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The Origin of Power and Acceleration of High-Redshift Galaxies in the Unicentric Model of the Universe

Ahmad A. Hujeirat

IWR, University of Heidelberg, Heidelberg, Germany
Email: AHujeirat@iwr.uni-heidelberg.de

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Abstract

Recently, a unicentric model of our observable universe was proposed. Accordingly, the big bang was neither a singular event nor invoked by external forces, but rather a frequent event in cosmic life cycles that occur sequentially or in parallel at the same and/or in different locations of our infinitely large, flat, homogeneous, and isotropic parent universe. The progenitor of our big bang is predicted to have been of a measurable size and happened to be in our neighbourhood. Based on theoretical arguments and general relativistic numerical calculations, it is argued that: 1) The surface of the progenitor is most appropriate for the hadron flash to run away; 2) The structure of the progenitor is immune to self-collapse into a hyper-massive black hole; and 3) The power and acceleration of high-redshift galaxies may be connected to the BB-explosion. We conclude that the currently observed high-redshift galaxies must have been old and inactive in older times, but turned into life through matter and momentum transfer from the fireball and the collision of the locally curved spacetime embedding the galaxy with the expanding one embedding the fireball. With the present scenario, the origin of the monstrous black hole candidates with $M_{BH} \geq 10^9 M_\odot$, that are believed to have resided at the centre of galaxies when the observable universe was 400 Myr old, could be straightforwardly explained. This implies that QSOs with ever higher redshifts should exist, though their detection becomes increasingly harder.

Keywords

General Relativity, Big Bang, Black Holes, QSOs, Neutron Stars, QCD, Condensed Matter, Incompressibility, Superfluidity, Super-Conductivity

1. Introduction

The state of matter inside the cores of massive neutron stars is probably one of the greatest secrets of the universe [1]. Here, the effects of both quantum and strong gravitational fields are at work, and as these objects are dynamically stable, their effects seem to be perfectly coordinated [2] [3] [4]. The related question here is: Do the laws of nature encode an upper limit on the maximum possible energy density, ρ_{max}^{uni}, beyond which matter becomes insensitive to further compression?

Indeed, careful inspection of the recent astronomical observations of high-redshift quasars, dark matter-dominated galaxies, mergers of neutron stars, glitch phenomena in pulsars, the missing first generation of massive neutron stars, the missing stellar mass black holes with $\mathcal{M}_{BH} \le 6M_{\odot}$, the cosmic microwave background radiation and experimental data from hadronic colliders, may not rule out this hypothesis, but they may support it indirectly [see [5]-[10], and the references therein].

Numerical modeling of the interiors of Ultra-Compact Objects (UCOs), such as massive Neutron Stars (NSs), pulsars, and magnetars, predict the central density, ρ_c, to be much higher than the nuclear density ρ_0 [11]. In the absence of nuclear fusion, UCOs must cool down on the cosmic time scale to finally turn invisible. As none of these old and dead objects has ever been observed to collapse into a BH, the existence of ρ_{max}^{uni} is even necessary, though it may not be sufficient. Relying on experimental data from hadronic collisions in labs [12] and that $\rho_c \gg \rho_0$ in NSs, we expect the matter in the cores of massive NSs to form oceans of fundamental particles occupying the lowest possible quantum energy states.

Here, the sound speed is expected to regulate the communications between their constituents, which, in a supranuclear dense regime, should be equal roughly to the speed of light. The related consequence here is that the cores of massive NSs are well-equipped to resist all possible external perturbations, including compression by external forces. Indeed, recent theoretical and observational studies of the merger of neutron stars in GW170817 may support this hypothesis, as to date, there is no conclusive observational evidence that pinpoints a collapse of the remnant into a stellar black hole [13] [14] [15].

Further inevitable consequences are: 1) Formation of black holes in the classical sense may turn out to be just a mathematical solution, though not necessarily physical. This may support Einstein's objection to the existence of BHs [16]. 2) The progenitor of the big bang had a finite measurable size and its explosion may have occurred in our neighborhood [17]. 3) Our universe may be a tiny part of an infinitely large and flat parent universe [18]. 4) Big bangs are not singular events, but rather; they are vital ingredients of cosmic life cycles that may occur from time to time sequentially or in parallel at the same and/or in different locations of our infinitely large, flat, homogeneous, and isotropic parent universe.

