Primordial Black Holes as dark matter, Gravitational Radiation as dark energy (P. W. Anderson): Unified Approach to Planck scale physics and Big Bang cosmology, early large scale structure and two stage accelerated expansion of the Universe

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The work based on the algebraic approach bequeted by Einstein to the unification of quantum and continuum description of reality. It is devoted to multi-aspect and multi-disciplinary analysis and solution of many unsolved problems and paradoxes in physics and cosmology. Presented approach is based on the modern data from experimental physics and observational cosmology. This approach allows to solve a large complex of interconnected physical and cosmological puzzles (such as Beginning of time and hot Big Bang process, the Dark matter and Dark energy nature, origin and evolution, Baryogenesis and baryonic asymmetry, cosmological constant problem, horizon problem, information loss paradox etc) using robust but effective mathematical tools. Main attention is paid to the key role of the primordial black holes in the birth and accelerated development of observable Universe. Based on the unification of quantum physics and general relativity the obtained results convincingly reveal and explain the hot Bing Bang cosmology and independently confirm the validity of L-CDM cosmology in the light of JWST and other discoveries. According to precise calculations, the first protogalaxies with supermassive black holes in their centers of gravity were formed before the Recombination epoch.

Keywords: Planck scale physics, primordial black holes, dark matter, dark energy, Bose-Einstein photon condensate, L-CDM cosmology, cosmological problems.

To the blessed memory of J. Bekenstein, S. Hawking and P. W. Anderson

Introduction

"What I cannot create, I do not understand." (R. Feynman)

The main goal of our work is to demonstrate the exceptional importance of primordial black holes (PBHs) in the emergence and development of the observable Universe as well as to solve and remove numerous problems and paradoxes such as connection gravity and quantum physics, Planck scale physics and Big Bang cosmology, baryogenesis, supermassive black holes formation, the very early "clumpiness" of the Universe, large scale structure with supervoids and superclusters formation, two stage accelerated expansion, "horizon" problem, "cosmological constant" problem, "information loss" paradox etc, that have accumulated in observational cosmology and astrophysics.

Ultimately we will demonstrate that the realistic black hole physics is the key to solving fundamental problems in cosmology. This is, by and large, the main content of the presented work.

An outstanding role in our research was played by the fundamental discovery of a previously unknown state of matter - selfgravitating condensed light[1,2]. We are talking about the quantized photon Bose-Einstein condensate predicted about a hundred years ago.

This indubitably suggested the idea that the initial state of the observable Universe was "grainy" spacetime consisting of Planck photon 3D condensate with maximal Planck mass-energy density, minimal possible entropy and extreme instability (Planck lifetime), and, that a PBHs represent spherical "membranes" consisting of 2D photon condensates. Due to the fact, that the geometrical sizes of black holes extend from Planck values to the dimensions of Solar system, it is impossible to imagine a better candidate to their physical background.

Moreover, the quantum nature of selfgravitating condensed light automatically entailed the natural quantization of the geometrical, gravitational, thermodynamical, informational and radiational characteristic of black holes.

All this opened the door to the Terra Incognita of the beginning of Time and to a more realistic history of the Universe caused by PBHs cosmology.

In the light of the new experimental and observational discoveries, of the prophetic conjectures of our great predecessors - A. Einstein, S. Bose, A. K. Raychaudhuri, J. Bekenstein, S. Hawking, P. W. Anderson and other outstanding physicists and cosmologists - began to be perceived in a new creative way.

Already in his early works S. Hawking payd a special attention to the exceptional role of PBHs in his cosmological research[3,4], while the young physicist and cosmologist V. Mukhanov had already began his research in the field of quantized black holes[5].

It should be noted that recently and increasing number of astrophysicists believe that dark matter is nothing other than microscopic PBHs with asteroid masses. A detailed overview can be found in Anne M. Green work[6].

In his prophetic scientific testament "Four last conjectures"[7], the outstanding physicist and Nobel laureate P. W. Anderson wrote: "IV. Dark energy as gravitational radiation ... This last point is the crux of the argument ... the mass is irreversible last ... therefore our expansion are accelerating ... this does not seem to be accounted in the present cosmology". In fact, it was this great insight that was the driving force behind our research, an insight that led to the idea of a profound connection between dark matter and dark energy.

In presented study we followed the two wise methodological principles of Niels Bohr and Albert Einstein. First: "Base your research on well established physical laws, but push them into the most extreme conceivable domains", second: "We cannot solve our problem with the same thinking we used when created them".

"Physics shrives on crisis" – wrote Steven Weinberg at the end of the last century in his profound article "Cosmological constant problem"[8]. It should be admitted with all sincerity that over the past quarter of century the situation has not only not improved, but has also worsened dramatically: the swarm of unsolved problems and paradoxes continues to grow in contrast to the new successful experimental and observational data.

It becomes absolutely clear, that without the unification of these two fundamental theories, we cannot further successfully and efficiently move forward along the path of space exploration and a deep understanding of the observable Universe. On what basis can this be done?

Gravitational waves, interpreted as "ripples of spacetime", and "probability waves" of quantum theory have a fundamentally different nature, but are related geometrically. For this reason further we will describe many phenomena and processes of black holes in terms of wavelengths and geodesic lengths. Secondly, it was necessary to find a quantum "background substance" in which the monstrous gravitational squeezing force must be equilibrated by quantum-mechanical repulsive one.

Fortunately, recent remarkable discoveries, such as Einstein's gravitational waves, "impossible" early galaxies and quasars discovered by JWST, 2D photon Bose-Einstein condensate with rest energy, etc. provide a solid experimental and observational basis for "fiery marriage of general relativity with quantum theory" (J. Wheeler).

1. The sketches of "Einstein's algebra"

Driven by his own deepest methodological principle, in his last work (1955) Einstein wrote the closing lines that sound like a testament: "... a finite system with it's finite energy can be described in full by a finite set of quantum number. Seemingly, it can not be compliant with continuum theory and requires a purely algebraic theory for a reality description. However, now nobody knows how to find the basis for such a theory" [9]. Note that the path to such a theory turned out to be much more dramatic than anyone might have imagined.

Consecutively, in a physical logic, nature inspires us that primordial black holes represent 2D spherical photon condensates trapped in their own gravitational fields. Such a physical model inevitably leads to the natural geometrical equation that directly connects Compton wavelength λ_{sm} of condensed light (quantum theory) with geodesic length (general relativity):

$$\lambda_{sm} = 2\pi R_s. \tag{1}$$

where R_s - Schwarzschild gravitational radius of black hole. Figuratively speaking, Spacetime tells condensed Light quanta how to curve; condensed Light quanta tells Spacetime how to quantize.

