European Journal of Interdisciplinary Research and Development
Volume- 26 April - 2024
Website: www.ejird.journalspark.org ISSN (E): 2720-5746

MODERN, NEW ASTROPHYSICAL AND COSMOLOGICAL CONCEPTS OF THE ORIGIN OF THE UNIVERSE

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Abstract:
Cosmology is one of the branches of natural science that uses various facts, methods and achievements from astronomy, philosophy, physics and mathematics. The natural scientific basis of this science consists of astronomical observations of the Galaxy, various stellar systems, A. Einstein's theory of relativity, relativistic thermodynamics and various other physical theories. This article outlines astrophysical theories of the structure and dynamics of change in the Metagalaxy, which includes a certain understanding of the properties of the entire Universe. The Universe in the modern picture of the world no longer appears as a being that has become, but as a stream of becoming, generating such fundamental objects of nature as elementary particles, from which the observable hierarchy of levels of organization of the Universe is formed.

Keywords Hubble's Law, Big Bang theory, quarks, anisotropy, curved space, Universe, cosmology, non-stationary Universe, “red shifts”, galaxy, quantum fluctuations, ultra-high temperatures, matter densities, radiation.

Introduction

Throughout the history of its development, humanity has directed its gaze to Heaven, trying to find an explanation for many, many phenomena, the nature of which it could not comprehend.
Solving Einstein's “world equations” from the General Theory of Relativity allowed the Russian mathematician and theoretical physicist A.A. Friedman to build mathematical models of the Universe. However, the first model of the Universe was proposed by A. Einstein himself, who came to the erroneous conclusion that the Universe should be stationary (non-evolving) and have the shape of a four-dimensional cylinder. Friedman proved that the curved space of the Universe cannot be stationary. In 1922-1924, A. Friedman criticized Einstein’s ideas and showed the groundlessness of Einstein’s original postulate about the stationarity, the immutability of the Universe in time. Based on the opposite postulate about the possibility of changing the radius of curvature of world space in time, Friedman found new solutions to Einstein’s world equations.
Based on these solutions, he built three mathematical models of the Universe. In two of them, the radius of curvature of space increases, and the Universe expands (in one model it expands from a point, in the other - from a certain volume). The third model paints a picture of a pulsating Universe with a periodically changing radius of curvature. Friedman's first two models soon found exact confirmation in direct observations of the movements of distant galaxies - in the so-

called "red shift" effect in the spectra of galaxies. The "red shift" indicated the mutual removal of all galaxies and their clusters that were sufficiently distant from each other.

The name of the American astronomer Edwin Hubble (1889-1953) is associated with the discovery of a universal cosmological pattern - the effect of the expansion of the Universe. With his discovery, he received an answer to the main question of cosmology - about the finitude or infinity of the Universe. Hubble measured the speeds of 18 galaxies in the nearest constellation Virgo. He grasped the general pattern of galaxy motion: the "red shifts" in the spectra of galaxies grew in proportion to the distances from the observer (or from the center of our galaxy).

This pattern, established by Hubble in 1929, entered astronomy as Hubble's law. (ν = H•r), where ν is the speed of retreat of galaxies, H is the proportionality coefficient or Hubble constant, r is the distance to the observed galaxy. For the proportionality coefficient, Hubble found the value H==560 km/(s•Mpc) (Mpc is a million parsecs or the distance that light travels in 3.3 million Earth years). This meant that with an increase in distance by 1 Mpc, the speed of galaxy expansion increases by 560 km/sec. This value, called the "Hubble constant," is one of the fundamental ones in cosmology. However, Hubble greatly overestimated the value of H. This value has been refined several times and is currently accepted as equal to 50-100 km/sec • Mpc. For close regions of the Universe, Hubble's law is statistical in nature, that is, it does not appear for every pair of galaxies, but for a large number of them. For objects sufficiently far from each other, this law also manifests itself for individual objects.

