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DEVELOPING TENDENCIES OF PRESENTATIONS ON GALAXIES AND STARS EVOLUTION

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ABOUT ARTICLE

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Abstract: This article analyzes the scientific worldviews about the evolution of galaxies and stars. In addition to the usual stars, there are also many interesting objects in galaxies, star clusters, galaxy clusters and superclusters. Among them, we know red giants, white dwarfs, neutron stars, exploding stars called nova and supernova, and black holes with strong gravity, from which even light cannot escape. It turns out that in distant galaxies, the distance of which is determined by Hubble's law, the brightness of supernovae is lower than they should be. In other words, the distance to these galaxies calculated using the "standard candles" method turns out to be greater than the distance calculated based on the predetermined value of the Hubble parameter. This led to the conclusion that the universe is not only expanding, but expanding at an accelerating rate.

INTRODUCTION

The question of what is the universe has been thinking for several generations. In fact, the ideas about the structure of the world that exist at each stage of the development of human civilization can be considered cosmological theories of the corresponding period. Cosmology is the branch of astronomy that studies the properties, structure, and evolution of the universe as a whole. The basis of this science is mathematics, physics, astronomy and philosophy. The Universe is understood as all observable galaxies and their clusters, as well as the intergalactic medium. The earliest forms of cosmology are religious myths about the creation and destruction of the existing world. And the first scientifically based cosmological model of the universe was Aristotle-Ptolemy's geocentric world system. The world was believed to be limited by a fixed circle of stars, beyond which there was nothing. In 1440, Nicholas Cusa's treatise On Learned Ignorance was published with a revolutionary new cosmological model of the world. In particular, Kuzansky considered the Earth to be one of the planets. All celestial bodies are inhabited by people, and every observer in the universe can consider himself motionless. At the same time, consider that the universe is infinite, even though it has finite dimensions. About 200 years later, a new cosmological model appeared - the heliocentric system of Nicolaus Copernicus. Copernicus placed the Sun at the center of the universe, around which the planets (including the Earth) revolve. Copernicus still believed that the universe was confined to the sphere of the fixed stars. Digges system, in which the stars are located not on the same sphere, but at different distances from Earth to infinity. The decisive step from heliocentrism to an infinite universe filled equally with stars was made by the Italian philosopher Giordano Bruno. In particular, he was the first to point out that the stars are distant suns and that the physical laws are the same in infinite space. The emergence of modern cosmology at the beginning of the 20th century A. Einstein's theory of general relativity and the development of elementary particle physics. But, interestingly, Einstein himself believed that the universe is homogeneous, isotropic and, most importantly, stationary. Even after it was discovered that the objects in the universe are constantly changing, Einstein believed that this had no effect on the origin of the universe. This idea was so clear to the great scientist that he introduced the cosmological constant (sometimes called the lambda term) into the fundamental equation of his theory of general relativity.

$$R_{\mu\nu} - \frac{R}{2} g_{\mu\nu} + L g_{\mu\nu} - G\frac{8p}{c^4} T_{\mu\nu} = 0. \quad (1)$$

Here $R_{\mu\nu}$ is the Ricci tensor, represented by the partial derivatives of the metric tensor and obtained from the Riemannian curvature tensor of space-time $R_{\mu\nu\lambda\kappa}$ by transforming it along the upper and middle exponents, R the scalar curvature, that is, the convolution of the Ricci tensor $R = g_{\mu\nu} R_{\mu\nu}$, $g_{\mu\nu}$ — metric tensor, L — cosmological constant, $T_{\mu\nu}$ — energy-momentum tensor of matter, c — speed of light in vacuum, G — Newton's gravitation constant. The equation $4' \, 4$ relates the tensors to each other, that is, it formally contains 16 scalar equations. However, since all the tensors involved in the equations are symmetric, in four-dimensional space these equations are equivalent scalar equations. Bianchi identities $4 \times (4+1)/2 = 10$ reduce the number of independent equations from 10 to 6. The solutions to this equation are made to allow for the spatial uniformity and static nature of the universe. In 1922, the famous Russian mathematician A. A. Friedman proposed a non-stationary solution to Einstein's equation. His analysis showed that under no circumstances can there be a single solution. This means that the questions of what shape the Universe has, what is its radius of curvature, and whether it is completely stationary or not, could not be answered with certainty. But three possible consequences arose from Friedman's calculations, which can only be explained using the familiar concepts of Newton's theory of gravitation. So, assuming that the distribution of matter in the universe is indeed uniform. Then a galaxy located on the surface of a sphere with an arbitrary radius tends to its center according to the law of universal gravitation:

$$\mathbf{F} = G\frac{mM}{\mathbf{r}^2}. \quad (2)$$

In addition, all other galaxies located outside this sphere cannot change the magnitude of this force, because their motions are equal in absolute magnitude and directed in opposite directions. It follows that our studied galaxy is moving toward the center of the sphere with acceleration due to gravitational forces:

$$-ma = G\frac{mM}{R^2} \to -G\frac{M}{R^2} \ (3)$$

The minus sign indicates that the acceleration corresponds to gravity, not push. From this formula, it follows that the universe cannot be motionless, because gravitational forces act on it . The non-stationary model of the universe in 1929 E . The cosmological law of the expansion of the universe was confirmed by Hubble with the discovery of Hubble's law. After the discovery of Hubble's law, Einstein admitted that "the introduction of the cosmological constant was my biggest mistake." The removal of galaxies that occur in all directions from us does not mean that our Galaxy has some special position in the universe. Exactly the same picture of the "spread" of galaxies is observed for any other galaxy. Let's explain this with a simple example. Let's be in some A galaxy. Let's draw a straight line through the galaxy . It contains several galaxies that are moving away from us at speeds obeying Habbl's law. Now let's jump from our galaxy to another galaxy B away from us A and try to determine the speed of all galaxies relative to it. To do this, B need to subtract the speed of our galaxy from the speed of other galaxies. As you can see, we got another situation which is not fundamentally different from the original situation. That is, the speed at which galaxies are receding is still proportional to their distance. The constant H a bbl can be used to estimate the start of the observed expansion of the universe.

