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Hidden mass and dark matter

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Abstract

It is shown that the substance which is impossible to record in any spectra of electromagnetic radiation, which manifests itself in space only through gravity, cannot be considered a new, previously unknown type of matter – "black matter". The fundamental, unsolvable problems with this approach are demonstrated. The unrecorded substance is a common baryonic substance that makes up the "hidden mass". It has been hypothesized that the bulk of the hidden mass consists of asteroids composed of solid hydrogen. Their formation took place as a result of explosions of the first generation stars (the population III stars) during the gravitational compression of hydrogen clouds in the warm-hot phase, accompanied by self-cooling due to losses associated with electromagnetic radiation. The paper shows at what ratios of physical parameters a similar process is triggered and its physical essence is explained. The possibility of yet another previously unknown direction of spontaneous gravitational compression is shown: compression with self-heating of small mass clouds, resulting in the formation of structures with a degenerate electron gas, including unstable ones. A separate chapter of this work is devoted to a discussion of the problems of the hot Universe model, on which the Big Bang model and the ΛCDM model are based.

***Keywords*:** hidden mass; dark matter; gravitation; hot Universe model; population III stars

1. Introduction

At the beginning of the 20th century, physicists clearly realized that the current astronomical observations in the optical range were not sufficient to detect weakly luminous space objects. Therefore, the term "dark matter", which implies the existence of invisible objects in space that manifest themselves only through gravity, and are not only ordinary matter, but well-known forms of its existence in space, appeared about 100 years ago.

In the 1930s, Fritz Zwicky, using the virial theorem, found that for stability of a large cluster of galaxies, known as the "Coma Cluster", given the observed velocities of the galaxies inside it, the mass of the cluster should be 400 times greater than the one observed. Due to the fact that overestimated Hubble constant was used in these calculations, an overestimated amount of dark matter was obtained. But it showed that there is a lot more dark matter in space than observed matter. Later, with the development of X-ray astronomy, an intergalactic heated hydrogen gas was discovered. As expected, the mass of the intergalactic gas was insufficient to explain the stability of the cluster of galaxies. Moreover, the presence of hot gas, in turn, also required an explanation for its confinement in a cluster of galaxies: another argument appeared in favour of the hypothesis of the presence of unobservable matter. Determining the nature of dark matter with a large total mass has become a vital problem.

Due to the fact that in that historical epoch the term "dark matter" meant ordinary matter, and not necessarily cold, but simply difficult to observe with the available technical means, it was often called "hidden mass". It is now generally accepted that the bulk of all dark matter consists of a new type of matter of unknown nature. Therefore, in order to make it clear in the course of the presentation of the material, in this work, the term "hidden mass" is used to mean space objects consisting of ordinary matter, and the term "dark matter" – only of an unknown form of matter. Unobservable matter can consist only of hidden mass, only of dark matter or of their fractional parts, i.e. all substance unobservable at the current technical capabilities in all ranges of electromagnetic radiation is designated in this work by the term "unobservable matter".

Soon, after it became necessary to explain the stability of a set of galaxies in their cluster, a similar problem was discovered for a set of stars in a galaxy. According to the law of universal gravitation, proposed by Newton based on the analysis of Kepler's laws, the orbital velocities of space objects rotating outside the visible part of the galaxy should decrease in inverse proportion to the square root of the radius of their orbit (if the orbit is elliptical, then the root-mean-square orbital velocity is considered, depending on the length of a large semiaxis of the ellipse). But in fact, the speed, before starting to decrease, went through a flat section, remaining approximately unchanged. This dependence, called the galaxy rotation curve, was plotted for many galaxies, but the situation described above was repeated. The shape of the rotation curve can only be explained in one obvious way: by placing the galaxy in a cloud of unobservable matter that carries gravitational interaction.

With the development of radio astronomy, clouds of atomic hydrogen have been identified inside galaxies. However, according to the calculations, they did not significantly affect the shape of the rotation curves.

Due to the fact that a corollary of the Gauss theorem for a spherically symmetrically distributed substance allows, when determining the gravitational attraction of an external object to the centre of mass of a galaxy, to replace the substance inside the sphere along which the object's orbit passes, with a point mass located at the centre of mass of the galaxy and equal to the mass of matter enclosed inside the sphere (if the orbit is elliptical, then the mass affecting the object is determined for the space inside the sphere with a diameter equal to the major axis of the ellipse), and the external mass relative to this sphere should not be taken into account at all, then the flat section of the rotation curve with approximately constant velocity (in reality, the velocity in this area can both increase and decrease gradually) obliges the average density of the unobservable matter to decrease layer by layer in inverse proportion to the growth of the square of the radius to the layers under consideration. Unobservable matter can be either continuous or discrete. Even faint stars, such as brown and red dwarfs, can be considered if, due to their remoteness, they cannot be observed. The main thing is that the average density of any type of substance should decrease according to the specified law. But the problem is that no models can explain such mass distribution of ordinary matter (it is not clear how clouds or compact space objects can accumulate at large distances from the centre of mass of a galaxy outside the cluster of visible objects in the galaxy, while obeying the discovered pattern of the distribution of the average masses). Therefore, the rotation curves of galaxies, inherently referring to observational rather than theoretical data, began to be considered significant arguments not in favour of hidden mass, consisting of ordinary matter, but in favour of dark matter in the new sense of this term.

And the third observational factor, which also testifies not just to the existence of unobservable matter, but to its prevailing presence in outer space, is gravitational lensing. The essence of gravitational lensing is that straight beams of electromagnetic radiation bend near massive objects, and the closer they pass by them, the more the bend becomes (accordingly, such lenses cannot focus). Therefore, rays from distant objects, crossing clusters of matter more closely located to the terrestrial observer, create certain effects in the lens, for example, the formation of a ring, a section of an arc or several sections of arcs instead of a point image.

Distances to the source and to the distorting lens are determined by redshift. Therefore, a distinctive feature of observing gravitational distortions of an image in a lens is the ability to accurately estimate the mass of a gravitational lens (most often, clusters of galaxies serve as gravitational lenses). Another distinctive feature of this effect is the ability to detect objects that could not be identified without lensing (rays that do not go directly to the observer are refracted by the lens and are still directed to the observer). Such observations become possible when a weakly luminous lens passes between an unknown object and the lens of an Earth observer, increasing its luminosity at that moment. Another distinctive feature of gravitational lensing is the ability to detect completely non-luminous gravitational lenses. Moreover, it is even often possible to determine the spatial distribution of the unobservable matter.

The successes of gravitational lensing are attributed to the 21st century. First of all, it is useful to mention the observation of the collision between two galaxy clusters in the Bullet Cluster of galaxies. In this particular case, the collision of galaxy clusters has already occurred, and we see the scattering of these clusters. Gravitational lensing made it possible to visualize the spatial distribution of unobservable matter formed as a result of such a collision, i.e. gave more information about it.

Further, it is useful to emphasize that gravitational lensing makes it possible to determine unobservable matter between galaxy clusters.

And finally, gravitational lensing makes it possible to refine the masses of various space objects used as lenses. Thus, gravitational lensing makes it possible to not only visualize unobservable matter, but also to describe its general characteristic properties.

The main result of the described achievements is an indisputable proof of the existence in space of unobservable matter, which exceeds the visible matter in mass, and the main intermediate result is the absence of a direct indication of the need to replace the hidden mass, consisting of ordinary matter, with dark matter of unknown nature. At the same time, the collision of clusters of galaxies in the Bullet cluster demonstrated that the gas, present in the galaxy clusters during their collision, as expected, heated and decelerated, and unobservable matter passed through the gas clouds, as if not noticing them. Since the resulting distribution of unobservable matter was diffusely blurred, the results obtained persuaded theorists to choose the essence of unobservable matter in favour of dark matter of a new nature, weakly interacting with ordinary matter, instead of hidden mass. At the same time, this does not mean that the formations of hidden mass from ordinary matter cannot create the detected observed averaged mass distribution in the collision zone of galaxy clusters. The observed mass distribution only introduces certain restrictions on the forms of possible formations from ordinary matter.

So, the observational facts listed above, indicating the existence of invisible gravitational objects, significantly exceeding the visible objects in mass, are as follows:

1. Kinematics in galaxy clusters.
2. Curves of rotation of galaxies.
3. Hot gas of galaxies and galaxy clusters.
4. Gravitational lensing.

Clusters of galaxies turned out to be very informative from the point of view of studying unobservable matter, since many methods could be used to estimate the magnitude and distribution of its mass: using the velocities of galaxies inside the clusters, or studying hot gas and using gravitational lensing.

Additional evidence for the existence of unobservable matter is provided by the analysis of spherical harmonics of the temperature of the cosmic microwave background (CMB). But in this case, the choice remains uncertain: hidden mass and dark matter turn out to be equal contenders for the consistency of unobservable matter.

The existence of a large amount of unobservable matter in outer space is also suggested by the observed shape of the large-scale structure of the Universe. But these observations cannot give preference to hidden mass or dark matter, and even to impose restrictions on their form of existence.

Why, in the end, the choice fell on dark matter, will be explained in the chapter on dark matter.

2. Historically considered candidates for the role of hidden mass, consisting of ordinary matter

Considering the stability of galaxy clusters revealed only the very fact of the existence of unobservable matter of a large mass, significantly exceeding the mass of visible matter, but the compilation of rotation curves indicated where this matter is located. It turned out that the size of the invisible part of an individual galaxy is an order of magnitude larger than its apparent size (the gently sloping areas of the rotation curves extended up to ten galaxy diameters). Moreover, the making the rotation curves was greatly hampered by a natural circumstance, which we will recall below, associated with the absence of any type of observed matter in the spatial zone corresponding to the flat section of the curve (it is impossible to determine the orbital velocity if there is no object located on this orbit: beyond the visible zone of the galaxy, even discrete clouds of gas are very rare). Nevertheless, due to the individual single objects, the rotation curves could still be created.

The technical capabilities of astronomy have developed in a revolutionary way. Depending on the peculiarities of observing space objects outside of our galaxy, ordinary matter distributed in space, creating gravity, began to be divided into the following phases:

1. Condensed phase.
2. Warm-hot phase.
3. Hot phase.
4. Diffuse phase.

The condensed phase consists of stars and cold gas of galaxies. It is an easily detectable phase, subject to continuous monitoring and analysis.

The warm-hot phase is a gas heated, primarily by shock waves, to temperatures of $10^5 < T < 10^7$ K and emitting in the ultraviolet range. At the stage of the formation of a proto cluster in the evolution of the Universe (i.e., during the period of the Cosmic Dark Ages after plasma recombination), it was still absent, but then it began to actively accumulate and today it makes up most of the mass. It is difficult to detect due to the low intensity of radiation (due to its rarefaction) and the limited number of absorption lines (due to its ionization). At such temperatures, hydrogen becomes completely ionized and, accordingly, has no absorption lines at all; while other elements, such as oxygen, only absorb radiation from a higher temperature source.

The hot phase is a gas heated to more than $T > 10^7$ K. First of all, it is the gas of clusters of galaxies and elliptical galaxies. It is characteristic of the stages of the evolution of the Universe with moderate redshifts: up to $z < 3$. At higher redshifts, the evolution of the Universe is characterized by the ignition of radio sources and the fraction of this phase is thought to be approaching zero. Hot gas is easily detected using X-ray radiation.

The diffuse phase consists of a cold neonized gas of the first stages of the evolution of the Universe, observed along the absorption lines of radiation of quasars. Large gas clouds are usually detected, and small ones, as a rule, can only be detected due to the cumulative effect. At the same time, it is impossible to estimate the number of small clouds and, accordingly, their total mass.

