I. INTRODUCTION

Observing the sky reveals a great deal of mysteries not yet explained by the known physics. Though the standard cosmological model (SCM) pretty well describes the universe evolution, it does not fit the narrow frameworks of the standard model of particle physics and presents clear indications to something new beyond its frameworks. Moreover, even inside the SCM some internal inconsistencies are constantly arising and they are sufficiently persuasive to demand serious reconsideration of the basic principles of SCM.

According to the SCM the known world history started from inflation, which has created a suitable for life universe. In particular, inflation has generated primordial density perturbations at astronomically large scales. The calculated spectrum of these perturbations very well agrees with the measured spectrum of angular fluctuations of CMB and with the gross features of large scale structure of the universe. The main ingredients of the universe today are the usual baryonic matter, dark matter (DM), and dark energy (DE). The data allow to conclude that the fractional contributions of different form of matter into the total cosmological energy density are respectively:

\[ \Omega_b \approx 0.05, \quad \Omega_{DM} \approx 0.27, \quad \Omega_{DE} \approx 0.68. \] (1.1)

Dark matter is supposed to be cold (CDM), which means that its free-streaming length is much smaller than the galactic size. It consists of nonrelativistic particles whatever they are: new stable weakly interacting massive elementary particles (WIMPs) or huge non-luminous astrophysical objects (MACHOs), which can be primordial black holes, low luminosity stars or some other astrophysical objects. Dark energy is similar to vacuum energy (or, what is the same, to Lambda term), with negative pressure approximately equal by the absolute value to its energy density, \( P \approx -\rho \). That’s why the SCM is called \( \Lambda \)CDM cosmology.

\( \Lambda \)CDM cosmology basically works pretty well but there are quite a few troubling features, see e.g. [1]:
1. Cusps in galactic centers, \( \rho \sim (1/r)^\nu \) with \( \nu = 1 - 2 \), which are not observed.
2. Too many galactic satellites.
3. Disk destruction by the CDM clumps.
4. Much smaller angular momentum of galaxies than observed.

All them can be artifacts of numerical simulations when essential effects from normal dissipating baryonic matter are ignored or be e.g. an indication to existence of a new form of DM, say, warm DM (WDM).

In addition to these pretty old problems an avalanche of mysteries has emerged during the last few years, which can neither be helped by WDM, nor by an improvement of the numerical simulations. It is discovered that the standard \( \Lambda \)CDM cosmology, very well describing gross properties of the universe, encounters serious problems in numerous smaller details. The saying goes: ”The devil is in the details” but maybe better to say that not the devil but instead ”God is in the detail”, meaning that these small details are celestial indications to New Physics.

The data came both from the early universe at the redshifts \( z \sim 10 \) and from the contemporary one. In both cases the objects have been discovered, which could not be created by the accepted mechanisms based on the known physics. The young universe at high \( z \) and at the age of a several hundred million years is found to be abundantly populated by quasars, which are presumably the supermassive black holes (BHs) with the masses up to 10 billions solar masses. Even having in our disposal 13 billion years of the cosmological time, it is not an easy task to create the observed in the contemporary universe the supermassive BHs (in fact a convincing theory of the creation of supermassive black holes is absent), but their creation is practically impossible in much younger
universe assuming the standard mechanism of BH creation by the matter accretion on some preexisting seeds. In addition to the young quasars the early universe contains an unexpectedly large number of supernovae, gamma-bursters, very bright galaxies and a lot of dust. It also looks as "mission impossible" to make all that using the available conventional "instruments".

Plenty of mysteries are also found in the present day universe. There are supermassive black holes in all large galaxies with not yet established mechanism of their creation. Moreover, such black holes are observed in small galaxies where they make a too large fraction of the galaxy masses. Such BHs simply cannot be created through the mechanism of matter accretion, the only one which is known in the standard case. There is an unexplained accumulation of quasars in rather small patch in the sky. The origin of MACHOs discovered through microlensing remains mysterious. The last but not the least, there are several too old stars observed in the Galaxy, at least one of which looking older than the Universe.