From the definition of the Compton wavelength

$$\lambda_{sm} = \frac{2\pi\hbar}{M_{sm}c} \text{ and } 2\pi R_s = 4\pi G M_s/c^2$$

we immediately find the mass and rest energy of each condensed photon:

$$M_{sm} = \frac{2\pi\hbar}{\lambda_{sm}c} = \frac{\hbar}{R_s c} \text{ and } E_{sm} = M_{sm}c^2 = \frac{\hbar c}{R_s} \tag{2}$$

as well as their total number

$$N_s = \frac{M_s}{M_{sm}} = 2\frac{M_s^2 G}{\hbar c} = 2\frac{M_s^2}{M_p^2} = 2\frac{E_s^2}{E_p^2} = \frac{R_s^2}{2l_p^2} \text{ etc,} \tag{3}$$

expressed in the form of Planck mass M_p, Planck energy E_p and Planck length l_p. As we can see, already these simplest but consistent relation open the door to the Terra Incognita of Planck scale physics.

Taking into account that the number N_s of condensed photons cannot be less than two, we easily find a very important expression for their number, using the natural quantum number n_s:

$$N_s = 2n_s, n_s = 1, 2, 3... \tag{4}$$

From the obviously derived quantum relations such as

$$M_s = M_p\sqrt{n_s}, E_s = E_p\sqrt{n_s}, R_s = 2l_p\sqrt{n_s}, A_s = 4\pi R_s^2 = 16\pi l_p^2 n_s \text{ etc,} \tag{5}$$

we find a precise characteristics of the minimal ($n_s = 1$) Planck black hole:

$$M_{sp} = M_p, E_{sp} = E_p, R_{s_p} = 2l_p, A_{sp} = 16\pi l_p^2 \text{ etc.} \tag{6}$$

Relying only on the well established physical laws one can easily find the numerous quantized characteristics (mass M_s, rest energy E_s, size R_s, entropy S_s, temperature T_s, amount of quantum information I_s, lifetime τ_s, luminosity L_s etc.) and simple but very important laws that govern birth, growth and death of PBHs.

The first one to note is that all these quantized characteristics of PBHs are expressed only in Planck units and in the various degrees of natural quantum numbers:

$$M_s = M_p\sqrt{n}_s, E_s = E_p\sqrt{n}_s, R_s = 2l_p\sqrt{n}_s, S_s = 2k_B n_s, T_s = \tfrac{T_p}{4\sqrt{n_s}} \ ,$$

$$I_s = N_s = 2n_s(bit), \tau_s = \frac{4}{3}\pi t_p n_s^{3/2}, L_s = \frac{L_p}{4\pi n_s} \text{ etc,} \tag{7}$$

where $M_p, E_p, l_p, t_p, L_p, T_p$ are Planckian units of the mass, energy, lifetime, luminosity and temperatures consecutively, k_B the Boltzmann constant.

More information on these results can be found in our report on MG-16 [10].

We especially note that the quantum mechanical form of desicribing a black hole maybe replased in accordance with (7) using natural substitutions such as

$$n_s = M_s^2/M_p^2 = \frac{G}{\hbar c}M_s^2 = \frac{G}{\hbar c^5}E_s^2 = \frac{c^3}{4\hbar G}R_s^2 \text{ etc.} \tag{8}$$

As example, through these substitutions one can easily compare our results withe the results of Bekenstein [11] and Hawking [12]:

$$S_s = \frac{k_B c^3\hbar^{-1}G^{-1}}{8\pi}A_s = S_s(\text{Bekenstein})/ln2 = S_s(\text{Hawking})/2\pi, \tag{9}$$

$$T_s = \frac{\hbar c^3}{4 k_B G M_s} = 2\pi T_s(\text{Hawking}). \quad (10)$$

As we can see our results are not very different from the results of Bekenstein and Hawking (which clearly indicates that we are on the right track), howerever we received them not by intuitive assumptions, but from clear and precise physical principles and relationships, as well as the experimental basis.

2. On the fundamental importance of Planck equivalences and relations

As is known, one of the sure signs of consistence of a well founded theory is that some fundamental constats, equivalences and relationships directly follow from it. In our case, we independently came up with a remarkable Planck Units System. This forces us to take very seriously the consideration of the physical meaning and of the consequences arising from it. As example, we find the following amazing formulas and equivalences:

Planck force: $F_p = G\frac{M_p M_p}{l_p^2}(\text{Newton}) = M_p a_p(\text{Newton})$;

Planck work: $W_p = F_p l_p = \frac{\hbar}{c} a_p = E_p$;

Planck energy: $E_p = M_p c^2(\text{Einstein}) = \hbar\omega_p(\text{Planck}), \omega_p = 1/t_p$;

$g_p = G\frac{M_p}{l_p^2} = \frac{F_p}{M_p} = a_p(\text{Einstein equivalence principle})$;

Planck momentum: $P_p = E_p/c = M_p c = \hbar/l_p(\text{de Broglie})$;

$P_p l_p = E_p t_p = \hbar(\text{Heisenberg uncertainity principle})$;

Planck temperature: $T_p = E_p/k_B = \frac{\hbar}{ck_B} a_p(\text{Unruh relation})$ etc,

where a_p is Planck acceleration, g_p - Planck gravity, ω_p - Planck cyclic frequency, and so on. We'll be using them in what follow, especially when describing the initial state of the observable Universe and Big Bang processes.

3. Energy and entropy radiation of black holes

Presented description of a black hole is very close to the famous 2D Kip Thorne's "membrane" taken as "stretched horizon" [13]. With two significant differences:

(1) presented "membrane stretched horizon" if formed by 2D photonic condensate;
(2) in our case the tremendous gravitational squeezing force

$$F_s(gravitational\ squeezing\ force) = \frac{dE_s}{dR_s} = \frac{c^4}{2G} = F_p/2 \quad (11)$$

is perfectly equilibrated by the same but repulsive quantum-mechanical one:

$$F_s(quantum\ repulsive\ force) = N_s\frac{dE_{sm}}{dR_s} = \frac{R_s^2}{2l_p^2}\frac{d(\hbar c/R_s)}{dR_s} = -F_p/2. \quad (12)$$

To deep understand, what opposing half-Planck forces we are talking about, let us give the following example: the force of gravitational attraction between two supermassive black holes with 100 billion solar masses at a distance just 10 gravitational radii is equal to only half percent (sic!) of these monstrous opposing forces.