However, a comprehensive observation of all possible phases of matter still did not yield an answer to what the hidden mass might represent. Moreover, as can be seen from the presented classification of the carried out observations, first of all, we are talking about observations of the gas with its various parameters. And as mentioned in the previous chapter, gas cannot solve the problem of unobservable matter. Therefore, these observations are not so much used to determine possible candidates for the role of hidden mass, but to compare the theoretical amount of baryonic matter, which appeared as a result of primary nucleosynthesis, to the amount actually present in outer space.

Massless and lightweight particles, for example, neutrinos, should not be considered as a hidden mass, since they cannot clump together and form stable inhomogeneous gravitational fields.

Cold solid objects such as planets and asteroids would be quite suitable candidates for the role of hidden mass. However, two fundamental difficulties associated with this. Firstly, it is difficult to visualize such objects, especially those located far from the visible zone of the considered galaxy. Secondly, the main difficulty of such a solution is to determine the methods of formation or appearance of such objects in their final form in such distant orbits of galaxies. At first, even variants of clusters of weak orbiting stars were accepted as candidates for the role of hidden mass. But their appearance in such distant orbits is also impossible to explain theoretically. Variants of inactive white dwarfs, neutron stars and black holes look quite promising. However, the problem remains the same: they cannot concentrate in distant orbits.

In general, all compact candidates for the role of hidden mass are usually grouped by theorists into one group: "Massive Compact Halo Objects" (MACHOs).

But there are restrictions on the upper limit of the possible masses of single objects of hidden mass. If initially the limitation was dictated only by the need to maintain the stability of globular clusters, the emergence of various observational techniques of gravitational lensing revealed that the latent mass is rather strongly smeared in space. It turns out that compact objects of sufficiently large mass, like the masses of planets, can only be candidates for the role of hidden mass in an insignificant amount, i.e. most forms of known compact space objects can make up only a small fraction of the total amount of unobservable matter.

A detailed analysis of the composition of the Milky Way for the detection of a hidden mass consisting of MACHOs showed that the proportion of such objects is insignificant. For example, the results obtained by Tisserand et al. [1] while tracking the effects of microlensing while observing the stars of the Magellan Clouds selected by the team showed that MACHOs cannot be objects with masses greater than two times the mass of the Moon. In fact, these results completely rule out the assumption about the unobservable matter consisting of MACHOs.

Also, compact halo objects consisting of ordinary matter cannot have small unit masses, i.e. cannot be dust. The collection of large masses of unobservable matter requires large accumulations of dust. But, firstly, the dust affects the electromagnetic radiation passing through it and would have already been detected; secondly, dust is unstable and can grow larger; thirdly, it is difficult to explain the reasons that would distribute the average dust density according to the expected law. In addition, the reasons for the presence of dust on the periphery of the galaxy, if this option can even be considered, are also not clear.

From the point of view of restrictions on individual masses, the only possible option for compact objects consisting of ordinary matter is a cluster of formations similar to asteroids. But how asteroids are able to accumulate in large quantities in the distant orbits of galaxies is a mystery. Therefore, this option has never been considered.

Thus, it is not possible to form an unobservable matter from an ordinary substance. An ordinary substance is made up of atomic nuclei and electrons. Atomic nuclei are made up of nucleons. Nucleons belong to baryons and contain the bulk of the substance. The mass of electrons related to leptons is insignificant in comparison with the mass of baryons. Therefore, when it comes to gravity, it is customary to call ordinary matter baryonic. This name was promoted by the generally accepted theory of the evolution of the Universe, one of the initial stages of which was baryogenesis.

If there were stable particles in the Standard Model of the theory of elementary particles that could survive from the birth of the Universe to the present day; massive enough to create a sufficiently large total mass in the compacted zones of their clusters; passive in relation to interactions, in order to avoid the possibility of the formation of massive structures and to avoid the occurrence of active processes of interactions; having no electric charge, so as not to manifest themselves when irradiated with electromagnetic rays and not to participate in electromagnetic interactions, then the hidden mass would be easy to assemble and describe. But no such particles exist among the particles of the Standard Model.

3. New entity "dark matter"

As shown in the previous chapter, the composition of the hidden mass with ordinary matter has proven to be a difficult and so far remains an unsolved problem. Nevertheless, according to the principle of Occam's razor, this does not mean that it is permissible to introduce a new unknown type of substance different from the baryonic one into the theory. But such a step was taken. Such an extraordinary step towards making a decision about the real existence of dark matter of unknown nature was prompted by the following circumstance: problems arose with the cosmological model of the evolution of the Universe, which is based on the model of a hot Universe.

The hot Universe model implies the generation of matter from energy. This can only be associated with high energies, i.e. the resulting substance must be hot. The model of the hot Universe does not consider how matter is formed. It only implies the appearance of adiabatically expanding plasma at a certain stage in the evolution of the Universe. The created Big Bang model not only made it possible to describe in detail the prehistory of the appearance of plasma, but was also developed into a complete harmonious theory of the multi-stage development of the Universe.

Therefore, the Big Bang model is, as it were, a more detailed and expanded model of the hot Universe. However, some rather serious difficulties in explaining some individual fundamental questions of this model, the discussion of which is not related to the topic of this work, required its modification with consideration of the possibility of supplementing the model with the theory of cosmological inflation. The described historical sequence of refinements of the theory of the birth and evolution of the Universe means that all the refinements introduced relate, in essence, to a theory based on the model of a hot Universe. Today, the generally accepted standard inflationary model, which takes into account the creation of dark matter and dark energy, is considered to be the most developed. This is the Lambda-CDM model.

According to the accepted theory of the evolution of the Universe, matter at the dawn of the birth of the Universe was formed in two stages. After baryogenesis, as result of which, as predicted by the Standard Model of the theory of elementary particles, neutrons and protons were formed in a certain quantitative ratio and the stage of primary nucleosynthesis began, as a result of which the synthesis of light elements took place (isotopes of hydrogen, helium and, in a very small amount, lithium were formed). All the heavier isotopes had already been produced in the stars. These primary isotopes, if it is be possible to identify them in modern observations, should unambiguously characterize the total mass of baryonic matter in the Universe. In principle, such a possibility exists, although it is associated with certain difficulties. Therefore, the comparison of the composition and number of primary isotopes with the total amount of baryonic matter was carried out with some success. However, when compiling the actual observed balance between the primary isotopes and all baryonic matter, three uncertainties arose.

The first problem is related to the calculation of the amount of the isotope of lithium-7, which, as it turned out, was too small in comparison with the amount of isotopes of helium-4 and helium-3 (3 times less than theoretically predicted). This concerns primary lithium (secondary lithium, produced by stars, is 4 times the theoretically predicted amount of primary lithium). The problem of primary lithium is still unresolved, but it is believed that it is associated with solvable difficulties.

The second problem was considered more significant, but it was still solved in the first approximation. This is the problem of the missing baryons. An estimate of the amount of helium isotopes indicated a significantly larger amount of baryonic matter than had been estimated from observations. Not long ago, it was possible to observe less than 40% of the expected amount of baryonic matter. But recently this indicator has been constantly improving. The assessment of various independent groups of scientists, indicating that up to 28% of baryons are in the filamentary structures of the Universe in the form of a warm-hot phase (see, for example, the work of Graaf et al. [2]) provided the last, but far from final, straw to the solution of this problem. This concerns baryonic matter, since the change in the CMB intensity was measured due to the inverse Compton scattering, and dark matter, as discussed below, does not interact with electromagnetic radiation. The intensity changes are very slight. But such slight changes can be detected if a map of the large-scale structure of the Universe is superimposed on the CMB. It is very useful to note here that the estimation of the gas density of the warm-hot phase was carried out with the parallel application of gravitational lensing. This means that the presence of dark matter in the filaments is not implied. Indirectly, the result obtained indicates, although this is not stated in the work under discussion [2], that if dark matter is present in cosmological filaments, then its fraction is clearly insignificant. Attention is drawn to this in connection with the prevailing generally accepted idea that cosmological filaments, if not compiled from, are at least formed due to dark matter.

But the third problem was solved only by introducing a new entity "dark matter" into the theory. This is connected with the fact that, as shown in the introductory chapter, the existence of an unobservable substance is an indisputable fact. However, the theory of primordial nucleosynthesis cannot compare the observed abundance of deuterium with the amount of baryonic matter that includes hidden mass. The fact is that the higher the initial density of the Universe, the lower the amount of deuterium that should remain by the end of the primary nucleosynthesis. At present, no other ways of producing deuterium, after the primary nucleosynthesis, have been discovered. Therefore, it is believed that the amount of deuterium available in the Universe is a fairly reliable indicator of the amount of baryonic matter. In such a situation, there remains the last, inherently unpopular, possibility of combining the theory of primary nucleosynthesis, characterized by the observed abundance of deuterium, with the existence of unobservable matter – to add dark matter to the baryonic matter, which will become the main component of unobservable matter.

In addition to the generation of baryonic matter, the introduction of a new dominant component associated with the generation of dark matter into the model of the birth of the Universe becomes possible because a restriction is initially imposed on the nature of dark matter: it cannot interact with electromagnetic radiation and must be passive to interaction with protons and neutrons (if such interactions are possible, then the probability of their occurrence must be low).

The ban on interaction with electromagnetic radiation is associated with not only the unobservability of the matter surrounding made up of dark matter, but in connection with the emerging need to observe the principle of independence for the processes of baryon and dark matter production. The point is that the final result of this stage in the classical theory of primary nucleosynthesis depends on electromagnetic radiation. And since the primary isotopic baryonic composition of the Universe is considered in the first approximation to be consistent with the predictions of the theory, the introduction of a new position into the theory cannot violate the results already achieved within its framework. Similarly, the second limitation is connected not only with the explanation of the fact that manifestations of dark matter is undetected by modern experimental observations, but more so with the preservation of the coherence of the theories of baryogenesis and primary nucleosynthesis.

Thus, dark matter was formed together with baryonic matter from the initial energy in independent and non-interconnected processes. For this reason, dark matter does not interact with electromagnetic radiation and barely interacts with baryonic matter, but, at the same time, has gravity.

The introduction of a new category into physics requires its integration with existing knowledge alongside with an assessment of its applicability for observational (experimental) facts that were still unexplained at the time of introduction. At first glance, it may seem like the integration of a new category of "dark matter" into cosmological theory has brought overwhelming success. After all, not only was it possible to solve the problem of unobservable matter, preserving the old structure of the theory of the birth of the Universe, but also to carry out a comprehensive introduction of this new category into cosmology, as evidenced by the emergence of the new inflationary Lambda-CDM model. But it should be noted that complex implementation took place only in cosmology, without touching on physics, although the new category is physical.

When introducing the new category into cosmology, first of all, the material balance of the Universe was compiled, which includes not only a new category "dark matter", but also another new category "dark energy". Dark energy will be discussed in a later work, scheduled by the author for publication. Now it is only useful to note that it was also introduced into physics and cosmology to save the model of the hot Universe.

Friedman's nonstationary model of the Universe, developed in 1922-1924, showed that the macro characteristic of our Universe (open, flat or closed) is determined by the real density of matter in the Universe and the critical density of the Universe, which depends on the Hubble constant and the gravitational constant. Today, matter density refers to both baryonic and dark matter, as well as the density of dark energy. Our everyday experience suggests, but does not prove, that our world is flat. Modelling the CMB map at different curvature of space-time also indicates the absence of curvature. Therefore, the balance of the Universe was made on the assumption that our world is flat. Moreover, it is believed that the inflationary model of the evolution of the Universe helps to understand the reason why our world is flat.

The theoretically expected yield of baryonic matter in primary nucleosynthesis was improved, in the process of compiling the balance, by refining the numerical value of the ratio of the average density of the number of baryons to the average density of the number of photons from the CMB analysis.

Thus, dark matter not only helped to supplement unobservable matter with additional gravitational mass, which the theory of primary nucleosynthesis could not, but was also provided our world with the missing substance to make it flat.