The reciprocal of the Hubble constant (1/H), which meant the time during which the galaxies scattered, directly indicated that there should have been a beginning of such a scattering, and perhaps the beginning of the existence of the Universe itself. This interpretation of Hubble's law clearly confirmed the theory of a non-stationary Universe constructed by Friedman. The image of a non-stationary developing Universe has become established in the astronomical picture of the world. If the average density of matter in the Universe is less than the critical one (5•10–30 g/cm3), then the Universe will expand infinitely, that is, it will be infinite. Otherwise, the Universe will begin to shrink, collapse, that is, it will be finite. As the Universe expands, its density decreases if the curvature of space = 0 or < 0, but if the curvature > 0, then the density will, despite the expansion of the Universe, increase, that is, the Universe will, as it were, "spin."

In the relativistic model of the Universe, the idea of evolution is developed; it refers to the Universe as a whole. However, there is no reason to extend phenomena observed in a limited, albeit huge, part of the Universe to the entire Universe. In the endless expanses of space, individual finite regions with their own characteristic physical phenomena and even laws are conceivable. It is in this direction that the modern astronomical picture of the world is evolving. It strengthens the idea of the existence of large-scale non-stationarities in the Universe, which manifest themselves in the processes of formation of huge complexes of matter. For example, the entire Metagalaxy may constitute one such complex or even part of it.

The Big Bang Theory

The formation of the scientific evolutionary-cosmological theory of the Big Bang is associated with the name of the American physicist J. Gamow (1904-1968). According to the Big Bang theory, the entire modern observable Universe is the result of a catastrophic explosion of matter that was previously in a monstrously compressed superdense state, a state of singularity, so far inaccessible to understanding and description within the framework of modern physics. The expansion of matter that began with this explosion initially led to an inseparable mixture of radiation and matter. The huge amount of hydrogen in the observable part of the Universe suggests that in the initial phase of its expansion it was filled mainly with high-temperature radiation, although it also contained a number of particles and antiparticles. After the mutual annihilation of the latter, a certain excess of particles remained. Among the particles, heavy (neutrons, protons, gravitons) and light (electrons, neutrinos) can be distinguished. The original relationship between radiation (the number of photons) and particles is preserved in the modern Universe.

J. Gamow and his students predicted in 1948 that in the modern Universe, cooled primary radiation should be observed as thermal radiation, corresponding to a temperature of 50 K (00 K = -273.150 C). It seemed impossible to radiophysicists to isolate such a weak signal from the general radiation of stars, galaxies, and the interstellar medium. However, already in 1956, similar radiation was detected at the Pulkovo Observatory using a horn antenna, albeit with little accuracy (its temperature was determined to be in the range of 3.9–4.2 ^{0}K).

The final confirmation of J. Gamow's prediction was given by American radio engineers A. Penzias and R. Wilson in 1964 when testing a horn antenna for observing an American satellite. The detected primary residual radio emission, the intensity of which was the same in all directions, was called relict by I. S. Shklovsky. This discovery confirmed the theory of the Big Bang (hot universe) and showed that our universe has an early history and that it has indeed evolved.

There are a number of scenarios for the formation of the Universe as a result of the Big Bang. One of them was proposed by P. Davis.

The expansion of the Universe, judging by its current speed, began 15-20 billion years ago. The early Universe can be characterized as a sequence of eras. The earliest lasted 10–43 seconds, that is, this is an age equal to one Planck unit of time. By the end of this era, T was 1032 K, and the density of the substance reached 1097 kg/m3. During this same era, elementary building blocks (quarks) existed.

As the temperature (T) fell, hadrons were formed from quarks, which decayed with a further decrease in temperature. 1 microsecond (10–3 sec) after the start of expansion, the matter of the Universe consisted of particles (protons, neutrons, electrons, muons, pions, neutrinos and gravitons) and their antiparticles. After approximately 1 second, as a result of annihilation, only neutrons, protons, electrons, neutrinos, and gravitons remained.