However, this tremendous equilibrium is rhythmically disrupted by spontaneous V. Mukhanov - J. Bekenstein quantum transition[14] from n_s energy level to underlying n_{s-1} one (like in hydrogen atom), accompanied with two-particle emission (caused by the conservation of momentum law) and gravitational radiation with quadrupolar and octupolar modes, expressed by following fundamental scheme:

$$BH_s \to BH_{s-1} + 2\gamma_s + \Gamma_s \tag{13}$$

with

$$E(BH_s) = E_p\sqrt{n_s}, E(BH_{s-1}) = E_p\sqrt{n_{s-1}} \tag{14}$$

$$\Delta E_{s,s-1}(rad) = E_p\sqrt{n_s} - E_p\sqrt{n_{s-1}} =$$

$$= \Delta E_{s,s-1}qu(rad) + \Delta E_{s,s-1}gr(rad) \tag{15}$$

$$\Delta E_{s,s-1}qu(rad) = 2\frac{E_p}{4\sqrt{n_s}}(two\ particle\ energy) \tag{16}$$

$$\Delta E_{s,s-1}gr(rad) = \Delta E_{s,s-1}(rad) - \Delta E_{s,s-1}qu(rad) =$$

$$= \Delta E_{s,s-1}qu(\frac{1}{4n_s} + \frac{1}{8n_s^2} + ...), \tag{17}$$

where coefficients $1/(4n_s)$ and $1/(8n_s^2)$ are related to the quadrupolar and octupolar modes. From Clausius relation we obtain the radiated quantum and gravitational entropy:

$$\Delta S_{s,s-1} = \frac{\Delta E_{s,s-1}qu(rad)}{T_s(rad)} = \Delta S_{s,s-1}qu(rad) + \Delta S_{s,s-1}gr(rad), \tag{18}$$

$$\Delta S_{s,s-1}qu(rad) = k_s 2(bit), \Delta S_{s,s-1}gr(rad) = k_s 2(bit)(\frac{1}{4n_s} + \frac{1}{8n_s^2} + ...) \tag{19}$$

where $\Delta E_{s,s-1}(rad)$ - all emitted energy, $\Delta E_{s,s-1}qu(rad)$ - the energy of two emitted particles, $\Delta E_{s,s-1}gr(rad)$ - the energy of gravitational radiation, $T_s(rad) = T_s, \Delta S_{s,s-1}$ - the emitted entropy, that increases the total entropy of the Universe, $\Delta S_{s,s-1}qu(rad)$ - two particle radiation entropy, $\Delta S_{s,s-1}gr(rad)$ - gravitational radiation entropy. Typically, we are dealing with the two photons emission, with one very important exception when it comes to baryogenesis (see below).

To clarify the deep physical meaning of the results obtained, we must "dress" the "naked" mathematical form $\Delta E_{s,s-1}(rad)$ in clear physical garments.

The serious attitude towards Planck equivalences and relationships comes to our aid:

(1) taking into account the simple physical expression for the acceleration as , associated with the dynamical process of evaporating black hole

$$a_s = \frac{F_s}{M_s} = \frac{F_p/2}{M_p\sqrt{n_s}} = \frac{a_p}{2\sqrt{n_s}} \tag{20}$$

and mentioned above Planck equivalence $E_p = \frac{\hbar}{c}a_p$, one can easily find the very interesting physical form that links emitted energy and acceleration:

$$\Delta E_{s,s-1}(rad) = \frac{\hbar}{c}a_s - \frac{\hbar}{c}a_s(\frac{1}{4n_s} + \frac{1}{8n_s^2} + ...) \tag{21}$$

where the first term express the energy of two emitted particles, the second term is related to energy of gravitational radiation, expressed by quadrupolar $1/(4n_s)$ and octupolar $1/(8n_s^2)$ terms;

(2) from mentioned Planck equivalence $T_p = \hbar\frac{a_p}{ck_B}$ we immediately find the amazing expression for temperature and acceleration:

$$T_s(rad) = \frac{E_p}{4ck_B\sqrt{n_s}} = \frac{\hbar a_p}{4ck_B\sqrt{n_s}} = \frac{\hbar}{2ck_B}a_s = T_s \tag{22}$$

which surprisingly clearly and physically convincingly confirms famous W. Unruh theorem[15] about the connection of vacuum two-particle radiation, acceleration and temperature.

Here we must pay attention to the important historical fact that it was this Unruh theorem that allowed the remarkable physicist T. Jacobson to derive Einstein's equation from thermodynamics[16]. Above we also used the Clausius relation, inspired by his deep statement: "The black hole entropy without black holes".

Note that the values of gravitational radiation energy and the emitted gravitational entropy are very significant only in the Planck-scale range, i.e. in the Planckian epoch, where quantum numbers begin with first natural numbers. But it is these first numbers, that will open the door to the Beginning of Time.

4. Lifetime and luminosity of primordial black holes, removing the "information loss" paradox

Based on the strong conditions of causality and spherical geometry we can calculate the time of transition from one state to underlying one: it is equal to half the length of the geodesic line divided by the speed of light:

$$\Delta t_{s,s-1} = \pi R_s/c = 2\pi t_p\sqrt{n_s}. \tag{23}$$

A propos, from this formula we easily find the above mentioned expression for black hole lifetime

$$\tau_s = \sum_{n=1}^{n_s} 2\pi t_p\sqrt{n} \equiv \int_0^{n_s} 2\pi t_p\sqrt{n}\; dn = \frac{4}{3}\pi t_p n_s^{3/2} = \tau_s(Hawking)/3840 \tag{24}$$

and luminosity

$$L_s = \frac{\Delta E_{s,s-1}}{\Delta t_{s,s-1}} = \frac{E_p/(2\sqrt{n_s})}{2\pi t_p\sqrt{n_s}} = \frac{l_p}{4\pi n_s} = \frac{\hbar c^6}{4\pi G^2 M_s^2} = 3840 L_s(Hawking). \quad (25)$$

This time we got a very significant difference from Hawking results, since he proceeded from unsubstantiated assumption, that black hole radiates like a black body and obeys the Stefan-Boltzmann law. In contrast, we find that black holes emit with much greater intensity by the way of quantum transition and radiation.

If during this time the black hole does not receive the required dose of energy, it will begin to evaporate.