These indicate that our observable universe is a unicentric one, and that the cosmological principle may still hold, though not locally, but for the parent universe [17].

In this paper, we suggest possible answers to certain questions related to this scenario, namely: 1) Why hadronization of the progenitor must start at the surface and proceed inwards, rather than from the center outwards; 2) Without invoking inflation, how it was possible for the progenitor to escape collapse into a Supermassive Black Hole (SMBH); and 3) Could the power and acceleration of high-redshift galaxies be connected to the explosion of the BB-progenitor triggered by the hadronization process?

2. Formation of the Hadronization Front

Based on the theoretical and observational arguments, it was argued in [6] [19] that:

- The embedding spacetime of incompressible supranuclear dense matter with zero entropy must be flat.
- The supranuclear dense matter inside the cores of dead and massive NSs should be in an incompressible super-conducting superfluid state, termed SuSu-matter, which corresponds to the lowest quantum energy state.
- Similar to the cores of massive glitching pulsars, the interaction between the progenitor and the ambient media occurs at the interface between the enclosed flat and the ambient curved spacetime.

We note that there are at least four counterarguments opposing the conjecture that the hadron flash would have started the runaway process precisely at the center of the progenitor:

- The geometrical center of the progenitor, say $r=0$, in a perfectly homogenous and isotropic environment is ill-defined. Unlike in normal stars, where $\nabla P = \nabla \rho = 0$ at $r=0$, in perfectly homogenous and isotropic environment the physical properties at any point are identical.
- The topology of spacetime inside SuSu-matter cannot be communicated to the outside world by construction, as otherwise, gluon-quark superfluid would be transparent to outside observers.
- In the absence of theoretical mechanisms, such as inflation [20] [21], the event horizon will soon succeed the radius enclosing the newly created normal matter, thereby triggering its collapse into a BH.
- In the absence of inflation and in a supranuclear dense and cold environment, it is not clear, why the hadron flash should run away rather than stifling by the weight of the overlying matter.
- Exploring the internal structure of hadrons in labs is based on violently shaking their confining membranes from outside, rather than from inside.

To study how the topology of spacetime embedding the progenitor evolves with time relative to our preferred observer, $\mathcal{H}_0$ at the center of the progenitor, a new time-dependent $\mathcal{H}$-metric was proposed [17]. Here, a time-dependent curvature function, $\chi(r,t)$, is set to enter both the metric coefficients g_{00} and

g_{11} as follows:

$$\mathrm{d}s^2 = g_{\mu\nu}\mathrm{d}x^\mu \mathrm{d}x^\nu = g_{00}\,\mathrm{d}t^2 + g_{11}\,\mathrm{d}\overline{r}^2 + g_{22}\,\mathrm{d}\theta^2 + g_{33}\,\mathrm{d}\varphi^2 \quad (1)$$

where

$$\begin{aligned} g_{00} &= \mathrm{e}^{2\mathcal{V}(r,t)} = 1-\chi(r,t), \quad g_{11} = \mathrm{e}^{2\lambda(r,t)} = -\frac{1}{1-\chi(r,t)} \\ g_{22} &= -\mathrm{e}^{2\mathcal{C}(t)}r^2, \qquad\qquad g_{33} = -\mathrm{e}^{2\mathcal{C}(t)}r^2\sin^2\theta. \end{aligned} \quad (2)$$

Here, we term $\mathcal{V}(r,t)$ as the "gravitational potential", *r* is the comoving radius and *t* is the time relative to our preferred observer $\mathcal{H}_0$ located at $r=0$, while $\mathcal{C}(t)$ is a function of time only.