The success of introducing a new category was not limited to this. In the theory of the evolution of the Universe, based on the model of a hot Universe, with the discovery of the large-scale structure of the Universe, a serious problem arose: how do inhomogeneities form from a homogeneous plasma cloud in such a short time. Dark matter helped solve this problem, as mentioned above. While the equilibrium radiation of the primary plasma cloud contributed to the preservation of its homogeneity, dark matter located in the same spatial zone was not influenced by the electromagnetic radiation and was able to form inhomogeneous gravitational fields in its subsystem. After plasma recombination, in the epoch of the dark era, the structuration of baryonic matter began due to the spatial distribution of the gravitational potential formed by dark matter. Numerical simulations on supercomputers carried out by different groups of scientists made it possible to theoretically reconstruct the actually observed large-scale structure of the Universe. It is quite understandable that such a success served as a reason that a theoretical calculation of the large-scale structure of the Universe became an additional weighty independent argument in favour of the dark matter being introduced into the theory.

But if we consider its physical essence and not the benefits of dark matter for cosmological theories, then compared to the emerging physical uncertainties, the obtained positive results in cosmology will begin to lose their brilliance. In addition, in the next chapter it will be shown that not everything is as smooth as it seems even with cosmological questions. And such a result, according to the principle of Occam's razor, is quite expected. Moreover, a new essence (category), artificially introduced into the theory, in order to give it an external lustre, over time, must inevitably require the introduction of additional new essences (categories).

Therefore, the main focus should be on the realization of the physical essence of the new category. Since dark matter has gravity, then it must also have gravitational mass. But at the same time, dark matter is not made up of quarks and leptons. This means that it does not consist of corpuscles and has no inertial mass. Currently, only one possibility exists for such a variant: zero rest mass and movement only at the speed of light.

Of course, it can be argued that the gauge bosons with weak interaction, although not corpuscles, have masses. However, there are two "buts" in this conclusion. First, such bosons are virtual. Second, they take part in the Higgs mechanism. Dark matter is not part of the Standard Model. Therefore, new fundamental theories are required to explain its existence in the form of corpuscles or in other forms and its behaviour. If the dark matter particles do not have inertial mass, then they will change their energy in gravitational interactions not because of changes in kinetic energy; and if they have inertial mass, then will still be necessary to explain how such a mass arises and whether it is equivalent to a gravitational mass. Moreover, the attempts to artificially introduce dark matter particles into the Standard Model, for example, by assigning negative baryon numbers to them, are as impossible as the step to introduce a new category of "dark matter", and they will not bring anything but harm to the constructions of the Standard Model and create the need to introduce additional entities. But regardless of the form of existence that dark matter turns out to have, it is necessary to clarify in more detail two fundamental provisions:

1. Today, only one fundamental property of dark matter is known: of all known fundamental forces, it is only sensitive to gravity. This means that the dark matter particles must converge towards each other. If they do not converge, then there is a need to explain the new manifestation of the forces of gravity (the gravitational field depends on the magnitude and position of the gravitational mass, and the gravitational interaction itself is not feasible without changing the positions of the interacting gravitational masses). If dark matter particles converge, but do not merge, then it will be

necessary to introduce a new fundamental force into the theory to explain this phenomenon. If they merge, but immediately separate, it will again be necessary to introduce a new type of fundamental interaction into the theory. Based on the pre-established principles, when the dark matter particles are introduced into the theory they cannot stick together. In addition, the coalescence process itself will also need to be explained by new entities.

2. Our material world, described by the Standard Model, obeys the following rules:

- binding laws of conservation (mandatory conservation laws) of energy, momentum, angular momentum, electric charge, baryonic charge, lepton numbers;
- optional conservation laws of strangeness and isotopic spin;
- principles of invariance (time reversal, spatial reflection and charge conjugation in various combinations).

First of all, it is necessary to understand the mandatory conservation laws. Since dark matter was formed from the same substance as baryonic matter, namely, from primary energy, then, firstly, it is important to figure out what kind of energy it is (just to say that it is vacuum energy or make another similar statement is not enough, there is no physical meaning in it, there is only a mathematical one), and, secondly, dark matter must obey, at least, the law of conservation of energy. But to describe the principle of the fulfilment of the law of conservation of energy for dark matter, it will be necessary to create a new, not yet existing theory, different from the Standard Model. And this theory will inevitably include some new, still unknown conservation laws. It is fundamentally impossible to create a new theory without new laws.

The brief analysis conducted above demonstrates a stalemate situation of the chosen trend of development in physics. No mathematical analysis is required to substantiate the error of the chosen step. Not only does the chosen direction not have any basic provisions, but it also has nothing in common with scientific knowledge that has already proven itself in describing the world around us, reinforced by experience. The theory of supersymmetry and other theories that exist on the basis of hypotheses have no right to be the basis of a new theory otherwise it is like the construction of castles in the air. Moreover, the development of new theoretical models is proposed not for something specific, not for inexplicable experimental facts, but for something unobservable, which does not manifest itself either in space or in a laboratory, only on the basis of inconsistencies in the available knowledge. This is a purely theoretical assumption. There is only one experimental observation: the existence of an unobservable matter. But the reason was too weighty: the failure of the hot Universe model to explain this experimental fact. And solely for the reason that the model of the hot Universe is generally recognized, such an incorrect step of introducing a new entity into the theory has been taken.

The summary of this chapter is a categorical conclusion: dark matter does not exist. Accordingly, the hot Universe model is wrong. The problems of the hot Universe model are considered in more detail in the next chapter. In this chapter, since dark matter does not exist, the review of the supposed candidates for the role of dark matter is not considered.

It is useful to make an important point to conclude this chapter. The conclusion about the inconsistency of the model of the hot Universe was made on the basis of only one single reason so far: the inadmissibility of introducing a new entity "dark matter" into physics without irrefutable direct experimental confirmation, which the unobservable matter is not. It only points to the impossibility of explaining the balance of matter in the Universe using the theory of primary nucleosynthesis. At the same time, the negative result is connected only with the inapplicability of the theory of primary nucleosynthesis, and in no way negates its theoretical constructions, built on the basis of the Standard Model of elementary particles. Unquestionably, there are some difficulties in the Standard Model. There is no doubt that it will be radically modified in the future. Nevertheless, it is necessary to remember two very important circumstances: first, the Standard Model is a complex theoretical structure that has managed to explain and predict many of the characteristic features of the world of elementary particles; secondly, although only indirect but experimental evidence in its favour still exists.

Indeed, there are no instruments that can directly detect the quark-gluon plasma from which our world is supposed to have originated. Moreover, a free quark is fundamentally impossible to detect in experiment. But the fact that a quark is not an invented structural element can already be considered a semi-empirical fact. The quark model was proposed by Gell-Mann and Zweig back in 1964. In 1969, Feynman proposed the parton model of hadrons. Moreover, in the same year, experiments were conducted on the scattering of electrons using the analysis of the form factor (Bjorken scaling) which confirmed it. And this experimental data became indirect confirmation of not only the parton model, but the quark model as well. The existence of a quark-gluon plasma is still only an assumption. But experimental data in various accelerators irrefutably demonstrate that something similar, even if it is not quark-gluon plasma, but, for example, just quark plasma, certainly exists.

4. The Model of the hot Universe

So, the generally accepted cosmological model of the evolution of the Universe is based on the model of the hot Universe, which has generated the following fundamental uncertainties:

- the physical meaning of the singularity;
- the meaning of the physical categories used for the evolutionary stages of the Universe, which occurred before the emergence of matter and radiation (energy, thermodynamic parameters);
- the physical meaning of cosmological inflation;
- the need to explain the asymmetry;

- the reason for the strictly specific and low value of the CMB Planck radiation temperature;
- "dark matter" as a new essence and its physical meaning;
- "dark energy" as a new essence and its physical meaning.

The first uncertainty, the singularity, is an inevitable consequence of the Big Bang theory. The complexity of such a concept discussed in literature lies in the fact that the density of matter and temperature cannot be infinitely high at the same time. But there is another difficulty: the fundamental unobservability of a singular point by an external observer, for whom time stops in the vicinity of such a point. This means that our Universe can be observed exclusively from the inside, and for internal observers it will be fundamentally alone. Different conclusions for different observers is a significant nuisance. Cosmological inflation seems to have eliminated singularity (this will be explained below when considering the physical nature of inflation). However, only partially: the lambda-CDM model left it in the description of black holes. In addition, the reference to the internal observer in the theory of inflation was even more pronounced, since the existence of an external observer cannot be considered even hypothetically.

The second uncertainty, although it is usually ignored, as if it does not exist, nevertheless, is very important. It is impossible to talk about pressure, temperature and entropy of our Universe if the substance as such has not yet appeared. It is even impossible to use the category "energy", because without matter and radiation it also cannot exist in the sense in which it was introduced into physics.

The third uncertainty, cosmological inflation, should be discussed at the end, as the crown of abstract physics generated by an incorrect model of the evolution of the Universe. But in the chronology of the Universe, it stands at the very beginning, so the discussion about it will be conducted at now.

Regardless of which version of the inflationary model should be taken as a basis, it in any case includes the model of a hot universe in its evolutionary chain, which implies the appearance at a certain stage of the evolution of an universe first of a plasma cloud, and then, after its recombination, of residual electromagnetic radiation with the Planck spectrum.

The inflationary model emerged because with the reverse chronology of the evolution of the Universe, it does not fold into a point and does not reach the Planck length (Planck era). And this means that at the initial moment of the birth of the Universe there were zones that were not causally connected with each other. Of course, this is a fundamental problem. But it can be solved by cosmological inflation: a local point due to inflation can be stretched so fast that in reverse chronology the Universe can easily be folded into a point. In this case, the initial conditions for the processes of substance creation are determined not by the state of the local point, but a spatial zone (depending on the inflationary model, the size of the zone and the processes occurring in it may change), i.e., the inflationary theory not only succeeds in solving the problem of inverse chronology, but also the problem of the primary singularity. However, this happens with the appearance of some inconveniences. Firstly, because preference is given to an internal observer (meaning the adoption of a model of a closed Universe with a fundamentally incomprehensible world outside it, but with the admissibility of the hypothetical possibility of the existence of other closed universes, between which a connection is hypothetically possible; however, all hypotheses are beyond the possibility of testing in experience). Secondly, due to the mathematical possibility of space-time to expand even though the substance that bends it has not yet appeared. Moreover, without substance it is generally impossible to choose a frame of reference, not just inertial or non-inertial one.

In the framework of the lambda-CDM model, first, space-time began to expand from a point according to an exponential law with a speed that quickly exceeded the speed of light. Exceeding the speed of light is permissible, since it is associated not with the movement of matter, but with a change in the metric. The internal observer cannot know that the expansion occurs from a point, since the entire Universe was located at this point, and everything infinitesimal for the external observer is not so for the internal one. But it remains absolutely unclear how the internal observer can understand that the metric is changing if physical processes, objective reality, cannot depend on the metric.

Despite the fact that inflation took place before the appearance of the substance, it nevertheless did not stop after its appearance, but simply entered a calm phase. And if a change in the metric changes the kinetic energy of the corpuscles and creates a Doppler shift in electromagnetic radiation, then, firstly, it is not the metric that is expanding, but ether or something else, and, secondly, the physical laws must also constantly change. In particular, thermodynamic systems cannot exist. And if considered carefully, it becomes clear that inertial frames of reference cannot exist in physics. And it is absolutely incomprehensible why drawing energy from the outside, as if from nothing, from another dimension, is permissible.

The expansion of space-time has no physical meaning, only mathematical. Moreover, the physical meaning is absent not only in inflation itself, but also in the pre-inflationary epoch: it is not clear what the physical essence of the initial scalar field is, the physical content of the initial quantum fluctuations, the evolution of vacuum, etc. The singular point is gone, but the initial positions are still left without a physical meaning. On the other hand, many new provisions, inexplicable from the point of view of physics, arose: physics as an integral science simply faded into the background for the period of inflation, it disappeared (along with all its conservation laws). It is very important to realize that the expansion of space-time cannot be interpreted as an expansion of matter in time and in space. Expansions of space-time and the Universe are completely different categories, not related to each other.