With a further decrease in temperature, when the energy dropped below the binding energy of complex nuclei, protons combined with neutrons to form atomic nuclei. In this primary synthesis, 25% helium was formed, the rest of the substance consisted almost entirely of free protons. The temperature continued to drop and was already too low for nuclear fusion. During this time, only very few nuclei heavier than helium nuclei managed to form. Cooling continued further, but its pace slowed down, so that it took 1015 seconds for the temperature (T) to reach 104 K. At this stage, free protons and electrons formed atomic hydrogen. The substance became transparent to radiation and from that time on the matter and radiation were separated. The resulting and cooling gas formed clouds from which protogalaxies emerged. Areas of increased density attracted additional matter, and their gravitational force increased. The slow compression of protogalaxies occurred under the influence of self-gravity.

Successive epochs followed one after another until the process of star formation began in the gas clouds. As the protostars contracted, they gradually warmed up until the temperature of the central regions rose to several million degrees for a thermonuclear reaction to begin. From the moment nuclear energy is released, the compression of the protostar stops, since the temperature and pressure in its center increase and balance the force of gravity. The protostar finds equilibrium and becomes a star.

We find another scenario for the evolution of the Universe in Tulio Regge.

The matter of the Universe was in an extremely compressed state, with a density thousand billion times greater than the density of water and at a temperature (T) of 1 trillion. 0C. What was happening could be compared to the rapid expansion of air heated in a bicycle pump. What was the space filled with in these moments? If the particles are heated to 1 trillion. 0C, then they will collide with each other with such force that the atoms will break down into nuclei and electrons of which they are composed.

Moreover, the energy of the flying parts will be so great that it can materialize, according to A. Einstein's formula (E=mc2) and lead to the appearance of antimatter. Cosmic collisions first occur in a frantic rhythm, which subsides over time; and, eventually, collisions will become very rare. As the Universe expands, it cools at a rate inversely proportional to its radius. When increasing the time from 1 – 4 sec. The radius will increase by 2 times, and the temperature will decrease by 2 times. And only after 1 million years the temperature (T) will drop to 4 thousand 0C and free electrons will begin to combine with nuclei, forming atoms. Today, the image of an "exploding Universe" is complemented by the image of a "collapsing Universe".

Clarifying the average density of matter in the Universe (in the Metagalaxy) will answer the question of whether the entire Metagalaxy as a whole will ever collapse. Today, the average density of matter in the Universe is 10–30 g/cm^3, which is less than the critical density (5.10–30 g/cm3). One of the most pressing problems of modern cosmology is the problem of "hidden mass", on which the estimate of the average density depends matter in the Universe. One of the manifestations of hidden mass is "black holes". Scientists assume that 9/10 of the mass of the Universe is concentrated in them. A "black hole" is a huge mass in a relatively small volume; under the influence of self-gravity, this mass begins to shrink uncontrollably, and gravitational collapse occurs. Therefore, the "black hole" does not let anything out, does not reflect, and, therefore, it cannot be detected. Space there is strongly curved, and time slows down. The gravitational force on the surface is so strong that to overcome it it is necessary to develop a speed exceeding the speed of light.

Scientists suggest that "black holes" are located in the cores of galaxies. However, the concept of the expansion of the Universe (Big Bang) also has opponents. Thus, in 1988, Yu. Uchaev proposed the hypothesis of a rotating Universe. According to this hypothesis, all cosmic bodies, objects and their various formations rotate. Their own rotation is the same "innate" property of them as the presence of some mass. In this hypothesis, the "red shift" of galaxies is explained as a consequence not of the longitudinal, but of the transverse Doppler effect.

