Journal of Applied Mathematics and Physics, 2023, 11, 3009-3029
https://www.scirp.org/journal/jamp
ISSN Online: 2327-4379
ISSN Print: 2327-4352

About Worlds inside a Black Hole and Peculiarities of the Formation of Exotic Space Objects

Avas Khugaev, Eugeniya Bibaeva

Institute of Nuclear Physics, Tashkent, Uzbekistan
Email: avaskhugaev@mail.ru, bibaeva22@bk.ru

How to cite this paper: Khugaev, A. and Bibaeva, E. (2023) About Worlds inside a Black Hole and Peculiarities of the Formation of Exotic Space Objects. *Journal of Applied Mathematics and Physics*, **11**, 3009-3029.
https://doi.org/10.4236/jamp.2023.1110199

Received: August 27, 2023
Accepted: October 23, 2023
Published: October 26, 2023

Abstract

The article puts forward a hypothesis about the possibility of the existence of our Universe inside a supermassive black hole, analyzes the basic assumptions and verifiable physical consequences. The transformation of the Primary Particles obtained from the decay of Borromeo rings into binary and ternary structures is considered separately, taking into account how the percentages between Dark Matter, Dark Energy and Baryonic matter are formed. A system of kinetic equations has been compiled, which makes it possible to develop a theoretical approach to obtain these values depending on the geometric and physical characteristics of interacting particles. The possibility and necessity of the existence of a Primary Relic of Primary Particles are substantiated. The nature of the voids and the analytical solution of the Einstein equations obtained from the generalized Papapetrou solution, which leads to the existence of strings with an arbitrary distribution of matter along the string and with lengths comparable to the size of the Universe, are considered. In the case of a string of finite size and constant density, this solution leads to the well-known Weyl solution. An assumption is put forward about the existence of an Einstein-Rosen type transition, when the dimensions of the white and black holes at the ends of this transition have different dimensions.

Keywords

Black Hole, White Hole, Einstein-Rosen Bridge, Primary Relic, Voids, Strings, Dark Matter, Dark Energy, Borromeo Rings, Dark Stars, Generalized Papapetrou Solution, Weyl Solution

1. Introduction

Our practical experience is limited and this forces us to extrapolate existing knowledge into the field of very small and very large quantities. Then, of necessity, the question arises about the limit of the divisibility of matter and about the existence of the maximum possible mass of a material structure.

In the first case, if we assume that there is energy necessary for the division of matter at each i-level of its existence E_i, then our question boils down to the existence of a sequence limit: $E = \underset{i \to \infty}{Lim}\left[\sum_{k=0}^{k \to i} E_k\right]$ and since experience shows that $E_i < E_{i+1}$, the series for energy E must diverge if it does not break off at some limit and final value $i \to i_{Lim}$. Therefore, matter cannot divide indefinitely and there is a limit to its division. A simple consideration linking the local properties of matter with the global properties of the Universe shows that if it is necessary to expend energy equal to the energy of the entire Universe to divide matter at some level of its existence, then the process of division is impossible. It is also clear that if there is an extremely small mass, that it cannot decay into smaller masses if the law of conservation of energy is assumed to be fulfilled. The minimum possible mass is zero rest mass, so particles with zero rest mass are fundamental.

Moreover, based on the Heisenberg uncertainty relation, the radius of interaction is determined by the ratio: $\delta r \approx \frac{\hbar}{m \cdot c}$, where m is the mass of the particle carrying the interaction, c is the speed of light in vacuum and $\hbar$ is Planck's constant, and then, at $m \to 0$, $\delta r \to \infty$, these interactions can be considered, by their radius of action, universal, like electromagnetic and gravitational interaction.

And what about when determining the maximum possible mass limit? Of course, in our universe it has the maximum possible mass, which includes everything. But the question arises, is there a limit to the mass of the universe? Is there an upper limit for the mass of the universe, and if so, what causes it? If we assume that gravity attracts, forms the maximum mass growth, then this growth is not limited or there is a limit to it, and can we say that a black hole with the mass of the Universe can exist? These questions lead us to analyze the observed data and revise them, as well as clarify the basic concepts in our approach.

Indeed, according to modern observational data, the main specific gravity, up to 95% of the matter of the Universe, is "unmanifested" matter. Within the framework of our concept outlined in previous articles [1] [2] [3] [4], the category of "unmanifested" matter includes: 1) Elementary particles of primary matter ("0", "+", "−") and elementary particles ("3", "2", "1"), originated as a result of the Big Bang of special structures called "seeds of Creation"; 2) The dark energy of the double shell of the Universe ("+", "−") with an adjacent Field ("0"); 3) Three spheres of the Primary Relic ("0", "+", "−"); 4) and finally, Dark matter of 6 types: ITM 3(1, 2), ITM 3(2, 1); TTM 1(3, 2), TTM 1(2, 3); RTM 2(3, 1), RTM 2(1, 3).

One of the main properties of "unmanifested" matter is its infinitely small material density with an infinitely large density of vibrations. In addition, this matter is characterized by the unimaginable power of gravity, the highest degree of dynamism, the special brightness of the unmanifested glow and other qualities, the phenomenality of which can be guessed only by indirect signs.

If we proceed from the assumption that our Universe is a closed system, and ask where it draws matter from to create not only new stars, but also new galaxies, we will involuntarily have to turn to the hypothesis of the possible existence in its life of an important "tool", "factories" for processing obsolete space objects. We are talking about black holes (BH). We cannot know the true fate of matter falling into the "millstones" of this monstrous "machine", but we assume that some giant black holes (including black holes formed from Dark stars (DS) at the earliest stage of the formation of our Universe) ending in White holes (WH) thanks to the Einstein-Rosen "bridge", they can throw out into space the matter of galaxies, processed to the state of elementary particles ("3", "2", "1"). They, in turn, become the basic matter for the reproduction of 6 types of Dark Matter (DM) and the subsequent formation of "manifested" baryonic matter (BM) from it. So, in our opinion, with the help of Black-and-White holes (BH-WH), a "cycle" of these categories of visible and invisible matter in the nature of the Universe can be carried out.

We tried to substantiate the hypothesis about where 4 categories of practical eternal, unmanifested matter could have appeared in our Universe, assuming that the Universe is a closed system. According to our concept, only the world "before the Big Bang", designated by us as Superspace O_{SP}, had such high-quality matter. But how could this matter, possessing the super-qualities of "unmanifest", penetrate into the earliest Universe, or more precisely, create in? We assumed that the "mechanism" of the BH-WH could operate in O_{SP} space conditions, but taking into account a number of features: 1) The BH of this Superspace could be located on the surface of special "bubbles" of the "Ocean " of matter of the Highest of the Worlds (we will call it as Dun-Dune) in order to process the "Borromeo rings" into elementary particles of the Primary Matter ("0", "+", "−") and to throw them out in the form of an "exhaust" within the framework of a WH into space "bubble"; 2) This "Ocean", being a supermassive BH, could create on the surface and inside the "Bubble" an uncountable number of BH-WH, each of which turned into a universe. In our study, we consider in detail only one of them.

To substantiate the hypothesis put forward, we present calculations and formulate and investigate questions that we would like to answer: do we understand the role of BH in the universe correctly?; can our universe be inside a BH and how to check it?; are supermassive BH quantum objects?; is there radiation directed inside it near the horizon of a supermassive BH?; what structures can form in the void of voids?; is it possible to create Dark stars (DS) from DM what are their characteristics and role in the possible formation of BH?; what is the reason for the observed relative content of baryonic matter (BM) ("brick atoms"), Dark matter (DM) of 6 types and Dark energy (DE) ("+", "−")?; how could the spheres of the Primary Relic be formed (“0”, “+”, “−”) of the primary particles of Borromeo’s “rings”?; of what matter can the Field of the Universe consist (“0”) and is it possible to obtain solutions in the form of strings with an arbitrary density distribution from Einstein’s equations? Our work is devoted to the study of these issues.