In the meantime, let's go back to the work of Friedman and Hubble showing that the universe cannot be static. And the distance between the galaxies indicates that they were quite close to each other in the past. In addition, calculations based on Friedman's cosmological models showed that at the time of the expansion, the matter of the universe should have an infinitely high density contained in an infinitely small volume. But why did the universe begin to expand? To find an answer to this question, independently from each other, the Belgian priest G. Lemaitre and the Soviet-American physicist G. A. Gamov proposed a new model of a hot universe. According to him, in the early stages of expansion, the universe was distinguished not only by a high density of matter, but also by its high temperature. This hypothesis is called the Big Bang. According to this theory, the Universe is believed to have originated from a state of unity in an explosion. The cosmological singularity is the state of the universe at a certain point in the past, extending from 0 to 10^{-43} degrees. At this time matter had Planck energy (10^{19} GeV), Planck radius (10^{-35} m), Planck temperature (10^{32} K) and Planck density (~10^{97} g/cm^3). Then the universe began to expand and cool. As it cools, protons and neutrons begin to form. From the fourth minute, the universe cooled to such an extent that stable nuclei of the lightest chemical elements - hydrogen and helium - began to form. Five minutes after the expansion began, the temperature in the universe dropped so much that fusion reactions stopped. At this time, matter consisted of a mixture of hydrogen nuclei (about 70% by mass) and helium nuclei (about 30%). 380,000 years after the Big Bang, the temperature dropped so much that the existence of hydrogen atoms became possible (before that, the processes of ionization and recombination of protons with electrons were balanced). A million years after the expansion began, when the diversity of the present world began to evolve from a hot hydrogen-helium plasma with a small admixture of other nuclei, the age of matter began.

The most striking result of Gamow's hot universe theory was the prediction of the cosmic background radiation, or cosmic microwave background radiation. It represents photons produced 380,000 years after the Big Bang, when the universe became transparent and the matter in it was greatly depleted. Therefore, the photons produced at this time avoid scattering and reach the Earth through the space of the Universe, which continues to expand. At the same time, in 1950, Gamo and his colleagues were able to estimate the temperature of this residual radiation - only three kelvins. In 1964, American radio astronomers A. Penzias and R. Wilson were able to detect cosmic background radiation and measure its temperature. It turned out to be exactly 3 K. It was the biggest discovery in cosmology since Hubble discovered the general expansion of the universe. Thus, Gamov's theory was fully confirmed. The theory of a thermally expanding universe, based on the work of Friedman and Gamow, is generally accepted. But the universe smiled at people's attempts to understand it and raised a new question: how will my expansion take place in the future? To answer this question, it was necessary to find the dependence of the speed of removal of the galaxy on the distance to it. If we use Hubble's law, it seems that nothing could be simpler. But everything is not so simple, first of all, the Hubble parameter itself must be set somehow. And for this, we need to measure redshift values for galaxies calculated by other methods, for example, using photometric parallax. Thus, it is known that the flux of photons coming from the radiation source and recorded by the observer E is inversely proportional to the square of the distance to the source:

$$E = E_0 \left(\frac{10}{r}\right)^2 \ (4)$$

Thus, it is possible to calculate the distance of this object from the known radiation power (i.e., brightness) of the observed object and by measuring the light flux:

$$Lgr = 0{,}2(m - M) + 1 \ (5)$$

For this, astronomy uses so-called "standard candles" - objects whose brightness is known in advance. By far the best "standard candle" for cosmological observations is the Type Ia supernova. This is because all flares of this type at the same distance should have nearly the same observed brightness. By comparing the observed brightness of supernovae in different galaxies, it is possible to determine the distance to these galaxies. So, at the end of the 90s of the XX century. It turns out that in distant galaxies, the distance of which is determined by Hubble's law, the brightness of supernovae is lower than they should be. In other words, the distance to these galaxies calculated using the "standard candles" method turns out to be greater than the distance calculated based on the predetermined value of the Hubble parameter. This led to the conclusion that the universe is not only expanding, but expanding at an accelerating rate. In addition, scientists concluded that the observed acceleration should create a previously unknown type of matter with antigravity properties.

Thus, a hypothetical type of energy called dark energy was born. The discovery of antigravity confirmed Einstein's prediction. So the big and scary lambda term is back in the equation of general relativity. Further observational data showed that dark energy fills the void of the universe almost equally. In addition, in March 2013, according to the results of the study of cosmic microwave background radiation by the Planck Space Observatory, it was determined that the total mass-energy of the observable universe consists of 68.3% dark energy and 26.8% dark matter.

CONCLUSION

Based on these data, scientists proposed a new cosmological model of our universe, which was called the Lambda-CDM model (CDM). The new model also made it possible to determine the age of the universe, and it is 13.75 ± 0.11 billion years. Thus, the development of modern cosmology once again demonstrated the limitless potential of the human mind, which is capable of studying the most complex processes that have occurred in the universe for billions of years.

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