In the present study, we employ Equation (19) in [17], which, in the case of fixed coordinate systems, *i.e.* for a constant scaling factor $R(t)=1$, reduces into:

$$\begin{aligned} &\frac{1}{2r}\left[\frac{\partial}{\partial t}\left(\mathrm{e}^{-2\mathcal{V}}\right) + \frac{\mathrm{e}^{-2\lambda}}{\mathrm{e}^{-2\mathcal{V}}}\frac{\partial}{\partial r}\left(\mathrm{e}^{-2\mathcal{V}}\right) + \frac{\partial}{\partial r}\mathrm{e}^{-2\lambda}\right] \\ &= -\frac{1}{2}\kappa(\mathcal{E}+p)\left[\Gamma^2\left(g_{00}-V^2 g_{11}\right)\right] = -\frac{1}{2}\kappa(\mathcal{E}+p)\overline{\overline{\Gamma}}, \end{aligned} \quad (3)$$

where Γ is the Lorentz factor in curved dynamically varying spacetime and $\overline{\overline{\Gamma}}$ is termed the modified Lorentz factor, which reads:

$$\overline{\overline{\Gamma}}^2 = \begin{cases} \dfrac{g_{00}+V^2 g_{11}}{g_{00}-V^2 g_{11}} & : \text{General form} \\ 1 & : \text{Hydrostatic cores embedded in curved spacetimes} \\ \dfrac{1+\beta^2}{1-\beta^2} & : \text{Flat spacetime.} \end{cases} \quad (4)$$

In the case of slowly contacting matter-configurations or in hydrostatic equilibrium, $\overline{\overline{\Gamma}}^2$ was verified to be physically more indicative than the classical Lorentz factor [17].

The in above-mentioned study $\chi(r,t)$ is a time-dependent function of the following form:

$$\mathcal{X}(r,t) = \alpha_{bb}\left(\frac{m_n(r,t)}{r}\right), \quad (5)$$

where $m_n(r,t)$ is the enclosed mass of normal matter and α_{bb} is the so-called compactness parameter.

Based on various theoretical and observational studies of glitching pulsars, it was argued that incompressible and entropy-free SuSu-matter inside the cores of massive pulsars and neutron stars decouples from the embedding spacetime [19] [20] [22]. The consequence is that, in the absence of normal matter, both spacetimes inside and outside SuSu-objects become conformally flat.

Hence, the total mass content, $m_{tot}(r,t)$ that determines the curvature of the embedding spacetime reduces to that of normal matter, $m_n(r,t)$, which we classify as compressible and dissipative matter. In the stationary case, the curvature function $\chi(r,t) \to \chi(r)$ and therefore the metric ds^2 reduces to the Schwarzschild, Minkowski and/or to Friedmann metric, depending on the underlying type and spatial distribution of matter, namely:

$$\mathcal{X}(r) \sim \begin{cases} r^2: & \text{Schwarzschild \& Friedmann} \\ & \text{ToM: incompressible normal} \\ & \text{fluids \& dust} \\ r^\alpha: & \text{Schwarzschild}(\alpha < 2). \\ & \text{ToM: Normal compressible} \\ 0: & \text{Flat} \\ & \text{ToM: Vacuum (energy-free-space-)} \\ & \text{time, incompressible SuSu-matter,} \end{cases} \tag{6}$$

where "ToM" stands for "Type of Matter".

Prior to BB-explosion, the progenitor was levitating in flat spacetime as $m_n(r,t \le 0) = 0$. During the hadronization process, $m_n(r,t)$ was continuously increasing, thereby curving the embedding spacetime. The hadronization process is associated with four fronts that form at the surface of the progenitor and start propagating in different directions with different speeds (see **Figure 1**), namely:

- The hadronization front, f_{had}^-, which propagates inwards with the speed of light.
- The rarefaction/decompression front, f_{rar}^- which set to propagate inwards through the newly created normal compressible and dissipative matter with $V_s^- < c$.
- The expansion front f_{exp}^+, which separates the ambient flat spacetime from the enclosed curved one, is set to propagate outwards with the speed of light and would last forever, though its intensity decreases both with time and distance from the center of the progenitor.
- A shock front, f_{sh}^+, that propagate ultra-relativistically outwards with $V_{sh}^+ \to \approx c$.

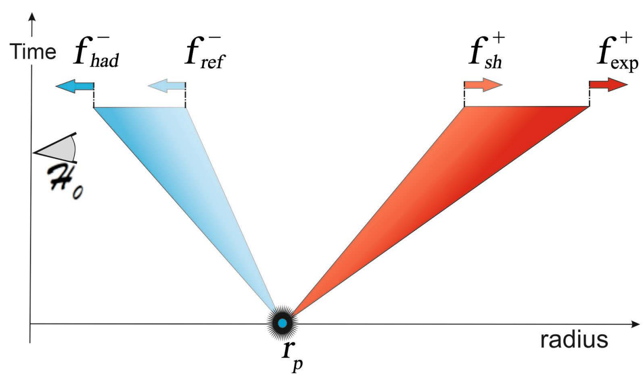

Figure 1. A schematic description of the four fronts: f_{had}^-, f_{rer}^-, f_{sh}^+ and f_{exp}^+ are the inward-propagating hadronization and expansion fronts, as well as the outward-propagating shock and spacetime expansion fronts, respectively.