The article is organized as follows:

In the first chapter, the hypothesis of the possibility of the existence of our Universe inside the BH is considered, based on simple estimates and known observable data, such as the radius of the Universe, its mass, the average density of matter in the Universe, etc. The calculation of the radius of the Universe from the observed data and the comparison with its Schwarzschild radius gives the basis for such a statement.

In the second chapter, possible physical consequences that can be observed to confirm this hypothesis are considered. To this end, the nature of the behavior of a scalar test particle near the “edge of the Universe” is investigated and it is shown that such motion is quantum in nature, the observed characteristics of this motion and radiation measured by a distant observer are calculated.

The third chapter of the article examines the dynamics of the transformation of composite structures, “bricks”, which are the main building material in the “matryoshka” of worlds and the physical consequences to which this leads. The mathematical description is reduced to a system of kinetic equations describing the transformation of the initial composition of primary particles into new composite structures obtained as a result of transformation reactions.

In the fourth chapter, the solutions of Einstein’s equations are analyzed, which correspond to the sources of the gravitational field in the form of strings with an arbitrary density distribution, both finite in size and comparable to the size of the Universe.

2. Could Our Universe Be Inside of Supermassive Black Hole?

The idea of considering the origin of our Universe in the World on the other side of the Big Bang [3] [4] made us face the need to understand the following question: can universes arise inside unimaginably big black holes (BH)? Let’s consider this problem using as an example our Universe. Its mass obtained in [3] was $M_{Un} \approx 2.73\times 10^{64}$ kg. Let’s start with simple numerical estimates and calculate the “event horizon” of a BH with a mass equal to the mass of our Universe:

$$R_{BH}^{Un} = 2\gamma \frac{M_{Un}}{c^2} \approx 2\times 6.67\times 10^{-11} \frac{\text{m}^3}{\text{kg}\cdot\text{sec}^2} \times \frac{2.73\times 10^{64}\ \text{kg}}{\left(3\times 10^8 \frac{\text{m}}{\text{sec}}\right)^2} = 4.0\times 10^{37}\ \text{m}$$

Knowing that $T_{BB} \approx 13.8\times 10^9$ light years have passed since the Big Bang, let’s estimate the radius of the modern Universe: $R_{Un} = c\cdot T_M \approx 1.3\times 10^{26}$ m. Then, from the relation: $\frac{R_{BH}^{Un}}{R_{Un}} = \frac{4.0\times 10^{37}}{1.3\times 10^{26}} \approx 3.1\times 10^{11} \gg 1$, we can conclude that our Universe is inside a BH, with a mass of order $M_{BH} \sim 2.73\times 10^{64}$ kg.

Based on this, it is easy to estimate the approximately $N = \left(\frac{R_{BH}^{Un}}{R_{Un}}\right)^3 \approx 3\times10^{34}$ such Universe as ours can fit inside such an unimaginably huge Black Hole. To realize the enormity of this value, let's count the number of water molecules H_2O in one cubic centimeter: $\rho_{WATER} = n\cdot m_{WATER}$, where n is the concentration, and m_{WATER} is the mass of the water molecule, from where we get that in one cubic centimeter of water, there is a number of molecules equal to:

$$n = \frac{\rho_{WATER}}{\mu_{WATER}} N_A = \frac{1}{18}\times 6.0\times10^{23} \approx 3\times10^{22}\ \text{cm}^{-3}$$

We have obtained the number of water molecules in one cubic centimeter under normal conditions. Then, to ensure that the number of molecules is equal $N \approx 3\times10^{34}$, a volume of water $V = \frac{N}{n} \approx 10^{12}\ \text{cm}^3$ is needed, that is, a cube with a side equal to 100 m. The calculations performed reveal a paradoxical situation. We used to think that the density of BH is always higher than the density of a body of the same mass. For example, the Schwarzschild radius for the Sun is much smaller than the actual average radius of the Sun:
$R_{(g,Sun)} \approx 3\times10^3\ \text{m} \ll R_{Sun} \approx 7\times10^3\ \text{km}$ Then the density of the BH with the mass of the Sun $\rho_{(g,Sun)}$ refers to the density of the Sun ρ_{Sun} as:
$\frac{\rho_{(g,Sun)}}{\rho_{Sun}} = \left(\frac{R_{Sun}}{R_{(g,Sun)}}\right)^3 \approx 1.3\times10^{16}$ and assuming that the density of the Sun $\rho_{Sun} \approx 1.4\frac{\text{g}}{\text{cm}^3}$, we get that: $\rho_{(g,Sun)} \approx 1.3\times10^{16}\cdot\rho_{Sun} = 1.82\times10^{16}\frac{\text{g}}{\text{cm}^3}$ what is much more than the nuclear density of matter $\rho_{Nuc} \approx 10^{14}\frac{\text{g}}{\text{cm}^3}$. In our case, when we consider the Universe, the opposite situation turns out, since the radius of the BH with the mass of our Universe turns out to be greater than the radius of the Universe itself $\frac{R_{BH}^{Un}}{R_{Un}} \approx 3.1\times10^{11} \gg 1$. How it can be understand? On the one hand, assuming that after $T_{BB} \approx 13.8\times10^9$ light years have passed since time, we have obtained that the radius of the Universe is equal to $R_{Un} = c\cdot T_M \approx 1.3\times10^{26}\ \text{m}$. On the other hand, using the calculation of the mass of the Universe [3], we come to the conclusion that the radius of a Black hole with a mass equal to the mass of the Universe is $R_{BH}^{Un} \approx 4.0\times10^{37}\ \text{m}$, which is much larger R_{Un}. An increase R_{Un} of 2 - 3 orders of magnitude does not greatly change the final conclusions, and an increase in mass only M_{Un} aggravates the situation. Is this possible?

Indeed, if we assume (see **Figure 1**) that the radius of the horizon of a certain BH is equal to R_g, and at $R > R_1$, the body radially falls on the BH horizon, then the velocity is reached $V \to c$ on the surface of the event horizon. Then, if the matter under the BH horizon is located inside a region with a characteristic radius $R_2 < R_g$, then this means that under the horizon the velocities of bodies should be greater than the speed of light, since there is no resistance of the medium,

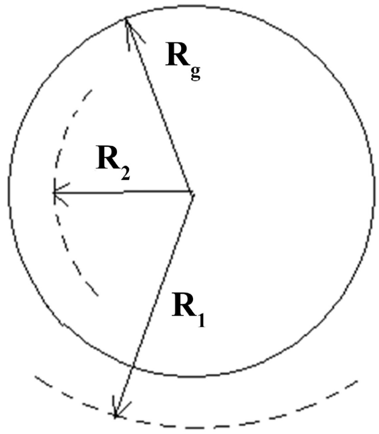

Figure 1. Inside the event horizon of the Universe.

and the effect of gravity continues, which is impossible due to violation of the principle of causality, since this will be an area outside the light cone, where the causal communication.

Thus, we got a very important conclusion that causally related events can only be in the region, inside the BH event horizon, if this area is completely filled with matter.

Therefore, when considering the Kerr BH, which by virtue of its peculiarity has two event horizons, the region of space-time enclosed between them is not a causally connected region and closed time loops can exist in it when cause and effect pass into each other.