The fourth uncertainty associated with asymmetry is the most fundamental one. All of our knowledge and experience is based on the fact that the world around us is symmetrical. However, the model of the hot Universe requires a reason for the presence of baryonic matter in the absence of antimatter. Asymmetry at the very early stages of the evolution of the Universe, when an explanation of the appearance of one extra quark per billion quark-antiquark pairs is required, causes so many misunderstandings that, as a rule, the absence of antimatter is usually attributed to the later appearance of asymmetric processes. So far, however, all attempts have been unsuccessful. And since the question of asymmetry is posed exclusively by the model of the hot Universe (the observed asymmetry within the Standard Model does not solve the problem of the excess of baryonic matter over antimatter), then at this stage of the presentation of the material it becomes clear that it will remain unresolved forever. The appearance of matter from a vacuum only together with antimatter is as fundamental a law as the law of conservation of energy.

The fifth uncertainty associated with the observed characteristics of the cosmic microwave background not only deprives the model of the hot Universe of support by experimental data, but, in fact, immediately, independently and unconditionally, refutes this model, since other explanations of the CMB origin will inevitably contradict it in principle.

First, it is necessary to understand whether a very accurate temperature of an ideal black body is compatible with the recombination process. It is important to note that the model of the hot Universe was taken as the base before the appearance of the theory of inflation. And since the process of recombination of plasma expanding in space occurs from the periphery of the plasma cloud and is, at the same time, a gradual, smooth process, then the spectrum of the released radiation, for whatever moment of recombination time it is considered, cannot be characterized by a strictly defined temperature of the black body (the peak of the spectrum must be blurry). The ideal Planck spectrum is possible only for an equilibrium system, and is not applicable for transients, especially for the fast ones, which do not provide time for relaxation to an open system. For the word, the CMB spectrum is not an ideal Planck spectrum, whereas for a homogeneous plasma it is bound to be one. However, at this point the focus is on the possibility of the spectrum of the primary plasma to have such a shape, that would make it possible to judge the temperature of the emitting object with a high degree of accuracy. Even if we assume a simultaneous decrease in the temperature of the plasma cloud over the entire spatial volume it occupies due to the expansion of space-time (today it is accepted that the expansion of space-time, on the contrary, accelerates baryonic matter in violation of its equilibrium thermodynamic state, increasing only the radial velocities), the instantaneous recombination will still not occur. The ionization energy of the hydrogen atom is strictly fixed, but the energies of protons, electrons and photons are not. Moreover, in addition to the "energy" criterion, there is also the "impact distance" criterion. Therefore, photons must inevitably be released in stages, while the plasma cloud continues to cool simultaneously throughout the volume. No matter how difficult scenario of the release of electromagnetic radiation from recombining plasma is chosen, it will not allow the creation of a snapshot of the Planck spectrum without absorption lines, which remain unchanged for decades, which were spent on its study by terrestrial observers. It is clear that, in astronomical standards, decades are an instant. But we are talking about a physical process, and not about astronomical distances and history.

Further, it is necessary to understand, what physical phenomena caused the temperature of the released radiation to decrease. After all, photons that are not in equilibrium with matter cannot cool down. They are not a thermodynamic system, especially a gas. If the ideal gas can be described by the Maxwell distribution, the thermal radiation of a blackbody is described by the Planck distribution, which does not coincide with the Maxwell distribution. The Planck distribution can be obtained from the Bose – Einstein distribution, which takes into account quantum effects. But free photons are not associated with oscillators, are not related to any quantum effects and do not comply with any statistics. Photonic gas does not contain a mechanism that can lead it to a state of thermodynamic equilibrium. Thermodynamic equilibrium occurs either from thermostatic walls that limit the photon gas, or, in the case of mirrored walls, as Planck suggests, by absorption and emission of photons by a blackbody located inside the cavity. The interaction of photons with matter is a prerequisite when considering them as a thermodynamic system. Even if the photons released after plasma recombination are enclosed in a volume surrounded by mirrors, they will still not become a thermodynamic system. At the same time, the gravitational forces of the substance of the recombined plasma are unable to create the effect of walls, particularly mirror walls, for the released photons. Moreover, in equilibrium electromagnetic radiation, the number of photons is proportional to the cube of temperature. A free photonic gas cannot change the number of photons depending on the energy distribution of photons (on the photon spectrum). An attempt to explain the cooling of the relict background by reducing the photon density by a geometric increase in the volume occupied by the photon gas (due to the expansion of the photon gas) with a simultaneous decrease in the photon energy spent on overcoming the forces of gravity does not stand up to criticism.

At the time of the adoption of the model of the hot Universe as a basic assumption, there was no discussion about the expansion of space-time, which, for some inexplicable reason, is able to cool photons. But even if we assume that free photons form an expanding gas and cool down during the exchange of momentum and energy with each other, or that photons are decelerated by the gravitational field of all of the created matter, or that photon flows from the surface of the last scattering to the terrestrial observer lengthen their wavelengths due to expansion space-time, then all these processes cannot preserve the Planck spectrum with compliance of Wien's displacement law. The impossibility of cooling of the free electromagnetic radiation with a Planck spectrum in any way is such a significant fact that it alone is sufficient to establish the erroneousness of the accepted position on the connection between the CMB and the primary plasma.

Thus, the observed CMB parameters are not so much an uncertainty associated with the need to explain them as a relic from past eras, but rather a decisive argument for the lack of proof of the hot Universe model (it was the detection of the background that gave rise to the general acceptance of the hot Universe model).

The sixth and seventh uncertainties are associated with the explanation of the meaning of the categories "dark matter" and "dark energy" newly introduced into the theory. Both categories, as mentioned above, were introduced in order to save the model of a hot universe. But at this stage it is already becoming clear that the number of "life rings" has already exceeded all conceivable and inconceivable critical points. The model of the hot Universe has no right to be a theory, but is only one of the hypotheses that is not destined to survive.

All of the above uncertainties associated with the hot Universe model have already been discussed by the author in peer-reviewed journals.

In the work of Belyaev [3], there are a number of important arguments, in addition to those mentioned above, which forbid regarding cosmic microwave electromagnetic radiation as a relict background. In another work of Belyaev [4] it is explained that it is not required to introduce a new category of "dark energy" to describe the accelerated divergence of distant galaxies; classical gravity, if the model of a hot Universe is ignored, is quite enough for this. Despite the completely different topics considered in the aforementioned works, a single conclusion was reached: the Universe is surrounded by a dense halo with generally uniformly distributed matter. A homogeneous cloud of primary plasma is unable to generate a halo around itself. Therefore, the first stages of the evolution of the Universe cannot be characterized by the appearance of a uniform plasma cloud.

To develop a new model for the birth of the Universe, it is first important to understand what the essential characteristics of the early Universe should be. In the work of Belyaev [5], an attempt was made to develop a concept for constructing a new theory of the birth of the Universe to replace the existing theories based on an erroneous model of the hot Universe. It is also useful to note that in the above-mentioned work [5], one more weighty argument was given for the erroneousness of the model of the hot Universe, which was not included in the above list of fundamental uncertainties generated by the model.

It is believed that the law of the expansion of the Universe discovered by Hubble (the divergence of matter in space, not the expansion of space-time) confirmed Friedman's nonstationary model of the expansion of the Universe, i.e. that it confirms the Big Bang model. However, the analysis carried out in [5] showed that Hubble's law does not confirm the accepted model of the Big Bang based on the model of the hot Universe, but, on the contrary, contradicts it.

Further, in work [5], which showed that the birth of the Universe is not associated with the emergence of an isolated cloud of matter consisting of elements obeying statistical laws, the conclusion was drawn about the required initial form of matter distribution: "elementary particles that appeared in the act of birth of the Universe must have distribution obeying central symmetry, and should have preferential velocity along the radial lines". Based on this conclusion, a hypothesis of a possible variant of the emergence of a substance was proposed.

But in papers [4] and [5], one difficulty arose: they asserted that with a spherically symmetrically distributed mass of matter, the peripheral matter is capable of affecting the internal matter, which is a violation of the corollary of the Gauss theorem. Therefore, in the work of Belyaev [6], the physical meaning of the Gauss theorem was considered and it was explained why the corollary of the Gauss theorem for a spherically symmetrically distributed substance can be violated. Additionally, this conclusion made it possible to reveal new patterns of gravitational compression of single and calm gas-dust clouds: the physical principles of the proposed new model of the formation of a single star are described in the work of Belyaev [7] and the features of the formation of planets of a single star are described in the work of Belyaev [8].

Thus, the listed works not only demonstrated that a new concept of the evolution of the Universe is required, but also made it possible to determine the basic principles of its construction. The results obtained in these works were summarized in the work of Belyaev [9], in which it was shown that all the arguments in favour of the new category of "dark matter" can successfully be taken into account without using this category, if the model of the hot Universe is abandoned.

5. Possible compilation of hidden mass

5.1. Expected localization and form of existence of the hidden mass

It is well known that it is easier to destroy than to create. Of course, the model of the hot Universe did not appear out of this air, its appearance was a naturally result. In order to conclude that the model of the hot Universe has no experimental validation, it is enough to note that the Planck spectrum of high-temperature photons cannot be transferred into the Planck spectrum of low-temperature photons if the photons are not in equilibrium with the cooling matter (the Planck spectrum changes with observance of Wien's law of displacement). At the same time, an individual can remove a single brick of the foundation, which can lead to the destruction of the entire harmonious system created by the team. However, the labour of the entire scientific community is required to create a new harmonious system from.

So, the intermediate result is as follows. Astronomical observations unambiguously indicate the presence of unobservable matter in space, the mass of which significantly exceeds the mass of observed matter. Moreover, the unobservable matter is not some unknown new form of matter. It is a baryonic substance, i.e. is a hidden mass, and does not belong to the new category of "dark matter". The observed abundance of deuterium does not contradict the existence of hidden mass, since deuterium was not produced in primary nucleosynthesis, which, due to the erroneousness of the hot Universe model, simply did not exist. At the same time, the hidden mass cannot be gas or dust, nor an accumulation of free elementary particles. Due to the fact that the hidden mass stably retains its spatial location and penetrates gas clouds quite freely, it must consist of compact, but not large objects. This is also evidenced by the numerous results obtained using various gravitational lensing techniques. Searches for compact objects in our galaxy have demonstrated that the majority, which constitutes the predominant fraction of the mass of unobservable matter, cannot exceed two masses of the Moon. Since the hidden mass does not intensely emit electromagnetic radiation, compact objects are cold.

The data obtained from modern astronomical observations does not provide clues as to what processes may allow the production of cold compact objects from ordinary matter with a large total mass. Moreover, it is necessary to understand how such objects are able to accumulate outside the zones of observed matter. But first, it is necessary to work out the specific zones in which the unobservable matter is concentrated and according to which laws does it distribute its average mass density. To do this, it is useful to have another look at dark matter and get acquainted with modern ideas about its spatial distribution.

It is implied that dark matter is present in almost all of space, but with variable concentration. It is present in the form of clouds. In all likelihood, there is no turbulence or eddies in these clouds. It is assumed that dark matter is unaffected by torques. It does not collapse into dense clumps and does not join orbital movements. Somehow it always remains in the form of a static all-filling gas, locally changing its density under the influence of gravitational forces. How this can happen, remains a mystery (since the nature of dark matter is not known). But clouds of different densities create variable gravitational potentials and affect the accumulations of baryonic matter. For example, baryonic matter is drawn with increased density into a zone of dark matter and forms a galaxy in the central region of this zone. So much baryonic matter is accumulated that its mass in the spatial region it occupies becomes many times greater than the mass of dark matter in this region. At the same time, the mass of dark matter begins to dominate outside the accumulated baryonic matter, as if forming the halo of the galaxy. Many galaxies, including ours, include hot gas in their composition, which is not located in the disk of the galaxy, but in its volume. It would be impossible to contain such a gas without the halo.