Note, that from the energy of each emitted particle

$$E_\gamma(rad) = \Delta E_{s,s-1} qu(rad)/2 = \frac{E_p}{4\sqrt{n_s}} \quad (26)$$

one can easily find that their emitted wavelength is much more than R_s:

$$\lambda_\gamma(rad) = \frac{2\pi\hbar c}{E_\gamma(rad)} = 4\pi R_s > R_s \quad (27)$$

from which it clearly follow that for quantum two-particle emission the tremendous gravitational field of black hole do not represents any obstacle. They both leaving the black hole by tunneling effect, taking with it exactly two bit of quantum information that the black hole loses. As we can see this completely removes so-called "information loss" paradox.

5. Accretion of free light by quantum absorption, the disks and jets origin

On the other hand, taking into account the quantum properties of black hole condensed light, it becomes clear that only free light photons with a wavelength no greater than black hole geodesic length become objects of accretion by quantum absorption.

In other words, black holes "feed" only on free light or condensed light (i.e. other black holes through colliding and merger). All "ordinary" matter is "melted" in disks and "evacuated" by jets accompanied by swirling magnetic fields by the ways of "funnel" and "slingshot" effects. As we can see, this is in the exact accordance with the laws of conservation of the total baryonic number ("Eddington number" 10^{80}) in the observable Universe. We find that wavelength of the absorbed photon would not be greater than the geodesic length:

$$\lambda_\gamma(absorp) \leq \lambda\pi R_s = \lambda_{sm} \quad (28)$$

which is equivalent to the energy quantum absorption condition

$$E_\gamma(absorp) \geq \frac{2\pi\hbar c}{\lambda_{sm}} = \frac{\hbar c}{R_s}. \quad (29)$$

If during a mentioned above time interval Δt_s equal to the duration of quantum transition from n_s to n_{s-1} energy level, black hole does not receive the mentioned above free light quantum of energy, it continues to evaporate. If it receives, it grows according to law

$$\Delta R_{s\gamma} = \frac{2G}{c^4} E_\gamma(absorp) \geq \frac{2G\hbar}{c^3 R_s} = \frac{l_p}{\sqrt{n_s}}, \tag{30}$$

while the absorption area A_s increases by an amount equal to

$$\Delta A_{s\gamma} \geq 16\pi l_p^2. \tag{31}$$

Note, that similar results led Bekenstein to his famous formula for the black hole entropy[11].

However, for the cosmology (dark matter formation) the most important is the result that follows from presented calculation:

$$E_\gamma(absorp) \geq 2E_\gamma(rad), \tag{32}$$

that can be expressed in terms of temperature in the following striking way:

$$T_\gamma(absorp) \geq 2T_s, \tag{33}$$

what means the following: when temperature of the Universe (T_γ) drops below the double temperature of a black hole it begins to evaporate.

This is a very important conclusion; moreover, it is the key to understanding how, in the very early Universe, the death of one generation of primordial black holes served the growth of the next generation.

We will need respect these most important cosmological conditions in our analysis of how modern dark matter, consisting of asteroid-like mass black holes, was formed.

Another most important consequence of these relations: an evaporating black hole is capable of radiative transferring of it's electromagnetic radiation energy to another black hole only if the mass of the latter is twice the mass of the sourcing one:

$$M_{s2}(received) \geq 2M_{s1}(emitted). \tag{34}$$

These are the relationships that explain how, at the very early stages of the development of the Universe, there was a cyclic transfer of energy from dying, more numerous but lighter generation of black holes to a new, much less numerous but heavier one.

This is the key to understanding not only the very early formation of the structure of dark matter, but also the key to understanding the very early "clumping" of the Universe, since these regular cycles of the generation of regular dark matter were accompanied by the hyperexponential growth (see below) of future supermassive black holes (SMBHs), as centers of formation of future galaxies.

6. Quantum information conservation law and the gravitational radiation energies of colliding and merging black holes as the engine of the Universe accelerated expansion

We find that two-particle emission (both outside black hole) accompanied with gravitational radiation remove so-called "information loss paradox". Because, accordingly to the Jh. Preskill-L. Susskind definitions[17], each particle is the carrier of one C. Shannon bit of quantum information, corresponding to two spin states $|0>$ and $|1>$ in P. Dirac notation. This clearly demonstrates the inviolability of unitarity principle of quantum theory.

Based on the fundamental unitarity principle of quantum theory expressed in form of conservation information law for a binary black holes system (BH_1, BH_2):

$$I_{s1,2} = I_{s1} + I_{s2} = 2n_{s1} + 2n_{s2} \tag{35}$$

we find a remarkable expression for the energy of gravitational radiation caused by colliding and merger of binary black hole system:

$$E_{s1,2}(gr.rad.) = E_p(\sqrt{n_{s1}} + \sqrt{n_{s2}} - \sqrt{n_{s1} + n_{s2}}) \tag{36}$$

which in term of quantum numbers confirms the famous Stephen Hawking "areas theorem" for colliding and merger black holes (1971). More recently a team of Kip S. Thorne's disciples, analyzing the LIGO collaboration data related to the "ring-down" phase of this process, convincingly confirmed[18] the rightness of the great physicist.

For N successive collisions and mergers of N black holes we obtain the general expression for total gravitational radiation energy:

$$E_{sn}(gr.rad.) = E_p(\sum_{i=1}^{N} \sqrt{n_{si}} - \sqrt{\sum_{i=1}^{N} n_{si}}) = (\sum_{i=1}^{N} M_{si} - \sqrt{\sum_{i=1}^{N} M_{si}^2})c^2, \tag{37}$$

where

$$M_{sn} = \sqrt{\sum_{i=1}^{N} M_{si}^2} \tag{38}$$

is the mass of the "resulting" black hole; an amazing cosmological case of the famous Pythagorean theorem!

The last two formulas are extremely important solving key problems of cosmology:

(1) When the mass of the one of N black holes, for example, a mass of supermassive black hole (SMBH) in the center of a galaxy, is immeasurably greater than the asteroid-like mass of dark matter PBHs (accumulated in SMBH's "corona"), then as results of their mergers, almost all of their mass/energy is converted into the energy of gravitational waves. In other words we observe impressive cosmic effect of the irreversible conversion of the dark matter into the dark energy of

the Universe. Note, that this is a remarkable confirmation of P. W. Anderson last prophetic conjecture[7].
Moreover, as will be shown later, it is these processes that are the cause of the current stage of the accelerated expansion of the Universe.