For ordinary macroscopic objects, their sizes are always larger than the size of the BH into which they can turn. Let us now consider the density of BH, as far as it can reach Planck values, of the order:

$$\rho_{Planck} = \frac{c^5}{\hbar \cdot \gamma^2} \approx 10^{94} \frac{\text{g}}{\text{cm}^3}$$

The density of matter inside the BH is equal to:

$$\rho_{BH} = \frac{M_{BH}}{\frac{4}{3}\pi \cdot R_g^3} = \frac{3c^6}{32\pi\gamma^3} \cdot \frac{1}{M_{BH}^2} \approx \frac{7.8 \times 10^{83}}{M_{BH}^2} \left(\frac{\text{g}}{\text{cm}}\right)^3$$

If the mass is measured in grams for BH, then we get the density value in g/cm³. Substituting the value of the mass of the Universe from our work [3], we get the following values for the average density:

$$\langle \rho \rangle_{BH} = \frac{7.8 \times 10^{83} \left(\frac{\text{g}}{\text{cm}}\right)^3}{M_{BH}^2} = \frac{7.8 \times 10^{83} \left(\frac{\text{g}}{\text{cm}}\right)^3}{\left(2.73 \times 10^{67}\ \text{g}\right)^2} \approx 10^{-51} \frac{\text{g}}{\text{cm}^3}$$

We see that the average density of a BH decreases with increasing mass and for a BH with a mass equal to the mass of our Universe, its density is very small, which indicates the existence of huge voids in the Universe with very low density of matter. It is possible that the mass of the Universe is experimentally determined with a large error, but we can determine the densities of BH located in the center of galaxies whose mass ranges from $(10^6 - 10^9)\cdot M_{Sun}$. Then, for our Galaxy with mass $\sim 10^6 \cdot M_{Sun}$:

$$\langle\rho\rangle_{BH}^{(Gal)} = \frac{7.8\times10^{83}\left(\frac{\text{g}}{\text{cm}}\right)^3}{M_{BH/Gal}^2} = \frac{7.8\times10^{83}\left(\frac{\text{g}}{\text{cm}}\right)^3}{\left(10^6\times2\times10^{33}\ \text{g}\right)^2} = \frac{7.8\times10^{83}\left(\frac{\text{g}}{\text{cm}}\right)^3}{4\times10^{78}\ \text{g}^2} \approx 2\times10^4\ \frac{\text{g}}{\text{cm}^3}$$

which indicates quite acceptable densities of matter. If we choose a BH with even larger masses, of the order $\sim 10^9 \cdot M_{Sun}$, then the results will be less by 6 order of magnitude and equal to: $\langle\rho\rangle_{BH}^{(Gal)} \approx 2\times10^{-2}\ \frac{\text{g}}{\text{cm}^3}$, which is 50 times less than the density of water under normal conditions. What conclusions follow from these results?

- It follows from these simple estimations that matter inside supermassive BH can be described in a classical way.
- If we consider the estimate of the mass of the Universe to be correct, then its sizes are much larger than the radius of the horizon of the observable Universe, and then there must exist huge regions of voids, "vacuum bubbles" resembling entrances.
- The assumption that our Universe is located inside the BH, in the light of these calculations, does not seem unusual as it may seem.

3. The Physical Consequences of the Hypothesis Are the Nature of the Motion of a Scalar Particle near the "Edge of the Universe"

Let's consider what possible physical consequences of the idea that our universe is located inside the BH? In this case, the approach to the event horizon is possible only from the inside and the universe in this case is closed, by definition.

Suppose that a scalar particle approaches the event horizon from within, and determine the nature of its movement near the event horizon.

Since $R_{BH}^{Un} \approx 4.0\times10^{37}\ \text{m} \to K \sim \frac{1}{R_{BH}^{Un}} \ll 1$ we also get that the Gaussian curvature tends to zero near the BH horizon, then we can assume that the Newtonian approximation is quite applicable. It is also easy to see that in the non-relativistic limit, near the event horizon, we get that the Schrödinger equation for a scalar particle can be written, taking into account the Schwarzschild metric for the distribution of masses inside the BH as:

$$\text{d}s^2 = \left(1-2\gamma\frac{M}{c^2r}\right)c^2\text{d}t^2 - \left(1-2\gamma\frac{M}{c^2r}\right)^{-1}\text{d}r^2 - r^2\text{d}\vartheta^2 - r^2\sin^2\vartheta\cdot\text{d}\varphi^2 \quad (1)$$

taking into account the fact that the mass $M = M(r)$, depends on the radial variable and $(ct, r, \vartheta, \varphi)$ is the contravariant coordinates of the test scalar particle with mass. Then, the non-relativistic Schrödinger equation will be written, taking into account the curvature, as:

$$i\hbar c\cdot g^{00}\frac{\partial\Psi}{\partial ct}=-\frac{\hbar^2}{2m}g^{ij}\left[\partial_i\partial_j-\Gamma_{ij}^k\partial_k\right]\Psi+V(r)\Psi, \tag{2}$$

where g^{ij} are the contravariant components of the metric tensor, Γ_{ij}^k Christoffel symbols, $i,j,k=1,2,3$ spatial indices, Ψ the wave function of the test particle and the potential energy of interaction $V(r)=-\frac{4\pi\gamma\langle\rho\rangle}{3}m\cdot r^2$ here $\langle\rho\rangle=10^{-29}\frac{\text{g}}{\text{cm}^3}$ is an average density of matter in the Universe, $\gamma=6.67\times10^{-17}\frac{\text{cm}^3}{\text{kg}\cdot\text{sec}^2}$ gravitation constant and velocity of light $c=3\times10^{10}\frac{\text{cm}}{\text{sec}}$ and for repeating indexes, we use Einstein's summation rule. Taking into account the comments made, Equation (2) is presented in the following form:

$$i\hbar cg^{00}\frac{\partial\Psi}{\partial ct}=-\frac{\hbar^2}{2m}g^{ij}\left[\partial_i\partial_j-\Gamma_{ij}^k\partial_k\right]\Psi-\frac{4\pi\gamma\langle\rho\rangle}{3}m\cdot r^2\cdot\Psi \tag{3}$$

We will look for stationary solutions to this equation by presenting the solution in the form: $\Psi(r,ct)=\Psi_1(ct)\Psi_2(r)$ and then we write that Equation (3) will be written as follows:

$$\begin{aligned}&i\hbar c\frac{g^{00}}{\Psi_1(ct)}\frac{\partial\Psi_1(ct)}{\partial ct}\\&=-\frac{\hbar^2}{2m}\frac{1}{\Psi_2(r)}g^{ij}\left[\partial_i\partial_j-\Gamma_{ij}^k\partial_k\right]\Psi_2(r)-\frac{4\pi\gamma\langle\rho\rangle}{3}m\cdot r^2=E,\end{aligned} \tag{4}$$

which decays into a system of equations:

$$\frac{g^{00}}{\Psi_1(ct)}\frac{\partial\Psi_1(ct)}{\partial ct}=-i\frac{E}{\hbar c}\to\Psi_1(ct)=A_0\cdot\exp\left\{-i\frac{E\cdot t}{\hbar}\right\} \tag{5}$$

$$g^{ij}\left[\partial_i\partial_j-\Gamma_{ij}^k\partial_k\right]\Psi_2(r)+\left\{\frac{8\pi\gamma\langle\rho\rangle m^2}{3\hbar^2}\cdot r^2+\frac{2mE}{\hbar^2}\right\}\Psi_2(r)=0, \tag{6}$$

here A_0 is the integration constant in Equation (5) and the generalized normalization coefficient. When solving Equation (6), we first consider the planar case when

$$g^{\mu\nu}=\begin{pmatrix}1&0&0&0\\0&-1&0&0\\0&0&-1&0\\0&0&0&-1\end{pmatrix}, \tag{7}$$

where $\mu,\nu=\{0,1,2,3\}$ and all Christoffel symbols $\Gamma_{ij}^k\equiv0$. Further, solving this equation with taking into the account (1) and $\Gamma_{ij}^k\neq0$, comparing the solutions obtained, we will find corrections related to the curvature. In the first case, Equation (6) is written as:

$$\partial_i\partial_j\Psi_2(r)+\left\{\frac{8\pi\gamma\langle\rho\rangle m^2}{3\hbar^2}\cdot r^2+\frac{2mE}{\hbar^2}\right\}\Psi_2(r)=0, \tag{8}$$

from where, assuming that $\partial_i\partial_j \to \Delta$, where Δ is an ordinary Laplacian, we get that:

$$\frac{1}{r^2}\left(\frac{\partial}{\partial r}r^2\frac{\partial}{\partial r}\right)\Psi_2(r)+\left\{\frac{2mE}{\hbar^2}-\frac{8\pi\gamma\langle\rho\rangle m^2}{3\hbar^2}\cdot r^2\right\}\Psi_2(r)=0, \tag{9}$$

and assuming that $\Psi_2(r)=\frac{f(r)}{r}$ by substituting, we get the equation for $f(r)$:

$$\frac{\mathrm{d}^2 f(r)}{\mathrm{d}r^2}+\left\{\frac{2mE}{\hbar^2}-\frac{8\pi\gamma\langle\rho\rangle m^2}{3\hbar^2}\cdot r^2\right\}f(r)=0, \tag{10}$$

from where, taking into account the introduction of the designation of the effective frequency of the oscillator parameter $\omega=\sqrt{\frac{16\pi\gamma\langle\rho\rangle}{3\hbar^2}}$, Equation (10) leads to a discrete energy spectrum for a test particle inside the radius of the BH horizon caused by our Universe:

$$E_n=\hbar\omega\left(n+\frac{1}{2}\right)=\sqrt{\frac{16\pi\gamma\langle\rho\rangle}{3}}\left(n+\frac{1}{2}\right) \tag{11}$$