Each piece of data may be questioned but taken together they surely show the general tendency in the same direction, demanding a strong revision of the accepted picture. Almost quoting Marcellus from "Hamlet" we may conclude: "Something is rotten in the state of the Universe".

II. HIGH Z UNIVERSE

A. Universe age as a function of redshift

There is a large "zoo" of the recently discovered astronomical objects at high-z which simply could not be created in the corresponding surprisingly short times. To start with, it would be instructive to present the universe age as a function of redshift:

$$t(z) = \frac{1}{H} \int_0^{\frac{1}{1+z}} \frac{dx}{\sqrt{1 - \Omega_{tot} + (\Omega_m/x) + x^2 \Omega_v}},$$

(2.1)

where $\Omega_{tot} = 1$, $\Omega_m = 0.317$ (it includes densities of baryonic and dark matter), and the density of dark energy, $\Omega_v = 0.683$ (sub $v$ here means vacuum-like). $H$ is the present day value of the Hubble parameter. According to the Planck determination through the angular fluctuations of CMB, $H = 67.3 \text{ km/sec/Mpc}$, while the traditional astronomical measurements give a larger value up to $H = 74 \text{ km/sec/Mpc}$. The origin of this discrepancy is unclear [2]. If this is not systematics or some other measurement problem, this tension can be removed if there exists a new unstable DM particle with the life-time exceeding the universe age at recombination [3].

Depending upon the value of $H$, the universe age at different $z$ is equal to $t_U \equiv t(0) = 13.8/12.5$; $t(12) = 0.37/0.33$; $t(10) = 0.47/0.43$; $t(6.3) = 0.87/0.79$; $t(3) = 2.14/1.94$. The age is given in Gyga-years and the first higher values of $t(z)$ correspond to smaller value of $H$.

B. Bright galaxies at high $z$

Several galaxies have been observed at high redshifts thanks to amplification by the natural gravitational lens "telescopes. There is among them a galaxy at $z \approx 9.6$ which was created when the universe was about 0.5 Gyr old [4]. Moreover a galaxy at $z \approx 11$ has been observed [5], which was formed significantly earlier, when the universe age was below $t(11) \approx t(11) \approx 0.41 \text{ Gyr}$, or even shorter, $t(11) \approx 0.38\text{ Gyr}$, for larger $H$. Such an early appearance of the galaxies was not expected in the standard model.

An observation of not so young but extremely luminous galaxy was reported a year ago [6]. Its luminosity and age are estimated as $L = 3 \cdot 10^{14} L_\odot$ and $t \sim 1.3 \text{ Gyr}$ respectively. It is impressively $10^4$ more luminous than our Milky Way. According to the paper, the galactic seeds, or embryonic black holes, around which the galaxy was formed, might be bigger than thought possible. One of the authors of this work P. Eisenhardt said: "How do you get an elephant? One way is start with a baby elephant." But it is unclear how this baby was born. The BH formed, might be bigger than thought possible. One of the authors of this work P. Eisenhardt said: "How do you get an elephant? One way is start with a baby elephant." But it is unclear how this baby was born. The BH formed, might be bigger than thought possible. One of the authors of this work P. Eisenhardt said: "How do you get an elephant? One way is start with a baby elephant." But it is unclear how this baby was born. The BH formed, might be bigger than thought possible.

As it is asserted in ref. [8], the presence of GN-z11 implies a number density $\sim 10^{-6} \text{ Mpc}^{-3}$, roughly an order of magnitude higher than the expected value based on extrapolations from lower redshift. According to the estimate of this work, based on the existing observations, an enormous increase in volume which will be surveyed by

$$\Omega_{tot} = 1, \Omega_m = 0.317 \text{ (it includes densities of baryonic and dark matter), and the density of dark energy, } \Omega_v = 0.683 \text{ (sub } v \text{ here means vacuum-like). }$$
the new Wide-Field Infrared Survey Telescope (WFIRST) will provide observations of about 1000 galaxies with $M_{UV} < -22$ beyond $z = 11$ out to $z = 13.5$. But the origin of their creation remains unclear.