Thus, taking into account the above remark about cosmological filaments of the large-scale structure of the Universe, the unobservable matter of which should mainly consist of the warm-hot phase of baryonic matter and have a moderate share of the total mass of unobservable matter, the main part of the unobservable matter belongs to the galactic halo. But what are the requirements for the structure of the halo, for the distribution of the average mass density in it?

The article by Belyaev [10] was devoted to this topic. It explains that the average density of the hidden mass forming the galactic halo does not decrease inversely to the growth of the square of the radius from the centre of mass of the galaxy to the considered concentric spherical surface outside the observed cluster zone of visible matter of the galaxy, as is commonly believed today. Hidden mass does not form rarefied crown with a continuously decreasing density of matter towards the periphery, but is completely concentrated on the periphery, i.e. forms a halo, not a crown. As noted above, there is almost no matter between the visible zone of the galaxy and the largest radius of the flat portion of the rotation curve. This is due to the fact that matter from this zone, contrary to the corollary of the Gauss theorem about the absence of a gravitational field inside the central concentric cavity with a spherically symmetrically distributed mass, gradually flows, as shown in [10], to the peripheral massive shell, i.e., the substance "falls" not to the centre of mass, but to the periphery. Therefore, the spherical layer between the central visible zone of the galaxy and its distant halo becomes almost completely rarefied, and the observed rotation curve is characterised the gravitational attraction to the peripheral dense layer of the galaxy. Thus, it is not necessary to specially distribute the substance of the hidden mass according to a certain law with the imposition of restrictions on the unit masses of its constituent objects.

Since small compact objects can avoid colliding with each other for a very long time, even in the astronomical sense of this term, the galactic halo they form will be stable. Moreover, although these compact objects are part of the galaxy, they are not its orbital objects, but form a gravitationally bound structure of an independent invisible component of the galaxy on a distant equipotential surface formed by the visible component of the galaxy. The invisible component of the galaxy has its own Roche lobe and may be stationary (not rotating) as a whole with respect to the observed visible component (visible part of the galaxy). When galaxies they collide, compact objects of their invisible halos are almost not decelerated by the gas of galaxies, forming a blurred region of unobservable matter. In general, objects like asteroids cannot raise any objections as contenders for compiling the hidden mass of the galaxy. Not a single scientist would have a shadow of doubt about the fundamental possibility of such an option, if there was at least some hint of how such objects could arise en masse and concentrate on the distant periphery.

5.2. The description of the stage in the evolution of the Universe associated with the formation of hidden mass

At this stage in the presentation of the material, it becomes clear that the hidden mass was formed at the early stages of the evolution of the Universe, during the formation of galaxies. However, the terrestrial observer cannot observe events that are distant in time. This is not due to of the imperfection of the current technical capabilities, as has been thought, but in principle. There are simply no signals from that era in the vicinity of the Solar system. This is an important point, which contradicts many modern ideas. Therefore, a brief explanatory comment follows.

The further away the space object, the younger we observe it, since the propagation of the electromagnetic signal sent from it takes time. Because the signal comes with a delay, what we observe is the past. But it is impossible to observe any past, including signals from the moment of the origin of the Universe. The fact is that in order to send a signal from its periphery to the terrestrial observer located in the inner region of the Universe expanding from a geometric point, the signal generator still needs to get to the periphery and spend time on this. The farther a space object is from us, the longer it takes for it to move to this distant point. And we are not able to know what happened to it in this process of movement: the photons from the object move in a straight line, without interactions, therefore, earlier photons, related to the earlier history of the object, have already passed through the place of localization of terrestrial observers.

The illusion of the possibility of registering signals from the past took root due to the fact that the cosmic microwave background was mistaken for relic radiation. At that time, the theory of cosmological inflation did not exist, but there was an idea of the possibility of registering all cosmological events after plasma recombination (since the theory of cosmological inflation has no physical meaning, it will not be mentioned further, first it is important to deal with the initial positions). The fallacy of such a representation, including the possibility of observing equilibrium radiation of the primary plasma, can be explained by the following estimated averaging reasoning.

Each spheric layer of an adiabatically expanding primary equilibrium plasma in the hot Universe model has its own radial velocity. Let us assume that in the frame of reference associated with the singular point, the terrestrial observer was moving rectilinearly from the singular point to his present location with the identical average velocity v_1, and the peripheral plasma region, which subsequently formed a space object detected by the modern terrestrial observer, was moving along the same straight line at an average speed v_0, where $v_0 > v_1$. At a certain historical moment in the evolution of our Universe τ_0, a space object assembled from the peripheral matter of the primary plasma sent an electromagnetic signal to the terrestrial observer, which was received after a time interval τ_1. The signal moved at the speed of light c, so the terrestrial observer concludes that he has detected an object located at a distance of τ_1 light years (at a distance of $\tau_1 c$). The observed signal gives information about what happened to the space object τ_1 time ago. But this time is not taken from the moment of the birth of the Universe. At the moment of signal generation, the age of the Universe τ_0 was greater than the subsequent signal propagation time τ_1, since in order for the signal propagation time to be exactly that, this object still needed to get to the signal generation point with a speed relative to the terrestrial observer $(v_0 - v_1)$: $\tau_0 = \tau_1 (c + v_1) / (v_0 - v_1)$. The time it takes for a signal to travel from a distant object to a terrestrial observer will approximately equal the age of the Universe only if the average velocity of removal of peripheral matter from the point of the Big Bang approaches the speed of light: $v_0 \to c$. But it will only be possible to detect such a signal for the current age of the Universe at that time τ_0: the entire previous history of the peripheral space object, which we would like to obtain to study the evolution of the Universe, will be available for the terrestrial observer only in the record of a device that would have to had to be installed at that point a very long time ago by someone, even before the appearance of humans and the emergence of the Solar system.

Since the time interval from the birth of the Universe to the recombination of the primary plasma is significantly less than the age of the Universe (by five orders of magnitude), the events of the early epoch, including the release of a photon gas, are fundamentally impossible to observe at present. It is impossible for the simple reason that we consist of the matter that, albeit transformed, but, nevertheless, once constituted the primary plasma; and the equilibrium radiation of the primary plasma has long left not only the spatial zone previously occupied by the plasma, but also the zone occupied by the matter of the Universe at the current moment of time, no matter how fast the substance expands (it is assumed that the expansion rate of the primary plasma cloud is always lower than the speed of light). And if the Universe is expanding from a local zone, then it does not matter which model describes its evolution, be it the model of the hot Universe or any other. In any case, there will not even be a theoretical possibility of detecting electromagnetic radiation of the early stages of the evolution of the Universe.

So, we need to describe the initial evolution of the Universe associated with the stage of formation of galaxies, but it is impossible to see how this happened, since such information has already been erased by the halo of the Universe. So the only remaining option is modelling. But in order to create a model, the initial conditions are required, i.e. it is necessary to trace the stages preceding the emergence of galaxies. Since this topic is not related to the process of forming the hidden mass itself, we will perform all the indicated procedures only by describing the principles of the actions performed.

Practice shows that the space around us is homogeneous and isotropic. In fact, it is still unclear what "homogeneity" and "isotropy" are in relation to emptiness. But Euclid's geometry works in our space: all geometric figures assembled from matter can be freely moved (rectilinearly and uniformly) and rotated (slowly, without creating centripetal forces) without breaking their congruence, and the sum of the angles in a triangle is always 180 degrees.

The primary plasma of the hot Universe model was homogeneous and isotropic. But its existence at a certain evolutionary stage generates, as was demonstrated in the previous chapter, many uncertainties in the explanation of the actual observed properties of the Universe. In the above-mentioned work [9] it was shown, but not in detail, but in a principal, that the spherical symmetry of the Universe is consistent with its observed manifestation. However, the birth of a spherically symmetric Universe implies the appearance of preferred directions at the moment of the birth of the Universe. And these preferences should appear based on the fundamental property of isotropy for any single physical act of the birth of a pair of "particle – antiparticle".

Just like in the inflationary theory, in [5] it was assumed that the Universe was born from a vacuum. However, because it is not yet possible to judge the physical essence of the vacuum, as deciphered in this work, going beyond assumptions is not possible. This is a matter for the future. But we have some information about the processes of creation of pairs of elementary particles. For example, we know that pairs of virtual particles in highly inhomogeneous physical fields can turn into pairs of real particles. But this means that the direction of propagation of a generated pair of particle and antiparticle will be set by a field line of the vector field. This led to the assumption that at the initial moment of the birth of the Universe a local disturbance of vacuum arose, as a result of which a scattering decaying spherical wave of emerging "electron - positron" pairs appeared. It was believed that the positrons flew in radial directions, and the electrons flew towards the centre. The colliding electrons generated a wave of radially scattering antiprotons and protons stacking in the centre, forming an unstable formation, similar to a quark-gluon plasma. The result was the creation of elementary particles with radially directed velocities and with spherical symmetry of their quantitative distribution.

All assumptions of the discussed work [5] are speculative. Its main goal is not to create a real picture of the birth of the Universe, but only to demonstrate the fundamental possibility of the birth of matter with spherical symmetry, the possibility of such a situation when the principle of equal rights of all directions can hypothetically be violated without breaking the symmetry of single processes. It is obvious that in the future all the presented speculative conclusions will be radically revised. In the meantime, the physical essence of the initial moment of the birth of the Universe remains unclear. However, the new approach, albeit still completely vague and unrefined, makes it possible to describe our world without breaking the symmetry between matter and antimatter, as well as without introducing new entities into the theory.

In work [5], it was assumed that antimatter is concentrated at the periphery of the Universe. It is possible that this is not the case. But the conclusion of [3,4] about the existence of a halo in the Universe is not just weighty, but, apparently, inevitable and reliable. Perhaps the halo of the Universe is composed of antimatter, perhaps not. However, it is this halo that is the source of the CMB. The accelerated divergence of matter in the Universe is also due to the existence of this halo. And a halo with generally uniformly distributed matter can only appear due to the creation of matter with an initially spherically symmetric distribution (the generation of matter at the birth of the Universe is not a singular instantaneous event, but one lasting for a certain time).

Thus, there was no primary plasma cloud in the evolution of the Universe, but there were protons and electrons with spherically symmetrical distribution. Moreover, such a "plasma" cloud has one unique feature: although the protons scattering from the birthplace are characterized by relativistic velocities, nevertheless, they do not approach each other and have exclusively radially directed velocity components. This means that the temperature of the "cloud" of relativistic protons is equivalent to absolute zero, i.e. proton gas has no pressure. Accordingly, under such conditions, Jeans theory does not work.

But, firstly, the born substance expands and, accordingly, does not occupy an infinite volume. Therefore, the rate of expansion due to the presence of gravitational forces must slow down (as explained in [4], the accelerated expansion of matter at the periphery of the cloud does not mean the accelerated expansion of the entire Universe) simultaneously making the layers more compact, starting from the periphery towards the inner zone. Secondly, elementary particles move radially, so their quantitative and mass densities automatically decrease due to the geometric factor. Under conditions of variable density between the spherical layers, the gravitational forces will inevitably begin to pull the particles of matter first into annular spherical zones, and then, within these zones, into real clouds, in which collisions between particles will begin, i.e. the clouds will begin to gradually warm up and become gas clouds.