We introduce, following [5], standard notation to express the wave function of the test particle: $\xi=\sqrt{\frac{m\omega}{\hbar}}\cdot r$ and $\varepsilon=\frac{2E}{\hbar\omega}$, then, the $f_n(r)$ functions of its *n*-states will be expressed in terms of Hermitian polynomials, as follows:

$$f_n(\xi)=\sqrt[4]{\frac{m\omega}{\hbar}}\frac{H_n(\xi)}{\sqrt{\sqrt{\pi}2^n\cdot n!}}\exp\left[-\frac{\xi^2}{2}\right], \tag{12}$$

from where we finally get that:

$$\Psi_{2(n)}=\frac{f_n(r)}{r}=\sqrt[4]{\frac{m\omega}{\hbar}}\frac{H_n(r)}{r\sqrt{\sqrt{\pi}2^n n!}}\exp\left[-\frac{r^2}{2}\right], \tag{13}$$

Taking into account (5), for the wave function of a stationary state with energy E_n, we have:

$$\begin{aligned}\Psi(r,ct)&=\Psi_{1(n)}(ct)\cdot\Psi_{2(n)}(r)\\&=A_0\cdot\sqrt[4]{\frac{m\omega}{\hbar}}\exp\left\{-i\frac{E\cdot t}{\hbar}\right\}\frac{H_n(r)}{r\sqrt{\sqrt{\pi}2^n n!}}\exp\left[-\frac{r^2}{2}\right],\end{aligned} \tag{14}$$

where the coefficient A_0 is determined from the normalization conditions, where $0\le r\le r_g$:

$$A_0=\left(\frac{1}{\sqrt{\pi}2^n n!}\cdot\sqrt{\frac{m\omega}{\hbar}}\iiint_{Volume}\frac{H_n^2(r)}{r^2}\exp\left[-r^2\right]\mathrm{d}V\right)^{-\frac{1}{2}}, \tag{15}$$

Note that the root-mean-square radius $\tilde{R}_n$ for that *n*-state is defined as:

$$\tilde{R}_n=\left\langle R_n^2\right\rangle^{\frac{1}{2}}=\sqrt{4\pi\int_0^{r_g}r^2\Psi_{2(n)}^*(r)\Psi_{2(n)}(r)\cdot\mathrm{d}r}, \tag{16}$$

In this case, we see that near the inner region of the BH horizon, for any sample particle with mass, bound states are formed for which transitions $k \to l$, are possible, where $k - l > 0$ with a wavelength equal to:

$$\lambda_{k \to l} = \frac{2\pi}{\omega(k-l)} \tag{17}$$

Assuming that during the $k \to l$ transition, the radiation reaches a distant observer at a point R_{obs}, it is easy to determine the observed wavelength $\lambda_{k \to l}^{(obs)}$, which will be equal to:

$$\lambda_{k \to l}^{(obs)} = \frac{\lambda_{k \to l}}{1 - \frac{2\pi\gamma\langle\rho\rangle m}{\hbar}\lambda_{k \to l}\left(\tilde{R}_k^2 - R_{obs}^2\right)} \tag{18}$$

It can be estimated, taking into account the fact that when radiating from the $\tilde{R}_{k \to l} \to \tilde{R}_k$ region, the radiation energy flux Φ_{obs} entering the observation area R_{obs} will be proportional to:

$$\Phi_{obs} \sim E_{k \to l}\left(\frac{\tilde{R}_k}{R_{obs}}\right)^2 = \sqrt{\frac{16\pi\gamma\langle\rho\rangle}{3}}(k-l)\left(\frac{\tilde{R}_k}{R_{obs}}\right)^2, \tag{19}$$

where the proportionality coefficient depends on the permeability of the radiation, when passing from the radiation region to the observation region, from which it follows that it is more preferable to observe radiation in the long-wavelength range.

The results we obtained regarding the nature of the motion of a scalar particle near the "edge of the Universe" provide us with the necessary condition for the formation of shells (spheres, regions) consisting of particles of the same nature, in this case, according to our approach, of individual particles "0", "+", and "−" [1] [2] [3] [4]. These particles formed 3 shells (spheres, regions) in the early Universe the Primary Relic with their characteristic internal vibrations and energy spectrum according to the ratios (11) and the radius of the shell (16).

The importance of the formation of these shells (spheres) was that the primary chaos of matter consisted of elementary particles "3", "2", "1", formed after the Big Bang, which we called the "seeds of creation", with their help found Order. Moreover, the shells of the Primary Relic became the site of the formation of DM triads (ITM, TTM and RTM) due to the isolation of the leader particle in the triads, the nature of which was close to the nature of the particles that formed this or that region of the Primary Relic

A few words about the voids that form huge empty spaces in the Universe. Their volumes are of the order $V_{Void} \approx 10^8\ \text{Mpc}^3 \approx 2.7 \times 10^{69}\ \text{cm}^3$, and assuming that the average density in the Universe $\langle\rho\rangle = 10^{-29}\ \frac{\text{g}}{\text{cm}^3}$, we get that the mass of the void is of the order:

$$M_{Void} = \langle\rho\rangle V_{Void} \approx 2.7 \times 10^{40}\ \text{g} \ll M_G = 6 \times 10^{42}\ \text{g}, \tag{20}$$

here M_G is the mass of a galaxy comparable to ours. Based on these estimates, we can conclude that large galaxies cannot form in the voids, but dwarf galaxies and globular clusters, which are not visible due to weak luminosity, may well make up these voids. These are either areas in which the process of star formation can occur and then these areas should have an elevated temperature background, which may affect the fluctuations of the relic radiation, however, due to the weakness of this radiation, these areas remain dark for us. Perhaps, if we observe the inputs in the long-wave infrared range, we will be able to detect active dynamic processes in these areas and we can easily get the characteristic sizes of the activity areas from observations.

Separately, we would like to dwell on the nature of the formation of supermassive BH and their role. In our understanding, at the early stages of the Universe's development, there should be at least two channels for the formation of supermassive BH.

In the first case, their formation is due to DM (ITM:3(1,2) and 3(2,1)), since it is gravitationally active, which leads to the formation of stars from DM, DS (dark stars) [6]. Due to the fact that their constituent DM particles are light, they must, of necessity, be giant stars whose evolutionary path is much smaller than the life of ordinary stars, which is why they had to turn into BH, since their mass is of the order $(10\text{-}100)\cdot M_{Sun}$. The condition for the inclusion of synthesis reactions that lead to the fact that the DS "lights up" is provided by the critical temperatures, density and cross-section of the interaction of the particles that make up the DS, namely, ITM $m_{3(1,2)}$ and $m_{3(2,1)}$ particles.

The formation of giant Dark Stars leads to additional heating of the environment of the early Universe and the formation of supermassive Black holes.

Another channel for the formation of supermassive Black holes can be Giants stars (GS), consistent from light elements, hydrogen and helium nuclei. Then, the role of BH, which could become the centers of fragmentation of ordinary baryon matter at the formation of galaxies, becomes the determining factor.