According to ref. [9] "Rapid emergence of high-z galaxies so soon after big bang may actually be in conflict with current understanding of how they came to be."

### C. High redshift quasars

Another and even more striking example of early formed objects are high z quasars. About 40 quasars with $z > 6$ are already known, each quasar containing BH with $M \sim 10^{9} M_{\odot}$. Such black holes, created when the Universe was substantially younger than one billion years, is in strong confrontation with the conventional models of the formation and growth of black holes and the coevolution of black holes and galaxies. An interesting example is a quasar which has been observed with maximum $z = 7.085$ [10], i.e. it was formed earlier than the universe reached $t = 0.77$ Gyr. Its luminosity and mass are respectively: $L = 6.3 \cdot 10^{13} L_{\odot}$ and $M = 2 \cdot 10^{9} M_{\odot}$. The quasars are supposed to be supermassive black holes and their formation in such short time by canonical mechanisms looks problematic to say the least.

Very recently another monster was discovered at the redshift 6.3 and mass about 12 billions solar masses [11]. It has the optical and near-infrared luminosity a few times greater than those of previously known $z > 6$ quasars. There is already the mentioned above serious problem with formation of lighter and less luminous quasars which is multifold deepened with this new "creature". The new one with $M \approx 1.2 \cdot 10^{10} M_{\odot}$ makes the formation absolutely impossible in the standard approach.

In this connection it is proper to continue the quotation from the mentioned in the previous subsection paper [9]: "This problem of early formed galaxies is very reminiscent of the better known (and probably related) premature appearance of supermassive black holes at $z \sim 6$. It is difficult to understand how $10^{9} M_{\odot}$ black holes appeared so quickly after the big bang without invoking non-standard accretion physics and the formation of massive seeds, both of which are not seen in the local Universe." When the quote paper appeared, the champion quasar with $M \approx 1.2 \cdot 10^{10} M_{\odot}$ was not yet discovered. More discoveries of low luminosity quasars and bright galaxies at $5.7 < z < 6.9$ are reported in paper [12].

Some recent papers on possible conventional mechanisms of early black hole formation can be found in ref. [13]. At the present stage none of them is particularly persuading. Even the origin of much older supermassive black holes observed in the present day universe remains mysterious.

### D. Dust, Supernovae, and Gamma-bursters

The universe at $z > 6$ is found to be quite dusty, as it is observed in ref. [14] in numerous galaxies with the maximum redshift $z = 6.34$ (galaxy HFLS3), and in ref. [15] at $z = 7.55$ in the gravitationally-lensed galaxy A1689-zD1, which is the earliest known galaxy, where the interstellar medium (ISM) has been detected. This redshift corresponds to the universe which was only about 500 Myr old. The results of the last work are confirmed in ref. [16]. A catalogue of high-redshift dusty galaxies was created on the basis of observations [17], where it was concluded that the total number of these dusty sources is at least an order of magnitude higher than predicted by galaxy evolution models.

The sources of dust in the interstellar medium are stellar explosion. According to ref. [18], "even assuming maximally efficient supernova dust production, the observed dust mass of the z = 7.5 galaxy A1689-zD1 requires very efficient grain growth. This, in turn, implies that in this galaxy the average density of the cold and dense gas, where grain growth occurs, is comparable to that inferred from observations of QSO host galaxies at similar redshifts. Although plausible, the upper limits on the dust continuum emission of galaxies at 6.5 < z < 7.5 show that these conditions must not apply to the bulk of the high redshift galaxy population."