Mathematical modelling is required to determine the size of the gas clouds. At the moment, however, modelling is not yet feasible, due to the lack of a new developed model of the birth of the Universe with a qualitative and quantitative description of the processes taking place. Therefore, taking into account that from the moment of the formation of condensed spherical gas zones, the problem becomes similar to the Jeans problem, and also that this work is devoted not to the consideration of cosmological problems, but to the discussion of the impossibility of introducing a new entity "dark matter" into the theory and defining the general fundamental approaches to finding a complete set "hidden mass", it can be assumed without any evidence that a separate primary cloud will include in its composition such an amount of matter that is comparable to the mass of the galaxy. The reason for this decision is that current discussion focuses on the formation of the hidden mass of an individual galaxy. And galaxies began to form due to the discretization of the primary hydrogen cloud. Of course, one should take into account the theoretical possibility of discretizing the primary cloud into small clouds that give rise to stars, which subsequently merge into galaxies. However, the existing practice of considering the Jeans problem suggests that galaxies were formed first. Therefore, the accepted initial position is as follows: all galaxies begin to form from cold gas clouds consisting only of hydrogen (without helium and lithium).

A prominent characteristic feature can be distinguished for such clouds. Taking into account the large initial size of the cloud, its strong rarefaction and low temperature (i.e., low speed of sound), the heating of the cloud does not begin from the centre, as is currently believed in astrophysics, but from the periphery (maximum gravitational forces act on peripheral particles). Cloud pressure also begins to increase from the periphery. As the cloud compresses, the pressure will equalize throughout the volume and then rise to a greater extent in the centre. But the described prehistory will lead to the fact that thermonuclear reactions with the formation of deuterium (in proton-proton collisions, including reactions with electron capture) will occupy a vast zone, practically covering the entire cloud. These separately occurring high-energy thermonuclear reactions will significantly slow the compression of the cloud, preventing the start of the proton-proton chain reaction. It seems that the observed abundance of deuterium is associated with such mechanism of its production.

Taking into account that in separate thermonuclear reactions that occur independently of each other it is not the dwindling impurity (not lithium-7) that burn out, since there are no impurities in the hydrogen cloud, such a quasi-stable central zone, which does not lend itself to compression, could persist for a very long time. However, such a region heated before the onset of thermonuclear reactions appears primarily due to the massiveness of the contracting hydrogen cloud. Therefore, new portions of hydrogen will continue to supply the central zone. Therefore, the star will inevitably ignite. But, given the absence of turbulence and vortex flows (for their occurrence, favourable conditions could not appear in a gravitationally contracting initially rarefied cold gas cloud of large dimensions in the absence of small inhomogeneities and the absence of wave disturbances), only one star in the entire galaxy will ignite. This will be the first generation star. Furthermore, this will not be an ordinary star, but a hypergiant. The expected death of the hypergiant is a supernovae explosion. The main feature of the described evolutionary stage associated with first generation stars is the presence of dense and moderately hot (warm-hot phase) gas which surrounds the star, driven away and additionally compacted by the stellar wind while the star is alive. The mass of such a gas will greatly exceed the mass of a hypergiant.

This is not the case for stars of subsequent generations, however. As explained above, the stars of the first generation are inaccessible to modern astronomical observations, information about those times has already been erased. For this reason, astronomical observations cannot confirm or refute the suggested described mechanism of formation of galaxies and will not give clues as to how the hidden mass was formed.

We know that all space objects are created due to gravitational compression. Initially there is only gas. The gravitational compression of the gas ends in an explosion. Hypothetically, an explosion can occur with a complete scattering of matter, which then cools down and turns into hidden mass. However, astronomical observations and theory suggest that an explosion of a hypergiant cannot occur with a complete scattering of matter. But even if the explosion took place without a residue, with a complete scatter of matter, then all the same, the mass of the hypergiant would not be enough to form the hidden mass from its fragments. The hypergiant, with some fraction of the adjacent gas cloud, should be the progenitor of the visible part of the galaxy; and the hidden mass, which makes up the majority of the galaxy's mass, should be formed from the main part of the gas cloud surrounding the hypergiant. Taking into account that the hidden mass consists of objects similar to asteroids, the main part of the heated gas cloud must somehow transform into a huge number of asteroids, ignoring the stage of star formation (the cloud is gas, not gas and dust). To date, no possible mechanisms for such a transformation are known.

5.3. A possible process of formation of hidden mass

There is only one way out of this situation. In the work of Belyaev [11] it is shown that the gravitational compression of a gas cloud in outer space does not always have to occur with self-heating alone.

On the one hand, the gravitational forces of a single gas cloud are always compressive and do work when compressed. In the general case, as follows from the definition of the category "work", one type of energy, due to which the work is performed, decreases, while the other type of energy, to which the work is directed, increases, i.e. performing work is inevitably associated with a change in various types of energy while maintaining the total energy balance. During gravitational compression, the energy of the gravitational field decreases (it is negative, therefore, the modulus increases, which means that in the process of compression, the gravitational forces are continuously growing). And the internal energy increases.

The growth of the internal energy is due to the fact that the forces of gravity impart additional impulses on the gas particles, i.e. gravitational compression inevitably causes an increase in temperature (and accordingly, an increase in internal energy). Moreover, the rise in temperature would be unlimited if there was no resistance to compression. Resistance to the forces of gravity exerts pressure. If the increase in pressure was determined only by the increase in temperature, then there would never be enough back pressure to stop gravitational compression, since the temperature first rises, and only then, due to the rise in temperature, the pressure rises. But the pressure also depends on the density. Since compression, due to the geometric factor, also increases the density, the process of gravitational compression inevitably stops. However, this is true only for an isolated cloud.

Isolation of a physical system means the case when a zero balance of energy inflow and outflow is observed in it. In outer space, any material system with a temperature above absolute zero is non-isolated, since it has losses due to radiation. Only one known option for fulfilling the system isolation condition exists: when a star ignites. The external energy (for a thermodynamic system) of thermonuclear fusion compensates for the energy losses of the gas cloud and turns the non-isolated system into an isolated one. Therefore, the gravitational compression stops. But the star remains stable only until the thermonuclear fuel burns out. After that, while the object remains gaseous, its gravitational compression can no longer stop. Thus, for an uninsulated gas cloud, in the absence of an external energy source feeding the thermodynamic system, the process of gravitational compression, due to insufficient growth of back pressure caused by energy losses with electromagnetic radiation, cannot stop.

On the other hand, although the forces of gravity do work by heating the particles of the gas cloud, the energy loss of an uninsulated system can prevent the increase in its internal energy and radically change the principle of compression. As explained in [11], this can happen for the following reason.

All the processes of gravitational compression in space that we observe occur with self-heating due to the priority of gravitational forces: at first, the gravitational forces do work, and only then, as a result, the thermodynamic system creates a reciprocal backpressure. But radiation losses do not allow the system to create the required backpressure, and compression to increase the pressure continues, causing excessive heating and new excess losses. So, in the beginning, as a cause, gravitational compression occurs, and then, as a consequence, a change in heat losses occurs.

However, if the primary cause is losses, and gravitational compression turns out to be a consequence that attempts to restore the decreasing initial temperature, then the work of the forces of gravity will be directed not at creating backpressure and increasing internal energy, but at maintaining enthalpy. In this case, the internal energy will continuously decrease, since heating due to gravitational compression will occur to compensate for the losses that take place as a consequence, i.e. with a slight delay in relation to continuous losses. Thus, although the pressure will continuously rise, the temperature will continue to fall. This means that the gas compressed by the forces of gravity and cooling due to heat losses at a certain point in time will begin to condense, and then, due to the continuing heat losses from the liquid, crystallize.

If we consider hydrogen, the aggregate state of which in the region of absolute zero depends on pressure, then its crystallization will be dependent on the pressure reached at the beginning of the phase transition. Meanwhile, it should be understood that under the described conditions of compression, weak gravitational forces are capable of creating colossal pressure even with a small total mass of the initial hydrogen cloud, since the increase in pressure will be determined not by the increase in temperature, but by the increase in density. Therefore, the appearance of solid hydrogen is quite acceptable. However, the type of aggregate state of the objects being formed requires separate studies. It is useful to note that although liquid hydrogen is very unlikely for objects of latent mass, nevertheless, theoretically, nothing prevents them from being liquid.

It is also important to understand that self-cooling gravitational compression cannot spontaneously transform into self-heating gravitational compression, and vice versa. The laws of physics will not allow it. The change from one gravitational compression regime to another can only be forced.

5.4. Compression with self-cooling and the physical parameters required to trigger it

It is important to figure out what parameters trigger which type of gravitational compression of a gas cloud in outer space. To do this, we will consider gas as a thermodynamic system. For the system to be thermodynamic, it is not necessary to bring the gas parameters close to those similar to an ideal gas. The most important thing is for the laws of statistics to begin working. We are used to the fact that the laws of statistics work when the collisions of the particles that make up the system are of the same type and completely elastic. The latter means that in all pairwise collisions of particles, their total kinetic energy is conserved. However, if collisions of particles with each other become accompanied by quantum or other effects that consume kinetic energy, this does not necessarily mean a violation of statistical laws. The main thing is for the acts of energy absorption to be reversible, and the absorbed kinetic energy will then have the opportunity to be converted again into kinetic energy, so that each act of violation of the law of conservation of the total kinetic energy of colliding particles is characterized by strictly defined rules, so that the resulting interactions are persistent due to the multiplicity of elements that make up the system. Therefore, an arbitrary gas that does not imitate billiard balls, has complex molecules, is in equilibrium with its electromagnetic radiation and even allows reversible metamorphoses of its elements, still remains a thermodynamic system, but is somewhat more difficult to describe. The basic principle that allows us to describe a system using statistical parameters is when its elements with sustained interaction in the absence of irreversible processes constitute a closed and isolated system (the flows of particles and energy from the system and to the system must always be strictly the same or zero). Then the laws of conservation of energy, momentum and angular momentum will inevitably ensure the fulfilment of statistical laws.

Taking into account the above, we can conclude that the most perfect thermodynamic system consisting of gas is an infinite gas cloud. Then, regardless of the composition of the gas and its parameters, statistical laws will inevitably make the gas homogeneous in composition, in characteristics and processes occurring in it. If not for one complicating circumstance. The forces of potential interaction can violate not only homogeneity, but also the laws of statistics. All the particles that make up the gas necessarily create long-range gravitational fields around them, and electrically charged particles create additional long-range electromagnetic fields. But if the infinite gas cloud is initially homogeneous, then the gravitational and electromagnetic fields will also be homogeneous and will not be able to distort statistical laws, regardless of current characteristics of the cloud. The laws of statistics will constantly equalize the average density of the particles constituting the cloud, the average specific thermodynamic characteristics, including the specific internal energy, and even the intensities of phase transitions and reversible chemical or other transformations, if any exist.

Now imagine that there is such a large gas cloud in outer space that it can be taken as infinite. This assumption will be quite strict if we consider a small area of a large gas cloud. If we choose the spherical area for consideration and mentally instantly remove all the gas around this area, then at the initial moment of time the laws of statistics will still work for the selected area.

Due to the absence of surface tension forces in the spherical gas cloud formed from the former infinitely large gas cloud and in connection with the equal rights for gas particles of all spatial directions, half of the particles of the surface spherical layer of thickness dr at the initial time will leave the original considered gas cloud. The particles leaving the cloud will be decelerated by the cloud' gravitational field. But, depending on the initial conditions, these particles can either return back to the cloud or break away from it, i.e. fly away with no return. Particles leaving the initial gas cloud, including those subsequently returned by gravity, for the considered initial moment of time, carry away the energy of the cloud.

