the Pope* [the italic font in this phrase was chosen by AZ]. According to this "theory," the universe has a finite age; at the time of its formation, it occupied an infinitesimally small volume, and then began to expand; such an expansion is taking place at the present time." In this letter the authors also criticized Tamm, who chaired the session where Lifshitz's report was heard. Thus, the authors criticized and labeled as unprofessional almost all Soviet theoretical physicists who later became Nobel laureates, namely, I.E. Tamm, L.D. Landau, V.L. Ginzburg and only I.M. Frank was not criticised (probably because he was not presented at the Session). Naturally, the question arises as to the professionalism and impartiality of the experts rendering such a verdict on the incompetence of the most prominent Soviet theorists.

5 T. A. Shmaonov and the CMB discovery in Pulkovo

Since 1948 G. Gamow started to work American project to create a superbomb or in other words, H-bomb. During this period, refined cross-section data on the nuclear interaction of light elements became known, and these data could be used to calculate helium nucleosynthesis in the initial minutes of the evolution of the universe. At the end of 1940s, G. Gamow proposed his version of the hot Universe model where he estimated a helium nucleosynthesis in primordial Universe [?, ?], and soon after that his students calculated Cosmic Microwave Background (CMB) radiation [?] which should have now temperature around 5 K. In consequent calculations the CMB temperature was slightly different, but always it was a few kelvins. It would be reasonable to note that similar estimates for background radion temperature were done by Lemaître as we noted earlier. The CMB (cosmic microwave background) radiation or relic radiation in Russian literature is one of the key signatures of the hot Universe model developed by G. Gamow in the 1940s and 1950s. The CMB radiation was discovered by T. Shmaonov at the Pulkovo Observatory several years before A. Penzias and R. Wilson (who were awarded the Nobel prize in 1978) [?].[12] Now Shmaonov's discovery is widely known not only in Russia but also in the world, for instance, there is a description of this Shmaonov's result in a fundamental book [?] (10 years after publication of this book Peebles was awarded by Nobel prize in physics for CMB studies), and see also Trimble's review [?]. T. A. Shmaonov presented his lecture on the discovery 60 years after the events in Fig. 3. In Pulkovo observatory Shmaonov's supervisors were professor Naum Lvovich Kaidanovsky and professor Semyon Emmanuilovich Khaikin. Khaikin was one of the first L. I. Mandelstamm's students in Moscow, a great expert in theoretical physics, non-linear physics, radiophysics, radio astronomy, and the dean of the Physics Department at Moscow State University. Khaikin was fired from Moscow State University, MEPhI, and Lebedev Physical

[12]For In 1940, Andrew McKellar, analyzing the spectra CN and CH, found that interstellar medium was very cold with a temperature of approximately 2 K, or more precisely 2.7, 2.1 and 0.8 K [?]. However, astronomers did not have a correct explanation for this phenomenon for decades.

Institute after being accused of promoting idealism and Machism. A nice book was recently published about this remarkable scientist and teacher [?]. Shmaonov asked Khaikin about possible interpretation of his discovery, and Khaikin replied that he had no explanation, but it has to be published because it may be very important [?]. Since 1930s until 1960s Soviet physicists did not cite Gamow's papers at all, Khaikin worked as the head of the Radioastronomy Department at the Main Astronomical Observatory in Pulkovo, Gamow was one of the brightest representatives of Leningrad school of physics, and there is no doubt Gamow's works were known to many leading Soviet physicists, such as Khaikin, but he preferred not to declare that his PhD student (Shmaonov) had received a confirmation of the Gamow's predictions. Moreover, as indicated in the article on cosmology published in the Great Soviet Encyclopedia [?], scientists discussing models of the expanding universe are recognized as supporters of bourgeois and religious philosophy, which is hostile to the Soviet one. Earlier in the 1940s and 1950s, Khaikin had already been harshly criticized by his colleagues for allegedly promoting idealism and Machism at Moscow University and the Lebedev Physical Institute, which subsequently led to his dismissal. After defending his PhD thesis, T. Shmaonov left astronomy and later worked at the Institute of General Physics in the laser physics laboratory headed by A. M. Prokhorov, who got the Nobel prize in 1965 for the laser discovery and was Academician-Secretary of the Department of General Physics and Astronomy (1973–1993). In 1978, when A. Penzias and R. Wilson got their Nobel prize for CMB discovery, A. M. Prokhorov criticized Shmaonov that he did not inform properly scientific community about his CMB studies and did not promote his discovery. Sometimes people say that Shmaonov's achievements were not known for many years, since they did not have an appropriate cosmological interpretation. There is a popular opinion that no one in the Soviet Union knew about the Gamow model of the hot Universe and the predictions of this model. However, it seams to me this interpretation is not correct. After all, generally speaking, not discussing something publicly does not mean that the subject of discussion is not known. The fact that the predictions of the hot universe model were not publicly discussed does not mean that these predictions were not known. So already in an article in 1963 in the jubilee collection dedicated to the 75th anniversary of Friedmann's birth, Zeldovich critically discussed these predictions. As mentioned earlier, in the Soviet Union the models of expanding Universe (including Gamow's ones) were considered inadequate descriptions of the Universe and their consideration was not welcomed by official ideology and philosophy. In addition, despite the fact that Gamow was one of the most famous Soviet theoretical physicists, he did not return from a scientific trip abroad without the permission of the authorities. Thus, the mention of Gamow's works could be interpreted as a support for his disloyal attitude towards the Soviet government. A. D. Chernin called the story of the lack of a correct interpretation of Shmaonov's results a sad episode and noted that an American historian of science had found and interpreted Shmaonov's work in a cosmological context [?].