In reference [19], in addition to supernovae, another possible dust source was studied, namely asymptotic giant branch (AGB) stars. The conclusion was also pessimistic that the AGB stars are not numerous and efficient enough to create the observed amount of dust at $z = 4 - 7.5$. "Supernovae could account for most of the dust, but only if all of them had efficiencies close to the maximal theoretically allowed value. This suggests that a different mechanism is responsible for dust production at high redshifts, and the most likely possibility is the grain growth in the interstellar medium."

Probably the amount of supernovae in the early galaxies is considerably larger than expected. Another argument in favor of this conclusion it that the medium around the observed early quasars contains considerable amount of "metals" (elements heavier than He). According to the standard picture, only elements up to $^{4}$He and traces of Li, Be, B were formed by BBN, while heavier elements were created by stellar nucleosynthesis and dispersed in the interstellar space by supernova explosions. Hence, prior to or simultaneously with the QSO formation a rapid star formation should take place. These stars should evolve to a large number of supernovae enriching interstellar space by metals through their explosions which later make molecules and dust. (We all are dust from a neighboring
supernova explosion, but probably at much later time.) Another possibility to enrich the universe with metals is a non-standard BBN in bubbles with very high baryonic density, which allows for formation of heavy elements beyond lithium [20], see below.

Observations of gamma ray bursters (GBR) also indicate at an immense abundance of supernova at large redshifts. The highest redshift of the observed GBR is 9.4 and there are a few more GBRs with smaller but still large redshifts. The necessary star formation rate for explanation of these early GBRs is at odds with the canonical star formation theory. But despite an imperfection of the theory, such high-z objects do exist, and thus we have to conclude that prior to or simultaneously with the QSO formation a rapid star formation should take place. These stars could produce plenty of supernovae which enriched interstellar space by metals. A possible mechanism of GBR generation at high z through such early star collapse is considered in ref. [21].

In the model, which is discussed in this lecture below, such stars and heavy primordial black holes could be abundantly enough created in the very early universe.

III. CONTEMPORARY OR NEAR-CONTEMPORARY UNIVERSE

A. Old stars in the Milky Way

With an increased precision of the nuclear chronology the ages of several stars have been recently determined to be much older than expected. Below we quote a few recent results.

Employing thorium and uranium abundances in comparison with each other and with several stable elements the age of metal-poor, halo star BD+17° 3248 was estimated as 13.8 ± 4 Gyr [22]. For comparison the age of the inner halo of the Galaxy is 11.4 ± 0.7 Gyr [23].

The age of a star in the galactic halo, HE 1523-0901, was estimated to be about 13.2 Gyr [24]. First time many different chronometers, such as the U/Th, U/Ir, Th/Eu and Th/Os ratios to measure the star age have been employed.

The metal deficient high velocity subgiant in the solar neighborhood HD 140283 has the age 14.46 ± 0.31 Gyr [25]. The central value exceeds the universe age by two standard deviations, if \( H = 67.3 \) and \( t_U = 13.8 \), while for \( H = 74 \), and thus \( t_U = 12.5 \) the excess is by nine standard deviations. So this star really looks older than the universe.

A possible explanation of this discrepancy could be an unusual initial chemical content of such stars. Normally a pre-stellar cloud consists of 25% of \( He^4 \) and 75% of hydrogen. However, in the scenario discussed below the primordial nucleosynthesis is able to create much heavier elements, as is mentioned in the previous sections or/and the early supernovae could enrich the interstellar gas with heavy elements, so the initial chemical content of some stars would be much different from the traditional one. Such stars could evolve to their present state considerably faster than the usual ones. Of course this conjecture should be verified by the stellar nucleosynthesis calculations.

In addition to these very old stars a planet in the Milky Way was discovered [26], with the age 10.6±1.5 Gyr. For comparison the age of the Earth is "only" 4.54 Gyr. To create such a rocky planet SN explosion must precede its formation and this takes also a non-negligible time.