4. Kinetics of the Formation of Primary Structures in the Universe "before" and "after"...

In this section we are dealing with a very difficult topic, the solution of which is currently unknown and is an open problem. It is well known that the percentage of the content of Dark Energy (TE), Dark Matter (TM) and baryonic matter (BM) is obtained from observations of the relic spectrum by the nature of acoustic peaks [7], while the nature of TE and TM, at this stage, is also a debatable issue that does not have a generally accepted explanation. Nevertheless, let's consider this problem from the point of view of our approach [3] [4] and find out how much uncertainty of understanding in this matter can be removed.

In our concept, the formation of the Universe takes place inside a "bubble" that arises in an environment defined by super space O_{SP}, in which there are Primary Particles consisting of Borromeo rings that connect the three Beginnings, which we call conditionally "0", "+", "−" [1] [2] [3] [4].

Note that the presence of a bubble in a general multidimensional space [3] [4] does not seem so exotic, for example, in [8] it is shown that the Kaluza-Klein vacuum is unstable and leads to the formation of "bubbles" that can grow exponentially, while in [9] "bubbles" that retain constant sizes are considered. We can also propose another idea of "bubble" size growth in a multidimensional region, due to the fact that not all dimensions are stable and can decay, then when moving from the region of higher dimensions N to the region of lower dimensions D, there is an increase in volume, according to:

$$V_N = \frac{\pi^{\frac{N}{2}} R^N}{\Gamma\left(\frac{N}{2}+1\right)} \to V_D = \frac{\pi^{\frac{D}{2}} R^D}{\Gamma\left(\frac{D}{2}+1\right)} \gg V_N, \quad (21)$$

where $N \gg D \geq 7$ is the dimension of space and we see that multidimensional spaces with a fixed finite radius are point-like.

However, what can be the mechanism of formation of such a transition when there is a Black hole with one dimension of space at one end, and a White Hole (WH) with a smaller dimension at the other? We think that this is possible in the case when the BH rotates and at the same time the transition corridor between the holes can also rotate, so that the rotation of this transition increases, destroys some dimensions, and at the output we will already have a white hole with a different dimension. Spatial dimensions with a large radius of curvature will be destroyed.

For a multidimensional transition surface between BH and WH, when the dimension of BH and WH does not change, it is possible to introduce a generalized equivalent of Laplace pressure $P_{L(N)} = \sigma \sum_{i=1}^{N-1} \frac{1}{R_i}$, where σ is the effective surface energy density of the multidimensional transition surface, N is the dimension of the space in which this transition exists and $K = \sum_{i=1}^{N-1} \frac{1}{R_i}$, its generalized Gaussian curvature. Then the stability condition, from the condition of equilibrium between centrifugal and surface forces, can be written as: $\rho \omega^2 \sum_{i=1}^{N-1} R_i^2 \leq \sigma$, where ρ is the surface density of the transition, and ω is the velocity of angular rotation along the axis of symmetry with $i = N$. Mathematical description of such physical objects and questions of their existence present a separate interest.

When forming "clots", we believe that the "clot" is formed under the action of flows of heavier particles O_+ (S_+) and O_- (S_-), with respect to the pure zeroes O_0 (S_0), where O_N and S_N the designations for unexploded Borromeo rings and strings from ruptured rings, respectively, taking into account that $N = \{\text{"0"}, \text{"+"}, \text{"−"}\}$. According to [3], the main decay channel is the channel when one Borromeo ring breaks and we have two Borromeo rings and one string at the output. But it is also possible to consider other channels, with the output of two strings and one ring or channel with three strings. The destruction of Borromeo rings occurs in the environment of the O_{SP} space in which the BH is formed, forming a transition, such as the Einstein-Rosen bridge with an exit into the "bubble" space, in which a White Hole (WH) is formed from which flows of rings and strings come out as products of the decay of Borromeo rings. Note that the dimension of the "bubble" space may be different from the dimension of the original BH space in O_{SP} space. The mathematical study of such a structure is a separate problem that generalizes the Einstein-Rosen solution to the case when BH and WH have different dimensions on different sides of the Einstein-Rosen bridge. At first glance it seems, that such a structure cannot exist, however, it is required in this case to prove strictly. This task will be considered by us in a separate paper.

Let us now proceed to the study of the kinetics of the processes involved in the transformations of the content of various fractions, including TE, TM and BM. By introducing the appropriate notation for their concentrations, we obtain the following system of kinetic equations:

$$\begin{cases} \frac{\mathrm{d}n_+}{\mathrm{d}t} = \Lambda_+ - \sigma_{++}n_+n_+ - \sigma_{+-}n_+n_- \\ \frac{\mathrm{d}n_-}{\mathrm{d}t} = \Lambda_- - \sigma_{-+}n_-n_+ - \sigma_{--}n_-n_- \end{cases}, \tag{22}$$

here Λ is the rate of arrival in the flow of particles $\tilde{O}_+$ and $\tilde{O}_-$, σ_{++}, σ_{+-} and σ_{--}, are the probability of interaction of particles and the formation of bound pairs $\{\tilde{O}_+, \tilde{O}_+\}$, $\{\tilde{O}_+, \tilde{O}_-\}$ and $\{\tilde{O}_-, \tilde{O}_-\}$ among themselves. Those particles that are not bound remain free. At the same time, it is worth noting that each of the particles can be in two states, conventionally designated by us as:

$$\tilde{O}_+ = \begin{bmatrix} O_+ - loop \\ S_+ - string \end{bmatrix},\ \tilde{O}_- = \begin{bmatrix} O_- - loop \\ S_- - string \end{bmatrix} \text{ and } \tilde{O}_0 = \begin{bmatrix} O_0 - loop \\ S_0 - string \end{bmatrix} \tag{23}$$

Therefore, the cross-section of the interaction will be determined mainly by the cross-sections of the string-string and string-ring interactions, and the cross-section of the ring-ring interaction will be elastic, not forming bound states. It is remarkable that Equation (22) directly implies that there is a saturation regime for the formation of bound pairs of particles, which corresponds to the stationary solution of this system. Physically, this means that there comes a moment when the number of particles entering the stream binds into pairs and thus the number of free particles in the "clot" remains fixed.

Further, the dynamics of the formation of the triad nucleus is already determined by the flow of particles of pure gravity $\tilde{O}_0$, which will bind to the already formed pairs of "+" and "−" in "clumps". Let's proceed to the calculation for now, when we will not distinguish the states of the particle, according to relation (23), assuming that the interaction cross-section does not depend on the string-ring state. Of course, in general case, this is not the case, but for a particular case, to feel the internal logic of this process, it is quite acceptable. Then we should get that the necessary separation of 30% and 70% is determined precisely in connection with the formation of bound pairs in the "clot".

We introduce a symmetric cross-section matrix σ_{ij}, defining the interactions between "0", "+", "–" in the form:

$$\sigma_{ij} = \begin{pmatrix} \sigma_{00} & \sigma_{0+} & \sigma_{0-} \\ \sigma_{+0} & \sigma_{++} & \sigma_{+-} \\ \sigma_{-0} & \sigma_{-+} & \sigma_{--} \end{pmatrix} \tag{24}$$

It is reasonable to assume that this separation is associated with the exit to the stationary mode when saturation occurs, determined from the condition:

$$\frac{\mathrm{d}n_+^{(SAT)}}{\mathrm{d}t} = \frac{\mathrm{d}n_-^{(SAT)}}{\mathrm{d}t} = 0, \tag{25}$$

and then:

$$\begin{cases} \Lambda_+ - \sigma_{++} n_+^{(SAT)} n_+^{(SAT)} - \sigma_{+-} n_+^{(SAT)} n_-^{(SAT)} = 0 \\ \Lambda_- - \sigma_{-+} n_+^{(SAT)} n_-^{(SAT)} - \sigma_{--} n_-^{(SAT)} n_-^{(SAT)} = 0 \end{cases}, \tag{26}$$

from where we find, assuming that the flows $\Lambda_0 = \Lambda_+ = \Lambda_- = \Lambda$:

$$n_+^{(SAT)}(t) = \sqrt{\frac{\Lambda\sqrt{\sigma_{--}}}{\sqrt{\sigma_{++}}\left(\sqrt{\sigma_{++}}\sqrt{\sigma_{--}} + \sigma_{+-}\right)}} \tag{27}$$

$$n_-^{(SAT)}(t) = \sqrt{\frac{\Lambda\sqrt{\sigma_{++}}}{\sqrt{\sigma_{--}}\left(\sqrt{\sigma_{++}}\sqrt{\sigma_{--}} + \sigma_{+-}\right)}} \tag{28}$$