(2) On the other hand, from these formulas is quite obvious, that during N-fold collisions and merges of approximately equal massive black holes, a supermassive one can not be formed - the overwhelming majority of their total energy would be converted into gravitational radiation. Therefore, SMBHs could only have formed due to tremendous light energy of the radiative transfer in the very early Universe.

(3) This allows us answer a very important question: why do we not find visible traces of the massive presence of Dark matter in our Solar system and other similar systems? When the central star is formed, almost all of the enormous mass of Dark matter is lost in the form gravitational radiation via intensive colliding and mergers of PBHs, that also increasing the amount of Dark energy in the Universe. A small remnant of black hole in the core of star become the "seed" of the former stellar mass black hole.

As we will show below, without these important results it is impossible to describe and understand the most important role of PBHs and their gravitational radiation in the cosmogenesis.

7. Planck scale physics, hot Big Bang and first stage of accelerated expansion of the Universe

Perhaps the most surprising thing in the presented approach is the logical and natural appearance of Planck units system without any additional unreasonable and unfounded assumptions and hypothesis. Moreover, from this unexpected emergence we find the very realistic principles, laws and relationships that governed the observable Universe in it's primordial state. This directly opens the door to the Terra Incognita of Planck scale physics at the Beginning of Time.

Moving backwards alone the "arrow of times" we find the "graininess" spacetime consisting of 3D Planck condensed photons with a tremendous Plank energy and mass densities. These condensed photons are "encapsulated" in its own noneuclidean spacetime in which the ratio of the circumference to the radius is equal to one, which is confirmed by the tremendous value of Planck gravitational potential $\phi_p = c^2$. But this homogeneous and "grainy" 3D Planck photon condensate as whole represents extremely dense spherical package characterized by "ordinary" Euclidean metric.

From the mentioned above Planck-Heisenberg uncertainty relation $E_p t_p = \hbar$ it follows that the lifetime of such an extremely unstable initial state of observable Universe is equal to the Planck time. Due to its extreme instability this initial state "explodes" exactly with assumption of the hot Big Bang theory. The most questions arise: what happens during this explosion, what is its duration, and what happens next during Big Bang?

It is not difficult to see that among all the homogeneous "granular" spacetime with its dense spherical package, each condensed Planck photon is surrounded by twelve other condensed Planck photons. What is probability after the explosion this surrounded photon will become free? Exactly as the probability that the surrounding twelve will form Planck binary systems among themselves and with other nearest neighbors. Solving the simplest equation of the twelfth degree:

$$\aleph = (1 - \aleph)^{12} \tag{39}$$

we give the desired probability: $\aleph = 0.1474492855... \approx 0.14745$.

Taking into account the exceptional importance of this cosmological number, we have designated it with the symbol $\aleph$, "alef", which means "first", "most important".

Why are we talking about Planck binaries? Because during the Big Bang their merger gives rise to Planck primordial black holes accompanied with Planck gravitational waves. According to the law of energy conservation each Planck binary system, equal to two Planck mass-energy units inevitably converted into the mass-energy of Planck black hole, while the Planck work, associated with the merger process necessarily entails Planck gravitational radiation.

Mathematically the whole process is expressed as follow:

(1) with probability $\aleph$, condensed Planck photons turns into free ones:

$$(\gamma_p) \to \gamma_p(free) \tag{40}$$

the average value of energy density of free Planck light

$$\Omega_L = \aleph \approx 0.14745; \tag{41}$$

(2) with probability $1-\aleph$, the transformation of Planck binaries (γ_p, γ_p) into Planck black holes (BH_p) occur accompanied by Planck gravitational waves Γ_p:

$$(\gamma_p, \gamma_p) \to BH_p + \Gamma_p, \tag{42}$$

where the energy of the gravitational radiation is caused by Planck work W_p:

$$E(\Gamma_p) = W_p = F_p l_p = G\frac{M_p M_p}{l_p^2} l_p = E_p, \tag{43}$$

$$E(BH_p) = E(\gamma_p, \gamma_p) - E(\Gamma_p) = 2E_p - E_p = E_p, \tag{44}$$

we find the average value of Planck dark energy density

$$\Omega_{DE} = \frac{1-\aleph}{2} \approx 0.42628, \tag{45}$$

we find the average value of Planck dark energy density

$$\Omega_{DM} = \frac{1-\aleph}{2} \approx 0.42628. \tag{46}$$

In other words, we find that the energy densities of primary free light, dark matter and dark energy are distributed accordingly following proportion:

$$\Omega_L : \Omega_{DM} : \Omega_{DE} = \aleph : \frac{1-\aleph}{2} : \frac{1-\aleph}{2} \approx 0.14745 : 0.42628 : 0.42628 \qquad (47)$$

Note, if we take the primary 3D Planck photon condensate as the "dark" initial matter, then this process of the hot Big Bang amazingly corresponds to the biblical tale of Genesis: "...and the Creator separated Light from Darkness, and there was the First Day (ℵ, "aleph" - the first)..."

It is necessary to clarify that the breakdown of extreme homogenity, wich broke the initial "graininess" spacetime into Planck binaries and isolated condensed Planck photons, occurred due to the actions of spontaneous Planck fluctuation. Figuratively speaking, Planck "granules" acted as "binary explosive", while Planck fluctuations as "fuses".

It is also easy to calculate the duration process in two different ways. The wavelength of a Planck free photon is 2π times longer than that of Planck condensed one equal to Planck length. Naturally, the deployment of such a wavelength requires time equal to the $2\pi t_p$. The second similar solution follows from the time of formation of the Planck black holes. Based on principle of causality it is equal to half the length of its geodesic line divided by the speed of light, i.e., $2\pi t_p$. This amazing coincidence is far from accidental, since it proves the complete and universal synchronizations of all processes at the times of Big Bang.

Calculation shows that in this case the cosmic Λ-parameter reaches the highest value at order $1/l_p^2$, 122 decimal orders (!) of magnitude more than the recent one. Let us note that his value corresponds to the Hubble parameter of order $1/t_p$, the maximum possible one. As Dr. Goutam Manna noted in a private discussion, this astonishing result can effectively nullify a factor 10^{120} that erroneously was attributed to the so-called "vacuum energy". Note, that thus definitely remove the famous "cosmological catastrophe problem".

However what happened in the next "days of creation"? Further cosmological events begin to develop in full accordance with the premises, presented in the previous sections.