B. Supermassive black holes today

The astronomical observations very strongly suggest that every large galaxy and some smaller ones contain a central supermassive BH with masses larger than \( 10^9 M_\odot \) in giant elliptical and compact lenticular galaxies and \( \sim 10^6 M_\odot \) in spiral galaxies like Milky Way. The mass of the central BH is typically about 0.1% of the mass of the stellar bulge [27], but some galaxies may have huge black holes: e.g. NGC 1277 has the central BH of \( 1.7 \times 10^{10} M_\odot \), or 60% of its bulge mass [28]. The origin of these superheavy BHs is not understood. These observational data create serious problems for the standard scenario of formation of central supermassive BHs by accretion of matter in the central part of a galaxy. An inverted picture looks more plausible, when first a supermassive black hole was formed and attracted matter serving as a seed for subsequent galaxy formation [29].

More examples of the same kind can be found in ref. [30]. As the authors say, although supermassive black holes correlate well with their host galaxies, there is an emerging view that outliers exist. Henize 2-10, NGC 4889, and NGC1277 are examples of super massive black holes at least an order of magnitude more massive than their host galaxy suggests. The dynamical effects of such ultra-massive central black holes is unclear.

A discovery of a very compact dwarf galaxy older than 10 Gyr, enriched with metals, and probably with a massive black in its center also seems to be at odds with the standard model [31]. The dynamical mass of the galaxy is \( 2 \times 10^8 M_\odot \) and the radius is \( R \sim 24 \) pc, so its density is very high. The Chandra data reveal a variable central X-ray source with \( L_X \sim 10^{38} \) erg/s that could be an active galactic nucleus associated with a massive black hole or a low-mass X-ray binary. Analysis of optical spectroscopy shows that the object is quite old, \( \geq 10 \)
Gyr, and has more or less the solar metallicity, with elevated [Mg/Fe] and strongly enhanced [N/Fe] that indicates light element self-enrichment; such self-enrichment may be generically present in dense stellar systems.

In the recent paper [32] an over-sized black hole was observed in a modest mass galaxy. The black hole mass in the AGN of the galaxy, was deduced to be equal to \( M_{BH} = (3.5 \pm 0.8) \times 10^8 M_\odot \) with the accretion luminosity \( L_{AGN} = (5.3 \pm 0.4) \times 10^{45} \text{erg/s} \approx 10^{12} L_\odot \), which is equal to 12% of the Eddington luminosity. All that is much more than expected for a galaxy of such modest size. The data are in tension with the accepted picture in which this galaxy would recently have transformed from a star-forming disc galaxy into an early-type, passively evolving galaxy.

Recently an observation of a quasar quartet embedded in giant nebula was reported [33] in a survey for Lyman-emission Lyman-emission at redshift \( z \approx 2 \). According to the authors, it reveals rare massive structure in distant universe. As it is stated in the paper, all galaxies presumably once passed through a hyperluminous quasar phase powered by accretion onto a supermassive black hole. But because these episodes are brief, quasars are rare objects separated by cosmological distances, so the chance of finding a quadruple quasar is \( \sim 10^{-7} \). It implies that the most massive structures in the distant universe have a tremendous supply \( (\sim 10^{11} M_\odot) \) of cool dense \( (n \approx 1/\text{cm}) \) gas, in conflict with current cosmological simulations.

All these observations much better fit the inverted scenario mentioned at the beginning of this section.

C. Near-solar mass black holes and MACHOs

The mass distribution of black holes observed in the Milky way seems to demonstrate some peculiar features not understood by the conventional theory. It is found that their masses are concentrated in the narrow range \( (7.8 \pm 1.2) M_\odot \) [34]. This result agrees with another paper where a peak around \( 8 M_\odot \), a paucity of sources with masses below \( 5 M_\odot \), and a sharp drop-off above \( 10 M_\odot \) are observed [35]. Such facts are indeed very strange, if these BHs were formed by the stellar collapse, as it is usually assumed. Astronomical data also hints to a two-peak mass distribution of the PBHs and compact stars, which is probably observed, but not explained up to now [36]. Quoting this work: “sample of black hole masses provides strong evidence of a gap between the maximum neutron star mass and the lower bound on black hole masses”. These results may fit the mass distribution of our model of Sec. IV assuming that the lower mass BH are also created by a normal mechanism of stellar collapse.