Let's to assume, that interaction cross sections satisfies to the following conditions: $\sigma_{++} = \sigma_{--} \ll \sigma_{+-}$ and in this case the system of differential equations can be simplified by the following way:

$$\frac{\mathrm{d}n_-}{\mathrm{d}t} = \frac{\mathrm{d}n_+}{\mathrm{d}t} = \Lambda - \sigma_{-+} n_+^2 \tag{29}$$

which leads to the following expressions for the concentrations:

$$n_-(t) = n_+(t) = \sqrt{\frac{\Lambda}{\sigma_{+-}}} \frac{1 - C_0 \mathrm{e}^{2\sqrt{\frac{\Lambda}{\sigma_{+-}}}t}}{1 + C_0 \mathrm{e}^{2\sqrt{\frac{\Lambda}{\sigma_{+-}}}t}}, \tag{30}$$

where C_0 is an integration constant, which can be defined from the initial conditions:

$$n_-(t=0) = n_+(t=0) = \sqrt{\frac{\Lambda}{\sigma_{+-}}} \frac{1 - C_0}{1 + C_0} \tag{31}$$

Based on this, we can already determine the number of connected pairs of "+" and "–" formed in "clumps", which is equal to:

$$\frac{\mathrm{d}n_{+-}}{\mathrm{d}t} = \sigma_{+-} n_+(t) n_-(t) \to \sigma_{+-} \int_0^\tau n_+(t) n_-(t) \mathrm{d}t = \Lambda\sqrt{\sigma_{+-}} \int_0^\tau \left(\frac{1 - C_0 \mathrm{e}^{2\sqrt{\frac{\Lambda}{\sigma_{+-}}}t}}{1 + C_0 \mathrm{e}^{2\sqrt{\frac{\Lambda}{\sigma_{+-}}}t}} \right)^2 \mathrm{d}t \tag{32}$$

Here τ is a time of the action for the flux of the "+" and "–" particles. Knowing this value, we can already determine the number of free particles "+"

and "−" equal to:

$$n_{Free}\left(t=\tau\right)=2\Lambda\tau-n_{+-}\left(t=\tau\right) \tag{33}$$

We obtained the dependence of the concentration in the primary "clot" for the "+" and "−" pairs, as well as their concentrations, which did not form bound states. These relations depend on the properties of "+", "−", namely, on the cross section of their interaction (or the probability of formation of a bound state).

The properties of the quantities themselves σ_{++}, σ_{+-}, σ_{--} and their nature will be discussed below. Thus, a cloud was formed from the streams of particles "+", "−", inside which a nucleus of connected pairs was formed {"+", "−"}.

If Λ_0 is the rate of arrival in the flow of particles $\tilde{O}_0$, and the probability of formation of connected structures in an already formed cloud with particles "+", "−" and their associated pairs {"+", "−"} is determined by the values σ_{0+}, σ_{0-} and $\sigma_{0\{+,-\}}$, and in this case, the matrix for the interaction sections will have a more complex character, in view:

$$\sigma_{ij}^{*}=\begin{pmatrix}\sigma_{00} & \sigma_{0+} & \sigma_{0-} & \sigma_{0(+,-)}\\ \sigma_{+0} & \sigma_{++} & \sigma_{+-} & \sigma_{+(+,-)}\\ \sigma_{-0} & \sigma_{-+} & \sigma_{--} & \sigma_{-(+,-)}\\ \sigma_{(+,-)0} & \sigma_{(+,-)+} & \sigma_{(+,-)-} & \sigma_{(+,-)(+,-)}\end{pmatrix}, \tag{34}$$

and then, the kinetic equations for the processes of formation of triads under the action of the flux from the "0" particles will take the form:

$$\frac{\mathrm{d}n_0}{\mathrm{d}t}=\Lambda_0-\sigma_{00}n_0n_0-\sigma_{0+}n_0n_+-\sigma_{0-}n_0n_--\sigma_{0\{+,-\}}n_0n_{\{+,-\}} \tag{35}$$

$$\frac{\mathrm{d}n_+}{\mathrm{d}t}=-\sigma_{+0}n_+n_0-\sigma_{++}n_+n_+-\sigma_{+-}n_+n_--\sigma_{+\{+,-\}}n_+n_{\{+,-\}} \tag{36}$$

$$\frac{\mathrm{d}n_-}{\mathrm{d}t}=-\sigma_{-0}n_-n_0-\sigma_{-+}n_-n_+-\sigma_{--}n_-n_--\sigma_{-\{+,-\}}n_-n_{\{+,-\}} \tag{37}$$

$$\frac{\mathrm{d}n_{\{+,-\}}}{\mathrm{d}t}=-\sigma_{\{+,-\}0}n_{\{+,-\}}n_0-\sigma_{\{+,-\}+}n_{\{+,-\}}n_+-\sigma_{\{+,-\}-}n_{\{+,-\}}n_-+\sigma_{\{+,-\}\{+,-\}}n_{\{+,-\}}n_{\{+,-\}} \tag{38}$$

In this case, there is a saturation condition when we get that the transformation processes will stop when the condition is met:

$$\frac{\mathrm{d}n_0}{\mathrm{d}t}=\frac{\mathrm{d}n_+}{\mathrm{d}t}=\frac{\mathrm{d}n_-}{\mathrm{d}t}=\frac{\mathrm{d}n_{\{+,-\}}}{\mathrm{d}t}=0, \tag{39}$$

from where, we get a system for determining concentrations in case of saturation:

$$\sigma_{00}n_0^2+\sigma_{0+}n_0n_++\sigma_{0-}n_0n_-+\sigma_{0\{+,-\}}n_0n_{\{+,-\}}=\Lambda_0 \tag{40}$$

$$\sigma_{+0}n_+n_0+\sigma_{++}n_+^2+\sigma_{+-}n_+n_-+\sigma_{+\{+,-\}}n_+n_{\{+,-\}}=0 \tag{41}$$

$$\sigma_{-0}n_-n_0+\sigma_{-+}n_-n_++\sigma_{--}n_-^2+\sigma_{-\{+,-\}}n_-n_{\{+,-\}}=0 \tag{42}$$

$$\sigma_{\{+,-\}}n_{\{+,-\}}n_0+\sigma_{\{+,-\}+}n_{\{+,-\}}n_++\sigma_{\{+,-\}-}n_{\{+,-\}}n_--\sigma_{\{+,-\}\{+,-\}}n_{\{+,-\}}^2=0 \tag{43}$$

Here, using, that at the final state of the saturation in the field of the formation of the triads, at the conditions, that $n_+ = n_- = 0$, we can obtain from the (40)-(43), that:

$$n_0 = \sqrt{\frac{\Lambda_0 \sigma_{\{+,-\}}}{\sigma_{00}\sigma_{\{+,-\}} + \sigma_{0\{+,-\}}^2}} \text{ and } n_{\{+,-\}} = \sqrt{\frac{\Lambda_0 \sigma_{0\{+,-\}}^2}{\sigma_{\{+,-\}}\left(\sigma_{00}\sigma_{\{+,-\}} + \sigma_{0\{+,-\}}^2\right)}} \quad (44)$$

The solution of the system (35)-(38) gives us possibility to obtain concentrations of triads in the manner of relationships (32) with appropriate cross-sections and concentrations. It will gives us relations between the concentrations of triads, denoted by us as $\left[0\{+,-\}\right]$ in the triad nucleus, in combination with other particles formed during reactions: $[+,-]$, $[+,+]$, $[-,-]$ $[0,-]$ $[0,+]$ $[0,0]$ and further, combinations consisting of: $\left[+(+,-)\right]$, $\left[+(0,-)\right]$ etc. Note also that the probabilities of the formation of complex complexes are unlikely and therefore, the main structures will be triads $\left[0\{+,-\}\right]$, the remaining structures from "0", "+" and "–". Further, since each of the states "0", "+" and "–" can consist in the form of a string or a ring, then we have the following structure, which can eventually be formed: the central core-triads $\left[0\{+,-\}\right]$; the shell from $[+,-]$, which did not connect to "0"; the shell from "–"; the shell from "+" and the shell from "0".