In another article dedicated to Gamow's 90th birthday [?], Chernin showed how Gamow simply estimated the temperature of the cosmic microwave background radiation without a detailed analysis of primary nucleosynthesis.

Figure 3: Tigran Aramovich Shmaonov presented his talk on CMB discovery in Pulkovo Observatory in 1956 – 1957. The talk was given on 17 April 2017 at the S.I. Vavilov Institute for the History of Science (Moscow).

6 Relikt-1 and COBE discoveries

Because the Earth (together with Solar system, Galaxy, Local Group of galaxies) moves in respect to the CMB, a dipole temperature anisotropy of the level of is expected. A dipole temperature anisotropy of the level of $\Delta T/T = 10^{-3}$ was observed, it corresponds to a peculiar velocity 380 km/s of the Earth towards the constellation Virgo (first measurements of dipole anisotropy were not very precise [?], but later the accuracy was significantly improved [?]. Moreover, based on results of balloon measurements it was claimed several times about features of quadrupole anisotropy, however, the quadrupole term was too high in these experiments as further studies had indicated, or reversely the realistic level of quadrupole anisotropy was to low to be detected in the balloon experiments.

In 1983, in the Soviet Union the Relikt-1 experiment was conducted aboard the Prognoz-9 spacecraft in order to investigate CMB radiation from space for the first time in history. As many other Prognoz missions, the scientific payload was prepared by the Space Research Institute of the Soviet Academy of Sciences. Igor Strukov was the principal investigator of the Relikt-1 project. The spacecraft Prognoz-9, had an 8 mm band radiometer with an extremely high sensitivity of 35 mK per second and it was launched into a high apogee orbit with a 400,000 km semi-axis. The high orbit was a great advantage of the mission since it allows to reduce of geomagnetic field impact on measurements. A disadvantage of the experiment was that the observations were conducted only in one spectral band, therefore, it was a freedom for a theoretical interpretation of the results, in contrast, multi-band measurements provide very small room for alternative explanations of anisotropy. The radiometer scanned the entire celestial sphere for six months. Computer facilities (and therefore, data analyzing) were relatively slow in the time. Preliminary analysis of anisotropy studies indicate upper limits on anisotropy [?], but in this case even the negative results (upper limits) were extremely important to evaluate a sensitivity to design detectors for next missions, including COBE (COsmic Background Explorer).

At the NASA cite `https://lambda.gsfc.nasa.gov/product/relikt/` it is given a brief information about Soviet Relikt-1 mission: "Prognoz 9, launched on 1 July 1983 into a high-apogee (700,000 km) orbit, included the Relikt-1 experiment to investigate the anisotropy of the CMB at 37 GHz, using a Dicke-type modulation radiometer. During 1983 and 1984 some 15 million individual measurements were made (with 10% near the galactic plane providing some 5000 measurements per point). The entire sky was observed in 6 months. The angular resolution was 5.5 degrees, with a temperature resolution of 0.6 mK. The galactic microwave flux was measured and the CMB dipole observed. A quadrupole moment was found between 17 and 95 microkelvin rms, with 90% confidence level. A map of most of the sky at 37 GHz is available." After that at this cite references at key Relikt-1 publications are given where information about the Relikt-1 discovery was presented [?, ?]

In 1986, at the Space Research Institute it was decided to prepare a next generation of space experiments to study the anisotropy of CMB, and start to develop the Relikt-2 project. The sensitivity of the detectors was planned to be in 20 times better than the Relikt-1 sensitivity. The Libris satellite was scheduled to carry the Relikt-2 payload and the spacecraft was planned to be located near the Lagrangian point L2 (in the Sun – Earth system). Now several spacecrafts, including JWST, are operating around the L2 point. Originally, it was a plan to launch the Libris spacecraft in 1993–1994, however, the project has not been realized, basically due to a lack of funds. To prepare Relikt-2, the team members re-analyzed Relikt-1 data and finally in beginning of 1992 they discovered signatures of the quadrupole anisotropy, but I. Strukov required to check the conclusions again and again. The discovery of anisotropy by the Relikt-1 spacecraft was first reported officially in January 1992 at the Moscow astrophysical seminar and the Relikt-1 team submitted papers in Soviet Astronomy Letters [?] and Monthly Notices of Royal Astronomical Society [?] (soon after the papers were published).