A similar or maybe even connected problem is related to the nature of MACHOs discovered through gravitational microlensing by Macho and Eros groups. They are invisible (very weakly luminous or even non-luminous) objects with masses about a half of the solar mass in the Galactic halo and in the center of the Galaxy and recently in the Andromeda (M31) galaxy. Their density is significantly greater than the density expected from the known low luminosity stars but not enough to explain all dark matter (DM) in the halo. The present day situation with MACHOs is briefly reviewed in ref. [37], which we follow below.

MACHO group [38, 39] has announced 13 - 17 microlensing events in the Large Magellanic Cloud (LMC), a much larger number than expected if MACOS would be normal weakly shining stars. The fractional contribution of the density of these compact “lenses” with respect to the total halo density (which is essentially the dark matter density) was estimated to be in the range \( 0.08 < f < 0.50 \) (95% CL) for \( 0.15 M_\odot < M < 0.9 M_\odot \).

EROS (Expérience pour la Recherche d’Objets Sombres) collaboration has placed only an upper limit on the halo fraction, \( f < 0.2 \) (95% CL) for the objects in the specified above MACHO mass interval, while EROS-2 [40] gives \( f < 0.1 \) in the mass range \( 10^{-5} M_\odot < M < 1 M_\odot \).

AGAPE collaboration [41], working on microlensing in M31 (Andromeda) galaxy, finds the halo Macho fraction in the range \( 0.2 < f < 0.9 \), while MEGA group marginally conflicts with them with an upper limit \( f < 0.3 \) [42].

Detailed analysis of the controversial situation with the results of different groups is given in ref. [43]. Newer results [44] for EROS-2 and OGLE (Optical Gravitational Lensing Experiment) in the direction of the Small Magellanic Cloud are: \( f < 0.1 \) at 95% confidence level for Machos with the mass \( 10^{-5} M_\odot \) and \( f < 0.2 \) for Machos with the mass \( 0.5 M_\odot \).

Thus MACHOs for sure exist. Their density is comparable to the density of the halo dark matter but their nature is unknown. They could be brown dwarfs, dead stars, or primordial black holes. The first two options are in conflict with the accepted theory of stellar evolution, if MACHOs were created in the conventional way.

IV. POSSIBLE EXPLANATIONS

The described above problems in the sky both in the early, \( z \sim 5 - 10 \), and the present day universe strongly suggest that there exist some new effects outside the standard approach to the theory of formation and evolution of celestial bodies, so the latter demands an essential modification. One possibility is an unusual cosmological expansion law [46, 47], such that at these high redshifts the universe happened to be older than in the standard regime.
Another option is an efficient creation of stellar-like objects (compact stars, ancestors of supernovae, primordial black holes, including the supermassive ones) in the very early universe after the QCD phase transition. The necessary for that large density perturbations on cosmologically small but astrophysically significant scales can originate in a well known scenario of the supersymmetric, or Affleck-Dine [48], mechanism of baryogenesis after a simple modification. This modification was suggested long ago [29] and now permits to explain all the described above anomalies in a unique way.

Shortly the scenario is the following. In supersymmetric Grand Unified models there exists a scalar field, $\chi$, with non-zero baryonic number, $B \neq 0$. The potential of $\chi$ generically has some flat directions. In a toy model the potential can be presented as:

$$U_\lambda(\chi) = \lambda |\chi|^4 (1 - \cos 4\theta). \quad (4.1)$$

The $\chi$-bosons may condense along flat directions, $\cos(4\theta) = 1$, of this quartic potential. There also exists the quadratic potential which may appear as a result of some symmetry breaking and is essential at small $\chi$. It can be taken in the form:

$$U_m(\chi) = |m_1|^2|\chi|^2 - \frac{1}{2} \left( m_2^2\chi^2 + m_3^2\chi^2 \right) = |m|^2|\chi|^2[1 - \cos(2\theta + 2\alpha)], \quad (4.2)$$

where $\chi = |\chi|\exp(i\theta)$ and $m = |m|e^\alpha$. If $\alpha \neq 0$, both C and CP are explicitly broken. We took $|m_1| = |m_2|$, though it is not necessary.