For such an effect, the value of the "redshift" no longer has a linear, but a quadratic dependence on the distance to the galaxy moving in a circle around the signal receiver. It follows that for a given value of the recorded "redshift", the distances from distant objects determined within the framework of the rotating Universe hypothesis will be much smaller than the distances to the same objects determined on the basis of the concept of an expanding Universe. Naturally, a decrease in distances in a rotating Universe leads to both a decrease in its volume and, as a consequence of the first, an increase in the average density of matter.

Moreover, this increase increased by 3-5 orders of magnitude compared to the density of matter in the expanding Universe, which led to an excess of the critical average density by 1-3 orders of magnitude. It follows from this that it becomes impossible both the infinite expansion of our Universe and its subsequent compression into a small volume, an exorbitant increase in temperature and density of matter. Allowing in principle the possibility of a certain expansion or compression of matter, the model of the rotating Universe does not require expansion of the universe from an infinitesimal volume or subsequent compression into such a volume.

The "stability" of the model is achieved by the fact that the mutual attraction of galaxies is compensated by centrifugal forces that arise during their rotational motion along circular arcs. In this case, it remains possible to explain the observed "red shift" as a consequence of the Doppler effect.

The author of the rotating universe hypothesis notes that by solving some problems, scientists give rise to others, to which answers have yet to be found. For example, why is the angular velocity of the Universe constant? Another problem: in a rotating Universe, anisotropy (that is, unequal directions) of the distribution of "red shift" should be observed depending on the angle between the axis of rotation of the Universe and the direction to the corresponding galaxy. Such anisotropy has not been discovered explicitly to date.

The standard Friedman model predicts two options for the end of the modern Universe - either "thermal death" as a result of continuous expansion, or subsequent compression (Big Crush - Big Slam). According to the theory, the first scenario corresponds to an average matter density of less than 10-29 g/cm3; the second - more than this value. According to astrophysics, modern density estimates give exactly 1029 g/cm3, so the choice between both evolutionary scenarios, both of which are "worse," remains as if uncertain.

However, observations of anomalies in the movement of stars and galaxies led astronomers to the conclusion that, in addition to visible matter, there must be dark matter in the Universe, inaccessible to direct observations, the content of which far exceeds the amount of matter. The question of the nature of this matter is unclear. Perhaps it's cold interstellar gas, white dwarfs, neutrinos or other strange particles. A view of the future of the Universe that differs from standard forecasts can be obtained using the ideas of nonlinear science.

The fact that the Universe was born from a vacuum means that it cannot be considered as a closed system and, therefore, its evolution obeys the laws of the theory of self-organizing systems. And, therefore, the theory of Everything that physicists dream of must include dynamic instability. And this means, according to I.R. Prigogine that as the Universe evolves, circumstances create new patterns.

One of these non-standard circumstances is the possibility of the birth of daughter universes. The starting postulate of this hypothesis is that there is space-time foam—quantum fluctuations at the Planck scale. The existence of this foam can be verified experimentally by observing the reaction to it of powerful gamma rays with an energy of the order of 1016 GeV, emitted by galactic nuclei or quasars. If zones of such foam exist, then the spontaneous birth of separate space-time regions, gravitationally separated from the mother Universe, becomes possible. They can be observed by powerful flashes of radiation coming from "nowhere". An inductive mechanism for the emergence of such areas due to the collision of two ultra-high energy particles (fireball) is possible.

Anthropic cosmological principle

This principle is one of the most acute and controversial problems of the modern worldview. The scope of its application is the role and place of intelligent life in the Universe, and more specifically, humans. There are three historical paradigms that answer this question:

1. The Universe is anthropomorphic, it is an integral organism, and man is controlled by higher cosmic forces (Aristotle, Ptolemy).
2. The Universe is a mechanism created by God, who created man in his own image and likeness (Descartes, Newton).
3. Standard cosmological model, within the framework of which the emergence of intelligent life is a manifestation of the laws of chance.