Let us assume that the considered cloud at the initial moment of time is an ideal gas, still described by the formulas of thermodynamic equilibrium. The internal energy of an ideal gas is: $U_{int} = MnT$, where M is the mass of the cloud; $n = (i/2)\cdot(R/\mu)$ is the proportionality coefficient, depending on the number of degrees of freedom of the particles i making up the gas, the universal gas constant $R \approx 8{,}31$ J / (mol·K) and molar mass μ; T is the absolute temperature of the cloud. The mass of a surface spherical layer with a thickness dr and with a volume dV will be: $dM = \rho dV$, where ρ is the mass density of the cloud (at the initial moment of time, the cloud is homogeneous). The energy lost by the cloud with the entrainment of particles, equal to half the internal energy of the surface layer, will be:

$$dU_{int} = (1/2)nT\rho dV. \tag{1}$$

From the equation of state for an ideal gas $\rho = (\mu/R)\cdot(P/T)$, where P is the gas pressure (under initial conditions, the pressure in the cloud is uniform). Therefore, we can conclude that the initial losses of the cloud caused by scattering, due to which the internal energy of the cloud decreases, are completely determined by the cloud pressure: $dU_{int} = (i/4)PdV$. This conclusion looks quite logical and expected.

The instantly removed environment for the cloud in question not only makes the system open, but also non-isolated: energy losses appear due to thermal radiation from the cloud. The volumetric radiation energy density u_{em}, according to the Stefan-Boltzmann law, is proportional to the temperature T in the fourth power. Therefore, the amount of radiant energy contained in the peripheral layer of thickness dr is equal to: $U_{dV} = \alpha T^4 dV$, where $\alpha \approx 7.91 \cdot 10^{-16}/\ (\mathrm{K}^4\cdot\mathrm{m}^3)$ is a universal constant. The volumetric energy density of isotropic radiation u_{em} is completely determined by the thermodynamically balanced radiation intensity, which depends on the emission and absorption capacities of the gas, related by the Kirchhoff law (the cloud consists of an equilibrium mixture of gas particles and photons). For a gas surface layer that is infinitely small in thickness, energy losses with radiation are determined by the emission capacity of the gas. However, for assessing the instability of a cloud, one should consider a thicker surface layer in which the gas and photons are in equilibrium. This surface layer is also composed of elementary layers, but the intensity of outgoing radiation from the outer elementary layers will tend towards the intensity of equilibrium radiation. Therefore, the amount of lost radiant energy from the peripheral layer will be:

$$dU_{em} = \alpha T^4 dV. \tag{2}$$

In addition, by selecting the system under consideration in the described way not only makes the system open and non-isolated, but also instantly transforms a homogeneous gravitational field into an inhomogeneous one, tending towards the destruction of the existing statistical laws. At the same time, the cloud's own gravitational field tends to create a boundary around it, i.e. make the system closed. The energy of gravitational attraction of particles leaving the cloud, which can be equated to half the energy of attraction of the peripheral layer of thickness *dr* to the entire gas cloud having radius r, will be: $dU_{gr} = (1/2)G(M{\cdot}dM / r)$, where $G \approx 6.67 \cdot 10^{-11}$ m^3 / (kg·s^2) is a gravitational constant. If we express the masses in the written expression through the products of the density and the volumes occupied by these masses, then we get:

$$dU_{gr} = (2/3)\pi r^2 \rho^2 G dV. \tag{3}$$

If the expressions (1), (2) are associated with total energy losses from the cloud as a whole, which ultimately occur through the boundary layer of the cloud, then expression (3), although associated with the arrival of energy (the internal gravitational energy of the cloud, in fact is a source of energy external to the thermodynamic system), does not determine the total energy input, but only the energy supplied to the boundary layer. However, it is this part of the supplied energy that resists the scattering of the cloud and causes its geometric compression. Moreover, the released gravitational energy inside the cloud generates mechanisms that counteract compression (although these mechanisms do not lead to expansion of the cloud, but only to resistance to compression). Therefore, in order to understand whether the cloud at the initial moment of time will begin to compress or dissipate, it is necessary to compose an energy balance from expressions (1) – (3) only for the boundary layer.

Gravity and emission of electromagnetic radiation are associated with compression, and the loss of internal energy – with expansion (due to scattering). Therefore, if the sum ($dU_{gr} + dU_{em}$) at the initial moment of time is greater than the value of dU_{int}, then the selected cloud will begin to shrink, and if less, it will dissipate. Moreover, the initiation of the processes of compression and dispersal are irreversible: having begun to contract gravitationally, the gas cloud, while remaining gas, will only contract, and, having begun to dissipate, will dissipate completely. So the following comparison needs to be made:

$$dU_{gr} + dU_{em} \leftrightarrow dU_{int} \tag{4}$$

So, if the left side of expression (4) is larger than the right side, then gravitational compression is inevitable, since the left side is responsible for compression. But this inequality includes an important nuance. The first term on the left-hand side, related to gravity, is associated with the arrival of energy, and the second term, related to the emission of electromagnetic radiation, with the loss of energy. Therefore, if $dU_{gr} > dU_{em}$, then the compression of the cloud will begin to occur with the release of heat, and if $dU_{gr} < dU_{em}$ – with heat losses. However, just as compression cannot spontaneously turn into expansion, one type of compression cannot spontaneously turn into another (for more details, see [11]).

Thus, the condition for the spontaneous launch of the usual compression process, accompanied by self-heating, is as follows:

$$dU_{gr} + dU_{em} > dU_{int};\ dU_{gr} > dU_{em} \tag{5}$$

In Belyaev [12] it was explained that if the process of spontaneous gravitational compression with self-heating had been launched, it is impossible to stop without supplying external energy to the compressible gas to create back pressure regardless of the initial mass of the compressible gas cloud. This not only means that brown and red dwarfs will never cool down as long as the gas continues to contract, but also that even small clouds that are very insignificant in mass are capable of gravitationally contracting.

Indeed, even with small values of the initial temperature of the cloud formed according to the described rule, the fulfilment of the inequality $dU_{em} < dU_{gr}$ requires the cloud to have large masses and sizes. But if $T \to 0$, then $dU_{em} \approx 0$ and $dU_{int} \approx 0$, therefore $dU_{gr} > dU_{int}$ for any cloud size and density. Accordingly, despite the small mass of the cloud and the rising temperature of the gas, weak gravitational forces are enough to keep this glowing cloud stable. This will happen because the increase in pressure will primarily be caused by a decrease in the distance of the free path with an increase in the collision frequency, moreover, the magnitude of the gravitational forces at small distances will increase significantly. The increase in the gravitational forces will be able to resist the rise in temperature of the gradually densifying gas cloud, i.e. able to keep the warming gas of the light cloud from dispersing.

In the work just mentioned [12], it was assumed that "unexplored luminous objects found in the Earth's atmosphere are associated with this kind of plasma objects (they are most often observed in the Earth's troposphere: in the upper layers during ionospheric disturbances, geomagnetic storms, auroras; also in the surface layers above the faults of the earth's crust, or during earthquakes – in these cases, luminous objects seem to float right out of the ground; sometimes in tornadoes; in extremely rare cases, during thunderstorms)". Further it was concluded that "the final stage of evolution of any self-compressing light gas cloud is the same: degeneration of the electron gas". How such objects can actually form in terrestrial conditions is a topic for a separate study. Moreover, the processes occurring with a gas strongly depend on its characteristics and compressibility. Generally speaking, it is important to point of the fact that during fast processes, when heat exchange with the environment does not have time to take place, the Bernoulli equation suggests a drop in gas pressure and temperature with an increase in the flow rate.

Studies of unexplored natural luminous objects were carried out on a large scale in the Soviet Union in the 70s of the last century on the topic "Unusual Phenomena in the Atmosphere and Near Space". However, no official scientific publications have bene made on this topic. Therefore, it is impossible to make a reference to the achieved systematization for the observed natural phenomena of this type. In any case, it is pointless to look for small objects with a degenerate electron gas on Earth or in its vicinity. The reason for this was suggested in [8] and indicates that formations with a degenerate structure have a lower mass limit at which they remain stable. Nevertheless, in the topic under discussion, in conditions of the formation of the galaxy accompanied by a hypergiant explosion, objects with a degenerate electron gas and with a mass greater than the lower critical mass could well have formed. Obviously, such objects will be unobservable for the terrestrial observer and will take their place in the share of the composition of the hidden mass. Since this share cannot be significant, a more detailed discussion of possible ways of forming such objects will not be discussed in this work.

Now it is time to look at the gravitational compression with seflf-cooling in more detail, which should be responsible for the formation of the main part of the hidden mass. The initial conditions that the emerging model clouds must meet should look like this:

$$dU_{gr} + dU_{em} > dU_{int};\ dU_{em} > dU_{gr} \tag{6}$$

or:

$$(4/3)\pi r^2\rho^2 G + \alpha T^4 > nT\rho;\ \alpha T^4 > (4/3)\pi r^2\rho^2 G. \tag{7}$$

If both conditions indicated in (7) are satisfied, then the inequality $2\alpha T^4 > nT\rho$ will definitely be true or:

$$T^3 > [n/(2\alpha)]\rho. \tag{8}$$

5.5. The formation of hidden mass

Before moving on to specific figures, it is first necessary to understand how the chosen method of separating the initial gas cloud for gravitational compression with self-cooling can be combined with real events during the formation of galaxies. Based on the results of preliminary considerations, it was discovered that a dense hydrogen gas accumulates around the first generation star, a hypergiant, heated to a few million degrees, having a fairly uniform density distribution and making up a large part of the share of mass of the future galaxy. Presumably, as a result of the explosion of a hypergiant, under the influence of the resulting shock wave, the gas environment of the star is torn apart into small clouds. This conclusion is unfounded and without modelling can only be an assumption. However, only a scientific team with appropriate funding will be able to do the required work. At the same time, all the arguments provided earlier are significant and, therefore, relevant. Because of this, let us assume that small clouds with uniformly distributed hydrogen still managed to form. The losses due to electromagnetic radiation from the formed discrete clouds at expected temperatures will be so large that the pressure will begin to fall sharply, and the forces of gravitational compression start working. Although gravity will begin to increase the pressure and temperature, the trend will already be predetermined: first, heat losses will occur, and only then the gravitational forces work with continued losses. In this case, as already discussed above, the rate of gravitational compression is set only by losses due to radiation. Thus, let us assume that the clouds that appeared after the explosion of the hypergiant turned out to be close to the model clouds with the initial conditions corresponding to inequalities (7).

If the considered cloud consists of protons ($i \approx 3$, $\mu \approx 1.008 \cdot 10^{-3}$ kg / mol), then $n = 1.2 \cdot 10^4$ J / (kg·K), and inequality (8) takes the form:

$$T^3 > 7.8 \cdot 10^{18} \rho. \tag{9}$$

If $T \approx 5 \cdot 10^6$ K, then from (9) it follows that the density should not exceed $\rho < 16$ kg / m^3, otherwise, if, after checking condition (4), the process of spontaneous gravitational compression should start, the indicated temperature will not be enough to prevent the gas cloud from compressing according to the usual scenario with self-heating, regardless of its initial size and total mass. Higher density values can occur for spontaneous gravitational compression with self-cooling at the indicated temperature, but then a more rigorous test of the nature of cloud instability using inequalities (7) will be required.

The obtained density value is about 13 orders of magnitude higher than the density of cold molecular clouds of interstellar medium (their densities can vary greatly from each other), which looks quite logical, since we are not talking about accumulating gas in the regions of Lagrange points, when the outer gravity is weak, and the inner gravity of moderate-mass clouds is also moderate. The total matter of an already formed galaxy, contracting to a single centre of mass, i.e. the gravity of protogalactic gas (the density of future small clouds was formed in a single protogalactic cloud) is being considered here. At the same time, the obtained density value is three orders of magnitude less than the average density of brown dwarfs, despite the incomparably large mass of the substance involved in gravity. Moreover, the low density in comparison with the density of the brown dwarf does not mean that there will be no deuterium will be produced. The initiation of deuterium synthesis is determined not by the plasma density, but by its temperature. Moreover, the low value of the cloud density is not determined by thermonuclear reactions (in this case, thermonuclear reactions only slow down the compression of the cloud, but do not lead to its expansion), but by the gravitational compression scheme.