Almost all the energy of the Planckian free light is absorbed by the ℵ part of Planck black holes, that doubling their mass/energy. But this leads to a decrease in the energy of dark matter mass/energy density to the value $\Omega_{DM} = 2\aleph_s$. The remaining part of Planck black holes decays into two photons $\gamma_{p.0}$ and gravitational wave $\Gamma_{p.0}$:

(1) with a probability ℵ the next generation of black holes is formed by followed scheme

$$\gamma_p + BH_p \rightarrow BH_s(n_s = 4) \qquad (48)$$

with

$$M_s = M_p\sqrt{4} = 2M_p \qquad (49)$$

and average (typical) dark matter mass/energy density

$$\Omega_{DM} = 2\aleph \approx 0.29490; \tag{50}$$

(2) with a probability $\frac{1-\aleph}{2} - \aleph = \frac{1-3\aleph}{2}$ the Planck black hole decay occurs:

$$BH_p \to 2\gamma_{p.0} + \Gamma_{p.0}, \tag{51}$$

with

$$2E(\gamma_{p.0}) = 2 \times \frac{E_p}{4} \text{ and } E(\Gamma_{p.0}) = \frac{E_p}{2} \tag{52}$$

and average incremented dark energy:

$$\Delta\Omega_{DE} = \frac{1-3\aleph}{2} \times \frac{1}{2} = \frac{1-3\aleph}{4} \approx 0.13941, \tag{53}$$

the average irreversible dark energy density:

$$\Omega_{DE} = \Omega_{DE}(precedent) + \Delta\Omega_{DE} = \frac{1-\aleph}{2} + \frac{1-3\aleph}{4} = \frac{3-5\aleph}{4} \approx 0.56569, \tag{54}$$

the average Ω_L of emitted through the Planck BH_p decay $\gamma_{p.0}$ photons:

$$\Omega_L = 1 - \Omega_{DM} - \Omega_{DE} = \frac{1-3\aleph}{4} \approx 0.13941. \tag{55}$$

A propos, by direct calculation we find the same result:

$$\Omega_L = \frac{1-3\aleph}{2} \times 2 \times \frac{1}{4} = \frac{1-3\aleph}{4}. \tag{56}$$

If we compare this second phase (”the second day of creation”) with precedent (Big Bang) one, we find dark energy density at Big Bang increasing from zero to 0.42628, but while in the second phase of the Planck epoch it increases only with the value of $\Delta\Omega_{DE} \approx 0.13941$. We must notice that in parallel with this process the dark matter density drops from the 0.42628 to the value of 0.29490.

From this moment on, the gravitational mass of the Universe represented exclusively by dark matter will constantly fall, serving as a reservoir of energy for it's subsequent generations up to the formation of the modern dark matter, as well as for the subsequent formation of very massive and supermassive black holes and ”ordinary” matter.

Let us proceed, in the analysis of the third phase (the ”third day of creation”) of the Planckian Era. Through the quantum absorption, the generation of typical black holes $BH_s(n_s = 4)$ will quickly grow to the typical generation $BH_s(n_s = 8)$. How do we know this?

Based on the previous phase, we find that the maximum energy reserve for the growth of a typical primordial black holes $BH_s(n_s = 4)$ through the quantum absorption of free light must be expressed as the sum of preceding phase

$$\Omega_{DM}(max) = \Omega_L + \Omega_{DM} = \frac{1+5\aleph}{4}. \tag{57}$$

In terms of a typical black hole, this gives the average mass

$$M_s = M_p \frac{\Omega_L + \Omega_{DM}}{\aleph} = M_p \frac{1 + 5\aleph}{4\aleph} \approx 2.945498 M_p. \tag{58}$$

However, this number 2.945498 is not in the series expressed in the form of $\sqrt{n_s}$, because it needed to get a typical quantum number. Based on the principle of maximum of black hole entropy S_s, we find that the largest number n_s must satisfy the natural condition $\sqrt{n_c} < 2.945498$. Resulting we get typical $n_s = 8$ for third PBHs generation.

Using previously obtained results, we find the lifetime

$$\tau_s = \sum_{n=1}^{n_s=8} 2\pi t_p \sqrt{n} \approx 32.6\pi t_p \tag{59}$$

and emitted free light density

$$\Omega_L = \aleph \sum_{n=1}^{n_s=8} \frac{1}{2\sqrt{n}} \approx 0.32228, \tag{60}$$

which through radiative transfer is instantly converted into the Ω_{DM} density of the next generation of PBHs.

The first result tells us that, taking into account the previous phases, the total duration of the Planckian Era does not exceed the value $50\pi t_p \approx 8.46 \times 10^{-42}$ sec.

From the second result it follows that entire dead generation of primordial black holes emitted the enormous light energy, which was spent on the development of next generation:

$$\Omega_{DM} = \Omega_L \approx 0.32228. \tag{61}$$

Since practically all light energy was absorbed by this generation of primordial black holes, we come to a remarkable conclusion: at the end of the Planckian Era dark energy reaches almost it's maximum value:

$$\Omega_{DE} = 1 - \Omega_{DM} \approx 0.67771, \tag{62}$$

and it's last increment:

$$\Delta\Omega_{DE} \approx 0.67771 - 0.56569 = 0.11202. \tag{63}$$

The latter means that with the end of the Planckian Era the first stage of the accelerated expansion of the Universe ends, and, the stage of non-accelerated but very rapid expansion begins, what we will show below.

If we compare the obtained value of dark energy density 0.67771 with the modern data from 0.6847 and above, then we will get that over the five to six billion years the Universe has accelerated in accordance with the increment

$$\Delta\Omega_{DE} = \Delta\Omega_\Lambda \geq 0.6847 - 0.6777 = 0.0073 (\textit{i.e. } 0.73\% \textit{ and more}) \tag{64}$$

depending of the significant recent discrepancy in the results of different approaches to the cosmic measurements.

It is very interesting to note that primary gravitational waves with E_p and $E_p/2$ energies form around 95% of all amount of the dark energy in the modern Universe.

Having carefully examined presented results we can draw the most important conclusions:

- Big Bang cosmology gains firm theoretical background;
- moving backwards along the "arrow of time", we find primary state of the observable Universe as a "graininess spacetime" consisting of 3D Planck photons with the maximum possible planckian mass, energy, density, temperature, pressure and minimal possible entropy and minimum of the quantum information;
- according to the Plank-Heisenberg uncertainty law this extremely unstable initial state last no more than one Planck unit of time (t_p) and, due to the Planck fluctuation (act as "fuse"), is broken down into Planck binaries (act as "explosive") and "unpaired" Planck photons, as a result of which during the time $2\pi t_p$ the synchronous Big Bang occurs and free Planck photons, Planck PBHs and Planck gravitational waves was formed in the "freed" continuum spacetime;
- the so-called "horizon problem" is removed, since everything is decided by the PBHs thermodynamics, as well as by the synchronicity of spatially distant processes;
- the most striking fact is that we obtained presented results which are in agreement with Lambda-CDM cosmology independently and without resorting to it's equations.