The analysis of these problems led to the "anti-Copernican" revolution in cosmic philosophy. It turned out that in the Universe there is a very precise adjustment of fundamental physical constants, and even small deviations from standard values would lead to such a change in the properties of the Universe that the emergence of man in it would become impossible. This problem was studied by G.M. Idels, A.M. Zelmanov, B. Carter, F. Hoya, N.L. Rosenthal, J. Wheeler, F. Tipler, S. Hawking and other scientists. This amazing adaptability of the Universe to the existence of man in it is called the anthropic principle (AP).

Observing the Universe and studying the history of its evolution, many scientists have come to the conclusion that there is a certain principle at work in it that organizes the Universe in a certain optimal way. Thus, the expansion energy of the Universe was in very good agreement with its gravitational energy, providing the Universe with the longest possible lifespan. Some physicists have suggested that the structure of the physical world is inseparable from the existence of its inhabitants observing the world.

Physicists claim that there is a principle that carries out an incredibly fine adjustment of all phenomena and processes in the Universe, but this is not a physical principle, but an anthropic one, associated with man as a part of the Universe. The anthropic principle was first put forward by the English astrophysicist Benjamin Carter in 1973 as a counterbalance to the unjustifiably widespread use of the Copernican principle, according to which we do not occupy a privileged place in the Universe. The last position is erroneous from the standpoint of modern science, since our very existence as complex physical and chemical beings requires certain conditions that occur only in certain places of the Universe and at certain stages of its history.

Our very existence as intelligent beings depends heavily on the structure of the physical world. Thus, if any of the finely regulated conditions were violated, then life would be impossible (at least as we know it). Many of the basic properties of the Universe are determined, in essence, by the values of fundamental physical constants, such as the gravitational constant, the charge of the electron , proton mass, Planck's constant, speed of light in vacuum, etc. The properties of the Universe would be completely different if the listed constants had values even slightly different from the observed ones.
All this prompts us to ask the question: why is it that from the infinite range of all possible values of the fundamental constants, from the infinite variety of initial conditions that could have existed in the early Universe, a very specific set and specific values of the constants are realized? The Anthropic principle, which is divided into 4 types (modifications), tries to give answers to this and similar questions.

Weak Anthropic principle:

What we expect to observe must be limited by the conditions of our existence as observers. Thus, any cosmological observations made by astronomers are based on an all-encompassing selection effect: our own existence. We, for example, cannot observe phenomena that would contradict our existence (ultra-high temperatures, matter densities, radiation, etc.)

Strong Anthropic Principle:

The universe must have properties that allow life to develop within it at some stage in its history. Or, the Universe is like this because we exist. This principle points to the specifics of the Universe itself that we inhabit. It turns out that for the stable existence of atoms, stars, and galaxies, a very fine “adjustment” of a number of numerical values of fundamental physical constants is necessary.
A small deviation from these values, at least one of them, leads to a sharp loss of stability or to the loss of a certain link in evolution. It turns out that our Universe is “programmed” by someone specific, in the best possible way. This could be the Creator or some other higher intelligent power. Here we get access to theology. To avoid accusations of theologism, scientists (Guth, Steinhardt, Linde, etc.) proposed the hypothesis of a plurality of universes. According to it, our Universe is only one of many existing Universes, and we are lucky that, as a result of the game of chance, optimal conditions for our existence have developed in it.

Anthropic principle of participation:

Observers are needed for the Universe to exist /Wheeler/. This principle has physical content when considered in the light of attempts to interpret quantum mechanics (the Copenhagen school).

Final Anthropic Principle:

An intelligent information process must arise in the Universe and, once it has arisen, it will never die / F. Tipler /. If the formation of consciousness is necessarily implied in the universal order, then it will be difficult to reconcile with the prospect of its future destruction, which seems inevitable in a number of cosmologies. It would be more reasonable to assume that nature is not indifferent to the future fate of consciousness and will provide the conditions for its eternal existence, not necessarily in human forms. Although the Final Anthropic Principle is a statement of physics, it is nevertheless associated with moral values and implies an improved cosmos.

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