If on planets the density of the atmosphere, in the case of its composition unchanged with altitude, falls exponentially (on Earth, with altitude, the average molecular weight of the atmosphere falls, so the density of the atmosphere decreases more slowly than the exponential law), then when uncontaminated hydrogen is compressed under the conditions of galaxy formation, the density increases, as already mentioned above, are initiated from the periphery. Therefore, the protogalactic cloud has no core as such. The gas being compressed is fairly uniform. Accordingly, its density, in contrast to the brown dwarf, will be determined by other laws.

At a known initial cloud temperature, the feasibility of its spontaneous compression with simultaneous self-cooling will depend on the ratio M/r, which characterizes the compression potential. With a density of 16 kg/m^3 and a mass similar to the mass of the Moon ($7.3 \cdot 10^{22}$ kg), the initial radius of the cloud will be 10^{10} m (a million times smaller than the average size of molecular clouds of interstellar gas). But the parts into which the original protogalactic cloud will break in reality, can to predict only be determined using results of modelling.

Thus, hot hydrogen gas, clustering into small clouds after the explosion of a first-generation star, begins to cool rapidly, contracting and increasing its pressure. As a result, solid-state formations with temperatures close to absolute zero are formed from gas clouds. In other words, in the process of galaxy formation, the explosion of a hypergiant most likely gives rise to the formation of asteroids from solid hydrogen, which form the galactic halo. The halo of the galaxy, because it is made up of solid cold objects, turns out to be invisible. The central zone of the galaxy should be visible, formed by the forces of gravity according to the laws already described by science. In addition, the forces of gravity are also initiated to clear the area between the visible and invisible parts of the galaxy.

6. Results

On the scale of space, the forces of gravity manifest themselves above all. The kinematics of celestial objects unambiguously testifies to the presence in space of a large amount of matter that forms gravitational fields, which cannot be detected in any range of electromagnetic radiation. This is also evidenced by the analysis of the multifaceted manifestations of gravitational lensing. Rotation curves of galaxies and other astronomical data indicate that such unobservable matter is concentrated at the periphery of galaxies.

Originally, the unobservable matter was called "hidden mass". Soon after, it became clear that the hidden mass could not be filled with gas and dust, and that it was compiled of compact objects. In the early stages, it was acceptable to compile the hidden mass even with dim stars. Later, neutron stars, black holes, cold white dwarfs, planets like Jupiter, etc., which were united by the abbreviation MACHOs, became candidates for completing the hidden mass. But the latest astronomical observations have provided a lower limit on the permissible maximum unit mass of a space object that could act as the main component of the hidden mass. These limitations indicate that MACHOs cannot make up the hidden mass. In addition, whatever the main component of unobservable matter turns out to be, the total mass of which is an order of magnitude greater than the mass of visible matter, its concentration at large distances from the visible matter of galaxies is still puzzling.

The final weighty factor in the emerging picture of the remaining question of the composition and method of formation of the hidden mass was introduced by the calculation of the deuterium observed in space. Its amount turned out to be too large to allow, in the process of primary nucleosynthesis, the genesis of the hidden mass in addition to the genesis of the observed baryonic matter. Therefore, it was decided that the hidden mass consists of non-baryonic matter, i.e. that unobservable matter is composed of unknown elementary particles that form "dark matter" of unknown nature, born together with ordinary particles from the same process. Thus, it was assumed that dark matter does not have a quark structure, and of the known fundamental interactions, it has only gravity. The new category made it possible to some extent to eliminate the accumulated inconsistencies in cosmology, but in its physical essence, as shown in this work, it turned out to be completely untenable.

An analysis of the current situation showed that such an unprecedented step towards introducing a new entity into the theory was made to save the generally accepted model of a hot Universe. However, further analysis of the problems generated by this model showed that it should not be saved, and that it cannot be functional.

At the same time, all theories of the birth and evolution of the Universe, including alternative ones, to which at least some attention is paid, are based on the model of a hot Universe. It turns out that the theory of the evolution of the Universe requires a completely new approach. From the review of Belyaev's works carried out in this paper, it follows that the birth of the Universe, following the principle of spherical symmetry, removes all cosmological problems that today have to be solved by resorting to various assumptions. The new approach assumes that the Universe was born not momentary and not from a local point, but in a finite time interval from a local zone in the processes of an avalanche-like growth of acts of generation of "particle – antiparticle" pairs. As a result, galaxies began to form from pure hydrogen gas due to the discretization of a single very cold gas cloud ("cold" – in the coordinate system accompanying the movement of matter).

A characteristic feature of the formation of galaxies was the calm state of the original gas clouds, without signs of turbulence and vortex flows, which were isolated for gravitational compression. Under such initial conditions, gravitational compression did not heat up the central part of each cloud of future galaxies, but practically the entire cloud. As a result, firstly, the synthesis of deuterium in thermonuclear reactions was launched, and, secondly, the formation of a hypergiant in the centre of each separated cloud. Moreover, the resulting hypergiants, which used to be first-generation stars, were single stars in each galaxy. Such unique initial stages of the formation of the galaxy made it possible to embody the conditions for the origin of the hidden mass, which should have been formed from the dense and heated to a few million degrees hydrogen cloud surrounding the hypergiant.

The origin of the hidden mass occurred due to the process of gravitational compression with self-cooling. If at the initial moment of cloud formation there are very large energy losses due to electromagnetic radiation from it, then this leads to such a strong decrease in pressure in the cloud that the process of gravitational compression is activated, even despite the small initial cloud mass.

However, under such initial conditions, the process of gravitational compression becomes secondary: at first, the cloud cools down due to losses and for this reason the pressure decreases, and then the forces of gravity begin to raise the pressure, and along the way, as a side effect, try to restore the temperature. However, the losses are continuous, and the gravitational forces driven by the intensity of losses with electromagnetic radiation (driven by back pressure) cannot have time to restore the previous temperature level, from which the process started. Moreover, the pressure during gravitational compression increases not only due to the reverse increase in temperature triggered by gravity, which tends to restore the initial temperature, but also due to an increase in density (reduction of the geometric dimensions of the cloud). Therefore, as a result, gravitational contraction occurs with a constant decrease in the temperature and internal energy of the cloud, as well as with an increase in pressure, keeping the enthalpy unchanged. The ratio of the parameters necessary for the feasibility of such a course of gravitational compression is reflected in inequalities (7). A possible scheme for setting up an experiment in laboratory conditions to test the feasibility of gravitational compression with self-cooling will be discussed in a separate work.

The high initial temperature of dense scraps of gas scattered by the supernova explosion creates the necessary conditions for starting the process of gravitational compression of hydrogen with self-cooling. This results in the formation of solid-state asteroids from hydrogen. Such asteroids meet all the necessary characteristics of hidden mass: they do not emit electromagnetic radiation, are practically transparent for the electromagnetic radiation passing through as a whole, have gravitational mass, are barely decelerated by a gas cloud, have small unit masses and stable trajectories in rare collisions, and are concentrated in large quantities in the halo of the galaxy.

The galactic halo is not a rarefied one, with decreasing density towards the periphery, but a clearly expressed outer element of the galaxy with clear boundaries, in which asteroids are not satellites of the visible central part of the galaxy. The galactic halo gravitationally interacts with the visible part of the galaxy only as a whole, and its constituent asteroids are structured inside the halo in accordance with the laws of gravity, as if the visible part of the galaxy did not exist. However, the shape of the halo is determined by the shape of the equipotential surface created by the visible part of the galaxy.

Solid hydrogen asteroids make up the bulk of the hidden mass. But a part of the hidden mass can fall on objects with a degenerate electron gas, which have approximately the same unit mass. The formation of such objects can occur when the initial conditions (5) are met. But the question of the value of the minimum critical mass at which objects with a degenerate electron gas continue to be stable remains open.

7. Conclusion

In this paper, a conclusion is made about the illegitimacy of introducing a new category of "dark matter" into physics.

The new category made it possible to smooth out the emerging complexities in cosmology to some extent, but, as shown in this work, caused a chain of unsolvable fundamental problems to arise in physics. Such a result, according to the principle of Occam's razor, is quite natural. Premature introduction of new categories into the theory, without accumulation of experimental data that cannot be explained within the framework of existing knowledge, is inadmissible.

This step was taken due to the impossibility of explaining the birth of such an amount of baryonic matter at a certain evolutionary stage of the Universe that could compile unobservable matter, which definitely exists in outer space, but is invisible in any of the ranges of electromagnetic radiation. Astronomical observations indicate that the amount of unobservable matter is approximately one order of magnitude greater than the amount of visible matter. However, within the framework of existing cosmological models, which are currently all based on the model of hot Universe, it is indeed impossible to compare the abundance of deuterium observed in space with the required total amount of baryonic matter, which would include unobservable matter in its composition.

This work demonstrates the inconsistency of the hot Universe model. Accordingly, the introduction of a new category "dark matter" into the theory is premature. Unobservable matter consists of baryonic matter and represents another category, "hidden mass".

In this work, a hypothesis is put forward for the appearance and form of existence of the hidden mass. But there is still a long way to go to a rigorous theory. However, the new principle of gravitational compression, accompanied by self-cooling, put in the basis of the hypothesis, is significant. The principle of the possibility of the existence of a new type of gravitational compression was previously highlighted by the author in the publication of a peer-reviewed journal (see [11]). In the present work, the initial conditions that trigger such a process are considered. The fact that gravitational compression, accompanied by self-cooling, has the right to exist is an indisputable theoretical fact. But the possibility of its real occurrence in the evolutionary chain of the Universe still needs to be studied. Building a rigorous theoretical model of such a process is also a matter for the future.

References

[1] Tisserand P, Le Guillou L, Afonso C et al, *Limits on the Macho content of the Galactic Halo from the EROS-2 Survey of the Magellanic Clouds*, Astronomy and Astrophysics, 469 (2007), 2, 387–404

[2] Graaff A, Cai Y C, Heymans C & Peacock J A, *Probing the missing baryons with the Sunyaev-Zel'dovich effect from filaments.* A&A, 624 (2019)

[3] Belyaev A S, *Photon gas*, Universal Journal of Physics and Application, 10 (2016), 1, 11-15

[4] Belyaev A S, *Gravitational Contraction of a Dust Cloud in Space*, Universal Journal of Physics and Application, 10 (2016), 1, 22-30

[5] Belyaev A S, *A new model of the birth of the Universe*, Universal Journal of Physics and Application, 11 (2017), 5, 182-189

[6] Belyaev A S, *The Physical Meaning of the Gauss's Law*, Frontiers of Astronomy, Astrophysics and Cosmology, 6 (2020), 1, 1-13

[7] Belyaev A S, *The Process of Formation of a Single Star System for Gravitational Compression of a Gas-dust Cloud in Outer Space*, Universal Journal of Physics and Application, 13 (2019), 1, 15-28

[8] Belyaev A S, *The formation of a single star planetary system and heat balance of the planets*, Journal for Foundations and Applications of Physics, 7 (2020), 2, 66-100

[9] Belyaev A S, *Cosmic microwave background and matter disposition in outer space*. Journal of Applied Physical Science International, 11 (2019), 3, 128-139

[10] Belyaev A S, *Accounting for the geometric factor in classical gravity*, Frontiers of Astronomy, Astrophysics and Cosmology, 4 (2018), 1, 18-29

[11] Belyaev A S, *The Possibility of Spontaneous Gravitational Contraction of a Gas Cloud in Outer Space with Simultaneous Cooling of the Cloud*, Universal Journal of Physics and Application, 12 (2018), 2, 24-29

[12] Belyaev A S, *Trends of stellar evolution in modern physics,* Universal Journal of Physics and Application, 11 (2017), 6, 247-263