8. Solving the problem of supermassive black holes formation and the very early "clumping" of the Universe

As it was established above, the development of generations of black holes proceeded precisely through the radiative transfer of light energy from one much more numerous generation, but much "lighter", to a much less numerous, but much "heavier" ones.

All this can be expressed in a simple and clear form with far-reaching consequences:

$$\#_{sj} E_p \sqrt{n_{sj}} = \#_{sj-1} E_p \sqrt{n_{sj-1}} = \Omega_{DM} E_u = 0.32228 \times 1.5 \times 10^{62} E_p, \qquad (65)$$

where $\#_{sj}$ and $\#_{sj-1}$ represent the average numbers of the black holes in a given and previous generations respectively, while n_{sj} and n_{sj-1} refer to the typical quantum numbers representing these generations, E_u - the all energy of the observable Universe. It is not difficult to understand, that the time lag between generations is equal to the lifetime of the previous generations.

$$\Delta t_{sj,sj-1} = \frac{4\pi}{3} t_p (\sqrt{n_{sj-1}})^3. \qquad (66)$$

It is easy to see the direct relationship benween the $\sqrt{n_s}$ and the time:

$$\sqrt{n_s} \propto t^{1/3}. \qquad (67)$$

Taking into account that the cosmological scale factor a is proportional to $\sqrt{n_s}$, we find that

$$a \propto \sqrt{n_s} \propto t^{1/3}, \tag{68}$$

from which derive the Hubble parameter

$$H(t) = \frac{\dot{a}}{a} = \frac{dt^{1/3}/dt}{t^{1/3}} = \frac{1}{3t} \tag{69}$$

and Hubble radius

$$R_H(t) = \frac{c}{H(t)} = 3ct. \tag{70}$$

Let's check our results, knowing that the age of the Universe and it's observable radius are respectively $Age_U = 8.08 \times 10^{60} t_p$ and $R_U = 2.7 \times 10^{61} l_p$, we find

$$R_H(Age) = 3c \times 8.08 \times 10^{60} t_p = 2.424 \times 10^{61} l_p. \tag{71}$$

What do these surprising results mean? Firstly, that the proposed approach copes well with the difficult problems of cosmology. Secondly, this confirms the very rapid non-accelerated expansion of the very early Universe.

The difference of only minus 10% between the obtained Hubble radius and the radius of the modern Universe clearly indicates that the latter has increased significantly due to the second stage of the accelerated expansion.

Having understand the development of generations of the dark matter over time, we are ready to solve the puzzling problem of the birth and hyperexponential growth of SMBHs (see below).

Immediately after the end of the Planckian Era an incredibly rare events will begin to occur: some very rare primordial black holes acquire masses much greater than the masses of typical black holes . Each death of the next generation led to the colossal emission of light energy, a little part of which was absorbed by the rapidly growing accreted surface of these future monsters.

Based on the fact, that both the quantum information of the growing black hole accretion area are proportional to the quantum number, in accordance with Bohr's correspondence principle, it is not difficult to to write an equation describing $n_s(t)$ growth:

$$\frac{dn_s(t)}{dt} = B_s(t) n_s(t), \tag{72}$$

where $B_s(t)$ is accretion (light absorption) function, expressing the dependence on the radiation of each generation of typical black holes evaporation. We find that

$$n_s(t) = exp\{\int B_s(t) dt\}. \tag{73}$$

As the result we obtain the hyperexponential growth of the mass of a supermassive black hole:

$$M_{SMBHs}(t) = M_p exp\{\frac{1}{2} \int B_s(t) dt\}, \tag{74}$$

where the cumulative integral function $B_s(t)$ explains the hyperexponential growth of SMBHs.

As a result of this hyperexponential growth, the forming dark matter begins to "clumping" around the growing monsters and to shape dark halo formation regions of the future galaxies. As we will show below, it was the penultimate typical generation of primordial black holes that was producing baryogenesis and pass it's baton to the modern generation of the dark matter and the "ordinary" matter. According to our estimates, the Baryogenesis Epoch began not later than a hundred years after Big Bang.

9. Baryogenesis through primordial black hole production

What convinces us most of all that PBHs are directly related to baryogenesis is that it is a well known fact that baryonic matter is everywhere surrounded by dark matter. Moreover, we find that in general, where the concentration of dark matter is higher on large scales, the concentration of "ordinary" matter is also higher.

Strictly speaking, accordingly to (14)-(19) the two-particle emission process should be represented in the following general form:

$$BH_s \to BH_{s-1} + X_s + \bar{X}_s + \Gamma_s, \tag{75}$$

where X_s and $\bar{X}_s$ represents particle and antiparticle, Γ_s represents gravitational wave. Since photons are their own antiparticles, we can replace this pair with term $2\gamma_s$ and obtain previously presented (14).

But even we are dealing with birth and emissions of particles/antiparticles of different kinds, due to their inevitable annihilation, the substitution of $2\gamma_s$ remains valid one. With only exception - when the CP-violation can be caused by specific gravitational effects.

The problem of baryonic asymmetry, baryogenesis and leptogenesis is one of the most difficult unsolved problems of cosmology and particle physics. Note, that traditional theories of the baryogenesis and leptogenesis do not solve in two key aspects: the presence of a huge amount of "ordinary" matter in the observable Universe (at about 5% of the total mass-energy) and the actual equality of protons and electrons numbers (the equality of positive and negative electrical charges) over the small and large scales of the "Cosmic Web".

But we will take a different path - from facts to theory, taking into account the exceptional productivity of the PBHs and their specific gravitational and thermodynamical effects.