The discovery of anisotropy by the Relikt-1 spacecraft was first reported officially in January 1992 at the Moscow astrophysical seminar. Relikt-1 team submitted their paper in Soviet Astronomy Letters and Monthly Notices of Royal Astronomical Society on January 19, 1992 and on February 3, 1992, respectively. On April 21, 1992, G. Smoot (the head of DMR experiment aboard the COBE mission) and his co-authors submitted a paper in Astrophysical Journal (Letters) [?].

COBE orbit was rather low (around 1000 km) and therefore, it was a hard problem to separate a signal and a noise which was very strong at the low orbit. On April 22, 1992, Smoot reported at a press conference about the discovery of the CMB anisotropy with the COBE satellite. After that mass media reported this results as the main science success. In 1992, COBE results about discovery of the CMB anisotropy were reported elsewhere. However, no doubt, the COBE collaboration knew results of Relikt-1 team and even quoted their upper limit on the quadrupole anisotropy published at the paper [?]. However, summarizing, one could say that since papers of the Relikt-1 team were submitted on January 19, 1992 and February 3, 1992 in Soviet Astronomy and Monthly Notices of Royal Astronomy Society respectively, but COBE paper was submitted on April 21, 1992, one would conclude that the discovery one quadrupole anisotropy was done by the Relikt-1 team and published in papers [?, ?] and also independently and almost simultaneously the phenomenon was discovered by the COBE-DMR team. In 2006 J. Mather and G. Smoot got Nobel prizes in physics for SMB studies since the COBE-FIRAS group measured CMB spectrum while COBE-DMR group found quadrupole anisotropy. The results of the Relikt-1 group were criticized by the members of the COBE group, but subsequent analysis showed that the results of the Relikt-1 group were in agreement with the results of the WMAP group [?].

7 E. B. Gliner's ideas on cosmic vacuum, inflation and accelerated expansion of the Universe

Until the end of the 1990s, theorists and astronomers thought that Einstein's Λ-term is very small and they adopted $\Lambda = 0$. In 1998 astronomers discovered accelerated expansion of the Universe and in this case it is necessary to include into consideration $\Lambda-$term or so called dark energy. However, we have to remember that in 1965 Erast Borisovich Gliner considered cosmological (inflationary) models with accelerating expansion [?, ?] (see also an essay on the scientific life of this remarkable scientist and personality in [?]). Such Gliner's models looked very exotic and some outstanding Soviet cosmologists (including Ya. B. Zeldovich) criticized them; on the other hand, V. L. Ginzburg and A. D. Sakharov tried to support Gliner and his studies [?, ?]. For instance, recalling his work on cosmology in the 1960s, A. D. Sakharov wrote that "Gliner wrote about the same thing independently and with greater certainty in the same years" [?]. However, in spite of the undoubted importance of his studies, Gliner's results were nearly forgotten for decades [?].

8 Conclusion

This fall marks the 100th anniversary of the death of A. A. Friedmann and the 120th anniversary of the GR creation. The above are some results in the development of gravity and cosmology that are not covered in great detail in the Russian literature, for example, when discussing the Big Bang model in Russian literature, Lemaître's contribution is often forgotten, and the discovery of Shmaonov and the results of the Relikt-1 mission related to the discovery of the quadrupole anisotropy of the universe are very rarely mentioned. Unfortunately, very often our compatriots are not active to promote achievements of other researchers (including our domestic achievements). In these circumstances people remember the M. I. Monastyrsky's dictum [?] "...By the way, we (in Russia) are very fond of lamenting the underestimation of Russian scientists in the West. Russian (Soviet) scientists are the ones who hinder the recognition of Russian (Soviet) scientists the most, however, a careful analysis of the real facts shows..." The discussions of the fact that the quadrupole anisotropy of CMB was detected simultaneously from the analysis of Relikt-1 and COBE data were presented in [?, ?]. Some additional information related to the subject of this article can be found in historical introductions in the recent works [?, ?].

Acknowledgements

The author thanks the organizers of the XXVIth International Seminar on High Energy Physics Problems "Relativistic Nuclear Physics and Quantum Chromodynamics" (JINR, Dubna) for the invitation to present my contribution as an invited talk at this event and their attention to the research presented in the paper. The author appreciates A. A. Baldin, A. D. Chernin, A. D. Kaminker, V. O. Soloviev, M. V. Tokarev, D. Ya. Yakovlev for useful discussions of the subject.

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