In GUT SUSY baryonic number is naturally non-conserved. It is described here by non-invariance of $U(\chi)$ with respect to global $U(1)$ phase rotation, $\chi \rightarrow \chi \exp(i\alpha)$.

Initially (after inflation) $\chi$ was naturally away from the origin and when inflation is over it starts to evolve down to the equilibrium point, $\chi = 0$, according to equations of the Newtonian mechanics:

$$\ddot{\chi} + 3H\dot{\chi} + U'(\chi) = 0. \quad (4.3)$$

with the Hubble friction term $3H\dot{\chi}$.

Baryonic number of $\chi$, $B_\chi = \theta|\chi|^2$, in this language is analogous to mechanical angular momentum. The rotational degree of freedom in the course of $\chi$ decay transferred its baryonic number to that of quarks in $B$-conserving process. Since quite large baryonic number could be accumulated in such rotation, the Affleck-Dine baryogenesis might create the cosmological baryon asymmetry of order of unity, much larger than the canonical value $\sim 10^{-9}$.

If $U_m(\chi) \neq 0$, the angular momentum, $B$, would be generated by a mismatch of the directions of the quartic and quadratic valleys, when $\chi$ evolved down to zero from some large values. If CP-odd phase $\alpha$ is non-vanishing, then both baryonic and antibaryonic regions are possible with dominance of one of them. Matter and antimatter domain may exist but globally $B \neq 0$.

A minor modification of AD-scenario can lead to very early formation of compact stellar-type objects and naturally, though not necessarily, to a comparable amount of anti-objects, such that the bulk of baryons and possibly antibaryons (in equal or comparable amount) would be in the form of compact stellar-like objects or primordial black holes (PBH), plus sub-dominant observed homogeneous baryonic background. The amount of baryonic matter and antimatter in such compact objects may be comparable or even larger than the amount of the observed baryons, but such compact (anti)baryonic objects would not contradict any existing observations. To this end one needs to add to the usually accepted potential of the Affleck-Dine field $\chi$ a general renormalizable coupling to inflaton $\Phi$ [29]; it is the last term in the equation below:

$$U = \lambda|\chi|^4 \ln \left( \frac{|\chi|^2}{\alpha^2} \right) + \lambda_1 \left( \chi^4 + h.c. \right) + \left( m^2\chi^2 + h.c. \right) + g|\chi|^2(\Phi - \Phi_1)^2. \quad (4.4)$$

If $\Phi$ is close to $\Phi_1$, then the window to the flat directions, is open but only during a relatively short period. However, it could be sufficiently long, so that the bubbles with large values of $\chi$ would be created and hence huge baryon asymmetry even up to $\beta \sim 1$ would arise inside them. Because of the inflationary expansion after $\Phi$ passed through $\Phi_1$, the bubbles could easily become astrophysically large, but still the bubbles would occupy a minor fraction of the total volume of the universe. Despite that the mass density of these B-bubbles with high $\beta$ can make a dominant contribution to the total cosmological matter balance of baryons due to their huge baryon density which may be by far larger than the observed tiny value of the cosmological baryon asymmetry, $\beta \approx 6 \cdot 10^{-10}$.