Let's do what Einstein did: he accepted the experiments on the constancy of the speed of light as the postulate. We will also take the observed baryon asymmetry as a postulate and relate it to black holes production of two-particle according to the scheme:

$$BH_s \to BH_{s-1} + 2n^0 + \Gamma_s \ , \ 2n^0 \to 2p^+ + 2e^- + ..., \tag{76}$$

where n^0, p^+, e^- referred to the neutron, proton and electron. We can easily determine the restriction imposed to the "productive" quantum numbers of the respective PBHs from

$$\frac{E_p}{4E(c-q)} \leq \sqrt{n_s} \leq \frac{E_p}{4E(n^0)}, \tag{77}$$

where $E(n^0) = 0.9396GeV$ is the rest energy of the neutron, $E(c-q) = 1.25GeV$ of the free "charm" quark, next in this parameter after neutron. We needed the "charm" quark rest energy in order to determine the quantum number $n_s(c-q)$ at which neutron production stops. Using a simple equation

$$\frac{[2n_s^*(n^0) - 2n_s(c-q)]E(n^0)}{E_p\sqrt{n_s^*(n^0)}} = \frac{\Omega_b}{\Omega_{DM}}, \tag{78}$$

(where Ω_b is modern baryonic density) we can determine the boundary typical number $n_s^*(n^0)$ which characterizes the generation of black holes capable of production "ordinary matter" of the observable Universe.

Here the expression on the left side denotes the productivity of one typical black hole, expressed as the number of neutrons it produces (square brackets) times the rest energy of neutron and divided by the rest energy of typical producing black hole. This should be equal to the enegy density of baryon $\Omega_b = 0.0496$ divided by the energy density of the producing black hole $\Omega_{DM} = 1 - 0.6777$.

Solving this equation $\sqrt{n_s^*(n^0)}$ we find that it's equal to 2.99×10^{18}.

Solving these two quantum numbers, $n_s^*(n0)$ and $n_s * (c-q)$, we find, that the duration of the production process of baryonic matter is equal to 87 thousand years, while the all process of the evaporation and death of the producing generation of PBHs lasted for about 190 thousand years. It fit perfectly into half of cosmic time from Big Bang to Recombination Epoch, equal to 378 thousand years. All this was accompanied by the last process of the great reheating of the Universe. After cooling, all ordinary matter was restored in forms of relatively cold plasma of primary nucleosynthesis.

Note that all this processes was happened "in clumps" of nascent protogalaxies before the Recombination Epoch.

10. Completion of the creation of modern dark matter and large scale structure

Along with the process of baryogenesis and leptogenesis the process of radiative transfer of light energy from the last generation of dead primordial black holes to the modern ones is continued.

This process ended, when the temperature "in clumps" dropped below the hard cut-off at $511keV/k_B$ (the rest energy of electron) to the typical temperature $80keV/k_B$, then the high level of opacity falls sharply, the process of growth of modern generation of PBHs (present dark matter) quickly ends and process of their evaporation begins in the form of hard X-ray radiation.

Using the formulas that connect the threshold accretion temperature with the black hole masses and it's other parameters, we find the following typical characteristics of the modern dark matter:

$$typical\ \sqrt{n_s} = \frac{E_p}{2 \times 80keV} = 7.625 \times 10^{22}\ ,\ typical\ M_s = 1.659 \times 10^{18} g, \qquad (79)$$

$$min\ \sqrt{n_s} = \frac{E_p}{2 \times 511keV} = 1.194 \times 10^{22}\ ,\ min\ M_s = 2.598 \times 10^{17} g; \qquad (80)$$

the parameter of emitted hard X-ray spectrum: the peak $E_\gamma = 30kEv/k_B$, typical $40kEv/k_B$, hard cut-off at $250kEv/k_B$. The resulting estimate of the asteroid-like mass of dominated PBHs is in good agreement with the ideas of growing number of cosmologists about the PBHs nature of the dark matter [6].

It is this unsolved hard X-ray spectrum [19,20], that astrophysicists find throughout the Universe in the active centers of galaxies, clusters and superclusters. It appears especially brightly in the coronas of supermassive black holes, even in the so-called "non-jets" events [21]. The later clearly shows that these great clumps of dark matter in SMBHs coronas by the process of colliding and merging are among the most powerful sources of dark energy production, that cause increasing acceleration of the modern Universe.

Note that it is this process of transformation of dark matter into dark energy automatically solves and removes so-called "core-cusp problem" [22].

Regarding the exceptionally and therefore unusually fast early process of clumping of the halo of dark matter and produced by it "ordinary" matter, we should not be very surprised by the quite accomplished galaxies recently discovered by the "James Webb" telescope [23].

Knowing the modern parameter M_s (typical), Ω_b and Ω_{DM}, it is easy to calculate that, on average, the numerical density of dark matter (PBHs) is 10^{41} times less than numerical density "ordinary" matter. This is in perfect agreement with the cosmic phenomenon of the "Bullet Cluster" [24], in which giant clouds of dark matter freely penetrate each other, while the much more dense clouds of intergalactic gas enter into strong electromagnetic interaction.

We emphasize that in the very early Universe the galaxies were located very close to each other, forming one large "universal lumpy supercluster". However because of the rapid expansion of the Universe the cracks and fissures began to appear, and in the result of this fast process the giant voids, superclusters, great walls and filaments began to be formed. All this follows from the demonstrated above results of presented research.

Conclusions

We can not understand the history and phenomenology of of the observable Universe without a clear understanding and realistic description of fundamental interaction between the quantum theory and general relativity. In the presented work we decided to follow Einstein's last prophetic conjecture bequeathed to us (published posthumously in 1956), according to which the unified description of the quantum and continuous nature of reality should be based on an algebraic approach.

This became possible after the fundamental discovery of condensed light - self-gravitating photon Bose-Einstein condensate. The key was geometrical approach, which linked the Compton wavelength of quantum photon condensate with the gravitational radius of primordial black hole [1]. As a result we achieved a whole range of it's quantized characteristics of primordial black holes: geometrical, gravitational, thermodynamical, informational and radiation (two-particle emission accompanied by gravitational waves), as well as the precise laws of the birth, development and death of generations of PBHs.

This opened the door to Planck scale physics and PBHs physics, which made it possible to develop and apply a robust but effective mathematical tools for precise calculations and solutions of numerous fundamental physical and cosmological problems, such as Beginning of Time, Big Bang cosmology, origin and evolution of dark matter and dark energy, baryogenesis and baryonic assymetry, the very early protogalaxies with SMBHs in their centers formation before the Recombination epoch, Large scale structure formation and accelerated evolution of the observable Universe, removal of so-called "horizon problem", "cosmological constant problem", "information loss problem", "core-cusp problem", etc.

These results independently confirm the validity of Λ-CDM cosmology, clearing it of the so-called "hierarchical models" refuted by the JWST and other observations.

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