It should be noted that compounds from homogeneous elements are compounds of rings with strings forming shells from chains of such compounds. Here we have that the ratios of the concentrations of the triads, the matter of the shells and those structures that are not included in them can be compared to the observed ratios of concentrations between them, depending on the energies and cross-sections of the interaction, while the cross-sections of the interaction, in the first approximation, can be compared with the geometric dimensions of the string and rings. At the same time, we get that reactions of the type are possible: $S_+ + S_- \to O_+ \cap O_-$, $S_+ + O_0 \to O_+ \cap O_0$, that is, two strings, interacting, form a chain of two rings, etc.

Shells formed from "0", "+", and "–" are formed at different energies and therefore, we can talk about them as Relics, respectively, from "0", from "+" and "–". Each of these shells has its own vibrations and the structure of the energy spectrum, which can be described in the framework of quantum mechanics by estimating their shell radii, in the spirit of relation (16). In this case, the particles "0", "+", "–", which form the triads of the "seeds of Creation" in the "Clumps" of the early Universe, after the Big Bang are transformed respectively into "3", "2", "1".

Note also that, as a first approximation, we can estimate the interaction sections by introducing the geometric characteristics of the strings, assuming that S_+, S_- and S_0 strings have the corresponding lengths: L_+, L_- and L_0, which gives us the opportunity to write down the following relations for the interaction sections: $\sigma_{+-} \sim L_+ L_-$, $\sigma_{0-} \sim L_0 L_-$ and etc., which gives us the opportunity to relate the relative content between DM, DE and BM through geometric parameters of strings and Borromeo rings. For more complex cross sections, such as $\sigma_{\{+,-\}0}$ we can take the interaction cross section in the form of $\sigma_{\{+,-\}0} = L_0\sqrt{L_+^2 + L_-^2}$, etc. For a systematic and consistent theory, a new approach and new ideas are needed, however, as reasonable estimates, our approach may be useful.

5. Strings Arising as Generalized Papapetrou Solutions

Discussing strings and rings in the previous section, the question arises about their general relativistic description. We are talking about solving Einstein's equations for matter distributed in the form of a finite and infinite string, in the form of a ring and in the form of a torus.

For this aim, we will consider an example of purely theoretical interest. However, it makes it easy to investigate the mathematical structure of space-time formed by the configuration of masses distributed along one axis of symmetry. Our approach is based on work [10], in which a generalization of the Papapetrou solution of Einstein's vacuum equations was obtained [11]. This solution represents a class of axially symmetric solutions, the metric for which can be represented in the form [12]:

$$\mathrm{d}s^2 = f\left(\mathrm{d}t - \omega \mathrm{d}\phi\right)^2 - \frac{\rho^2}{f}\mathrm{d}\phi^2 - \mathrm{e}^{\mu}\left(\mathrm{d}\rho^2 + \mathrm{d}z^2\right), \tag{45}$$

where $f \cdot l + k^2 = \rho^2$, f, ω, μ, k, l are unknown functions of ρ and z in cylindrical coordinates. To solve the Einstein vacuum equation $R_{\mu\nu} = 0$, according to [10], we obtained that the solution can be represented in the following form:

$$f = f\left(\varsigma_{,z} - \int \eta(z)\mathrm{d}z\right), \tag{46}$$

where $\eta(z)$ is the density distribution of matter along the axis of symmetry. Thus, we assume the distribution of matter along the 1D axis. The variable ς is entered as $\omega = C\rho\varsigma_{,\rho}$, where C is a constant. Then, Papapetrou solution can be generalized and written in the form [10]:

$$f(\rho, z) = \left\{\alpha \cdot \cosh\left[\varsigma_{,z} - \int \eta(z)\mathrm{d}z\right] - \beta \cdot \sinh\left[\varsigma_{,z} - \int \eta(z)\mathrm{d}z\right]\right\}^{-1}, \tag{47}$$

α, β constants satisfying the condition: $C^2 = \alpha^2 - \beta^2$ and the function ς is the solution of a Poisson type equation:

$$\Delta\varsigma = \varsigma_{,\rho\rho} + \varsigma_{,zz} + \frac{1}{\rho}\varsigma_{,\rho} = \eta(z) \tag{48}$$

The difference between this solution and the classical Papapetrou solution is that there is no term on the asymptotics in the solution [11] $\sim r^{-1}$:

$$f(\rho, z) = \frac{1}{\alpha}\left[1 + \frac{\beta \cdot z}{\alpha \cdot r^3} + O\left(r^{-2}\right)\right], \tag{49}$$

this necessarily leads us to the conclusion that this solution is not physical. In our solution given in (47), there exists a term $\sim r^{-1}$ on the asymptotic, as it was shown in [10]. Moreover, from the generalized solution we have obtained, we can obtain a solution for the space-time of a linear Gravitomagnetic monopole:

$$f(\rho,z)=\frac{2m}{L}\cdot\cosh^{-1}\left(2m\ln\frac{\rho}{\rho_0}\right) \tag{50}$$

This is easy to do with the appropriate function $\varsigma(\rho,z)$ selection [10]. Also, it is easy to see that if we choose a distribution $\eta(z)$ for the density along the axis of symmetry in the form:

$$\eta(z)=\begin{bmatrix}\rho_0 & z\in[-z_0,z_0]\\ 0 & z\notin[-z_0,z_0]\end{bmatrix} \tag{51}$$

we can get an explicit form of the function $\varsigma(\rho,z)$ by writing it as:

$$\varsigma(\rho,z)=-\frac{1}{4\pi}\int_{-\infty}^{\infty}\frac{\eta(z')\mathrm{d}z'}{\sqrt{\rho^2+(z-z')^2}}=-\frac{1}{4\pi}\int_{-Z_0}^{Z_0}\frac{\eta(z')\mathrm{d}z'}{\sqrt{\rho^2+(z-z')^{22}}} \tag{52}$$

From where, integrating, the classical Weyl solution is necessarily obtained (see in the book [13]). Further, if we imagine the distribution of matter along the axis of symmetry in the following form:

$$\eta(z)=\rho_0\cdot\delta\left[\sin\left(\frac{2\pi}{a}z\right)\right] \tag{53}$$

Then, the metric in the case of a discrete distribution of gravitational field sources along the 1D axis of symmetry will be reduced to the definition of the function $\varsigma(\rho,z)$:

$$\varsigma(\rho,z)=-\frac{\rho_0}{4\pi}\int_{-Z_0}^{Z_0}\frac{\delta\left[\sin\left(\frac{2\pi}{a}z'\right)\right]\mathrm{d}z'}{\sqrt{\rho^2+(z-z')^2}}, \tag{54}$$

The resulting solution, taking into account the metric relations in [10], requires a separate consideration of space-time for such a gravitational configuration, taking into account its stability with respect to radial and transverse vibrations, taking into account its axis of symmetry. It is obvious that the transverse oscillations will be stable, up to certain limits, the violation of which will lead to the destruction of the initial distribution of matter along the axis of symmetry. The ways to solve this problem involve, at least at the initial stage, the linearization of the equations and the study of the perturbation parameters for the stability boundary. Solution (54) assumes a discrete distribution of matter along the axis of symmetry, however, any other axial distribution is possible, and the dimensions of the string can be given. The analyticity of the result, for an arbitrary distribution, is determined only by the possibility of expressing the integral (52) in elementary functions, where the function $\eta(z)$ can be such that the integration of the relation:

$$\int_{-Z_0}^{Z_0}\frac{\eta(z')\mathrm{d}z'}{\sqrt{\rho^2+(z-z')^2}} \tag{55}$$

could be performed in elementary functions. In the case $\eta(z) = const$, we get a tabular integral.