The distributions of B-bubbles over their radius and mass have log-normal form:

$$\frac{dN}{dM} = \mu^2 \exp[-\gamma \ln^2(M/M_0)], \quad (4.5)$$

where $\mu$, $\gamma$, and $M_0$ are some constant parameters, $M$ and $\mu$ have dimensions of mass, while $\gamma$ is dimensionless. The spectrum is practically model independent, because it is essentially determined by inflation.
Immediately after formation of the bubbles with large value of $\chi$ some inhomogeneities in the energy density were developed due to different equations of state inside and outside of the bubbles. The matter was less relativistic inside the bubbles than outside. But these inhomogeneities remain relatively small. There are large isocurvature perturbations due to much larger baryon asymmetry inside the bubbles. These isocurvature perturbations are transformed into large density perturbations, but at small scales, after the QCD phase transition, which took place at $T = (200 - 100) \text{ MeV}$, after massless quarks combined forming non-relativistic protons. Depending upon the value of the Jeans mass of B-bubbles they could make either primordial black holes (PBH) or dense compact stellar-like objects. The masses of them are expected to be in the range form a fraction of the solar mass up to millions solar masses and even higher. Due to the subsequent matter accretion, the log-normal mass distribution would be distorted amplifying the high mass tail of the distribution. The PBHs created through such mechanism can naturally explain the mentioned in subsection III C features of the several-stellar-mass black holes in the Galaxy.

A modifications of interaction potential between $\Phi$ and $\chi$ leads to a more intricate mass spectrum of the early formed stellar type objects, e.g., if:

$$U_{\text{int}} = \lambda_1 |\chi|^2 (\Phi - \Phi_1)^2 (\Phi - \Phi_2)^2,$$

we come to a two-peak mass distribution of the PBHs and compact stars, which is probably observed, but not explained up to now, if the BHs are dominantly created by the stellar collapse.

V. CONCLUSION

According to the suggested mechanism compact stellar-like objects and primordial black holes could be created in the very early universe when it was only $t = 10^{-5} - 10^2 \text{ second old}$. Their masses should be of the order of the mass of the matter inside the cosmological horizon, $m_{\text{hor}} \approx 10^5 M_\odot (t/\text{sec})$. As is well known, if the mass created by the density contrast is equal to the mass inside the horizon a primordial black hole would be created [49]. For smaller masses stellar type objects would be formed.

The mass distribution (4.5) is rather strongly cut at high mass tail but it can be enhanced by matter accretion on lower mass PBHs. In such a way one can easily populated the universe at $z = 5 - 10$ by the observed objects, such as high-redshift SN, gamma-bursters, including 10 billion solar mass quasars, which are very difficult, if possible at all, to create in other way. The big bang nucleosynthesis inside or in vicinity of the high-B bubbles creates heavy elements by far more efficiently that the standard BBN. This may lead to the observed evolved chemistry and a lot of dust at $z \sim 10$. The unusual primordial chemical content may explain the existence of stars which are formally older than the universe.

The B-bubbles which did not became PBHs would form very early stars. Such “stars” might evolve quickly and, in particular, make early SNs, enrich the universe with heavy (anti)nuclei and later reionize the universe.

The early formed superheavy BHs can be the seeds for the galaxy formation. This explains in particular, an existence of the observed superheavy BHs in small galaxies. Some or majority of these early stars may be dead by now and are observed as MACHOs.

Since the sizes of these objects are small at the cosmological scale they are neither forbidden by the data on the angular fluctuations of CMB nor by its frequency spectrum. The energy release from stellar like objects in the early universe is small compared to the CMBR energy density.

The anomalous abundances of light elements created by BBN at high $\beta$ are not dangerous for the observed abundances since the anomalous part of the universe volume is small. It is tempting to prescribe the Lithium problem if the metal-poor halo stars, where the anomalously low abundance of Li is observed, were created from the primordial clouds with abnormal $\beta$.

A natural, though not obligatory, outcome of this model is a prediction of cosmic antimatter, mostly in the form of compact high velocity stars in the Galaxy. The observational bounds on the abundance of such stars are quite vague, so we may have a lot of antimatter practically at hand. Such early formed stars would behave as cold dark matter and so should have much larger velocity than the normal stars and hence they would populate the galactic halo, see ref. [50].

However, it is unclear, if the CDM-problems mentioned at the beginning can be solved, provided galaxies are formed around earlier created seeds.

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