6. Main Conclusions, Results and Discussion

The hypothesis about the possibility of the existence of the Universe inside the BH allows us to take a fresh look at the fundamental processes of the formation of the Universe and the role of the Black holes, for which, at very large masses, it is permissible to consider them as classical objects. This opens up completely new perspectives in their research and understanding of their nature.

Of course, some of the tasks set in our article require further research and development. For example, we would like to obtain exact solutions of Einstein's equations, in the spirit of [8] [9], when matter is distributed in the form of a torus or in the form of a rotating disk with differential rotation of matter in it.

Further, the study of the nature of the Primary Particles {"0", "+", "−"}, "seeds of Creation" {"3", "2", "1"} and the structures they can form is also a priority of our future research. As we have noted, the study of solutions of the Einstein equations leading to transitions such as the Einstein-Rosen bridge transition, with the study of the stability of these solutions, is of particular interest to us. Questions concerning the physical nature of "bubbles", including their mathematical structure [9] [10], are also in the field of our research interests.

Below we briefly summarize the main conclusions and the results of our study:

- Conducted estimates obtained from comparing the density of a supermassive BH with the mass of our Universe, and the average density of the Universe, indicate the possibility of the existence of our Universe inside the BH.
- It is shown that such a BH, in general, can be considered not as a quantum, but as a classical physical object, due to the fact that the density of BH, determined from a simple relation: $\rho_{BH} = \frac{3c^6}{32\pi\gamma^3} \cdot \frac{1}{M_{BH}^2} \to 0$ at $M_{BH} \to \infty$, and then the equation of state for the cosmological description of such a universe within the framework of Einstein's equations can be put equal to $P = -\rho$.
- Taking into account the hypothesis of the existence of the Universe inside a supermassive BH, it is shown that the motion of a scalar test particle near the "edge of the Universe" is of a quantum nature. For this motion, the energy spectrum and the root-mean-square radius of stationary states and the radiation spectrum at internal energy transitions are obtained. Expressions are obtained for the energy flow and wavelength, which can be measured by a distant observer. The detection of such radiation can confirm the validity of the hypothesis about the possibility of the existence of the Universe inside the BH.
- The nature of the movement of a scalar particle near the "edge of the Universe" necessarily leads to the formation of Relic shells from Primary Particles "0", "+", "−", which become areas of adjustment in the primary Chaos

after BB and the place of creation of TM.

- Our approach shows the exceptional role of BH in the creation of the Universe and substantiates the hypothesis of where 4 categories of unmanifested matter could have appeared in our Universe, if we consider it a closed system.
- A comparison of the volume of a supermassive BH and the volume of the Universe immersed in a BH shows that there are a huge number of cavities inside such a BH that form voids. Based on the observed sizes of the voids, it can be concluded that if the processes of formation of dwarf galaxies or stars occur in them, then the dynamic manifestation of these processes must be observed in the long-wave spectrum of electromagnetic radiation or by studying the fluctuations of relic radiation at small solid angles $\delta\Omega$ satisfying the condition: $\Delta = \frac{\delta T}{T} - \left\langle \frac{\delta T}{T} \right\rangle > 0$, at $\delta\Omega = \pi \cdot \left(\frac{r}{R} \right)^2 \ll 1$, where r is the characteristic size of a star or dwarf galaxy, and R is the distance to this object equal to the distance to the void.
- DM gravity forms "Dark Stars" (DS) consisting of DM particles. Since DM particles are light, the size of DS should be huge, and the evolutionary life span small, which leads to their rapid transformation into BH at the early stages of the evolution of the Universe after BB. This could lead to additional heating of the medium, and the presence of BH born from DS could accelerate the formation of ordinary galaxies. An additional channel for the formation of BH in the early Universe is the formation of Giant stars (GZ) from the baryonic matter (BM), consisting of hydrogen and helium nuclei
- A system of kinetic equations describing the transformation of Primary particles into more complex compounds, including triads, as well as other binary and ternary structures, is obtained. The dependences of the concentrations of these particles on the interaction cross-sections were obtained, which are related to the physical and geometric parameters of strings and rings obtained from the decay of Borromeo rings. We have concluded that residual structures can form areas in which residual "0", "+" and "–" are concentrated, forming areas of the primary Relic of these particles.
- Since objects such as strings and rings are formed during the decay of Borromeo rings, the analytical obtaining of them as solutions to Einstein's equations is of undoubted interest. We have obtained that the generalization of Papapetrou solution leads to the existence of strings with an arbitrary density distribution (both discrete and continuous) having dimensions comparable to the size of the Universe. In the case of a string of finite length, such solutions are also possible, while if the string density is constant, then we arrive at the solution obtained by Weyl.
- We assumed the existence of a solution in the form of a generalization of the Einstein-Rosen bridge type solution, when different dimensions of the White and Black holes forming this bridge are possible. The possibility of the exis-

tence of such structures is associated with the rotation of the Black and White holes and the condition for the stability of the transition between them.

Conflicts of Interest

The authors declare no conflict interest regarding the publication of this paper.

References

[1] Khugaev, A.V. (2021) Concept of "Nested Russian Doll" Concept of 3-Principles and the Nature of the Dark Matter. *Sciences of Europe*, **1**, 34-40.

[2] Khugaev, A.V. and Bibaeva, E.A. (2021) Concept of Vibration in the Real World. Mechanism of the Universe", *Sciences of Europe*, № 74, 47-57.

[3] Khugaev, A. and Bibaeva, E. (2023) The Worlds on the Other Side of the Big Bang. *Journal of Applied Mathematics and Physics*, **11**, 276-302. https://doi.org/10.4236/jamp.2023.111016

[4] Khugaev, A. and Bibaeva, E. (2023) To the Self-Deployment of Worlds on the Other Side of the Big Bang. *Journal of Applied Mathematics and Physics*, **11**, 1498-1524. https://doi.org/10.4236/jamp.2023.111016

[5] Fermi, E. (1965) Notes on Quantum Mechanics. The University of Chicago Press, Chicago.

[6] Ilie, C., Paulin, J. and Freese, K. (2023) Supermassive Dark Star Candidates Seen by JWST? arXiv: 2304.01173v2 [astr-ph.CO] https://doi.org/10.1073/pnas.2305762120

[7] Smoot, G.F. (2007) Anisotropy of Relic Radiation: Discovery and Scientific Significance. *Physics-Uspekhi*, **177**, 1294-1317. https://doi.org/10.3367/UFNr.0177.200712d.1294

[8] Witten, E. (1982) Instability of the Kaluza-Klein Vacuum. *Nuclear Physics B*, **195**, 481-492. https://doi.org/10.1016/0550-3213(82)90007-4

[9] Chambini, A. and Emparan, R. (1997) Bubbles in Kaluza-Klein Theories with Spacelike or Timelike Internal Dimensions. *Physical Review D*, **55**, 754-765. https://doi.org/10.1103/PhysRevD.55.754

[10] Khugaev, A.V. and Ahmedov, B.J. (2004) Remarks on Papapetrou Class of Vacuum Solutions of Einstein Equations. *International Journal of Modern Physics D*, **13**, 1823-1830. https://doi.org/10.1142/S0218271804004748

[11] Papapetrou, A. (1953) Eine rotationssymmetrische losung in der allgemeinen relativitatstheorie. *Annalen der Physik*, **12**, 309-315. https://doi.org/10.1002/andp.19534470412

[12] Islam, J.N. (1985) Rotating Fields in General Relativity. Cambridge University Press, Cambridge. https://doi.org/10.1017/CBO9780511735738

[13] Kramer, D., Stephani, H., Herlt, E., MacCallum, M. and Schmutzer, E. (1980) Exact Solutions of Einstein's Field Equations. Cambridge University Press, Cambridge.