In **Figure 2**, we display a sequence of snapshots showing the time-development of mass of the newly created normal matter and the corresponding curvature function. In these calculations the progenitor is set to hadronize in a quasi-static manner. The plateau of the gravitational potential sinks with time to attain its minimum at $\tau = 1\tau_{dyn}$, at which the progenitor is entirely hardonized and reaches maximum compactness. For a progenitor of $10^{24} M_{\odot}$, the hadronization phase would last roughly 46 minutes, which is the dynamical time scale τ_{dyn}.

The one-to-one correspondence between matter and spacetime in GR may also be used to extract the mass content by measuring the curvature of the embedding spacetime. Recalling that the spacetime at the background of the progenitor prior explosion was perfectly flat and that at $t = 1\tau_{dyn}$, the volume enclosing normal matter is well-defined and calculable, using the causality condition. Outside the volume boundaries, there is no matter, and therefore $\chi(r,t)$ as well as the derivatives of the matric coefficients are set to vanish. The spherically symmetric surface bounding the curved spacetime at $t = \tau_{dyn}$ reads:

$$S\left(t = \tau_{dyn}\right) = \int_{S^2} \mathrm{d}S = 4\pi R^2 \left(t = \tau_{dyn}\right) = 16\pi c^2 t_{dyn}^2 \quad (7)$$

We may use the minimum energy theorem to calculate the ADM-mass [6] [23].

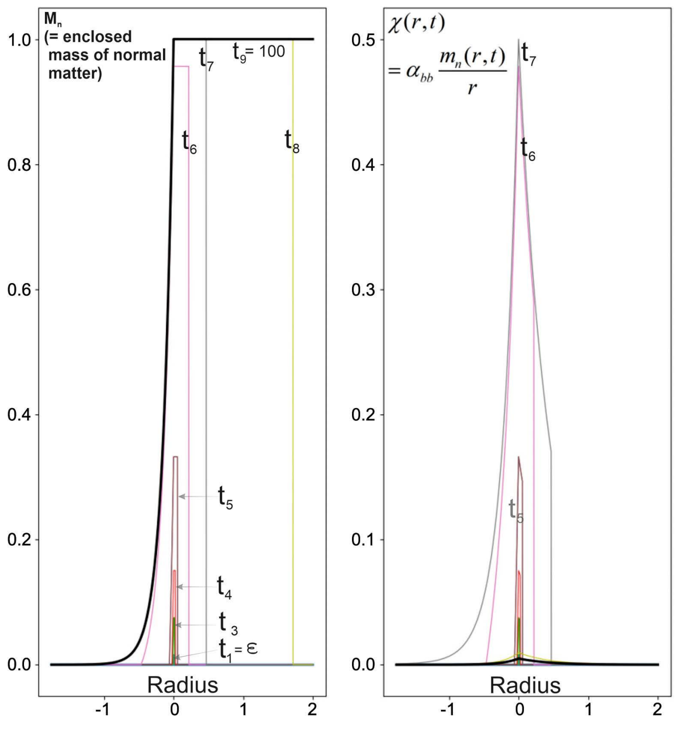

Figure 2. Different snapshots of the time-development of both the total enclosed mass of normal matter, $\mathcal{M}_n(r,t)$, and the curvature function, $\chi(r,t)$, starting shortly after the formation of hadronization front at the surface of the progenitor, $t_1 = \varepsilon$, and after t_9, which corresponds to $100\tau_d$. Here τ_d is the dynamical time scale, which amounts to roughly 46 min. In these calculations, the total mass M_n attains its maximum after $t = 1\tau_d$.

$$\mathcal{M}_{ADM} = a_0 \int_0^{\tau_{dyn}} \int_{S^2(t)} n^i g^{k\ell} \left(g_{\ell i,k} - g_{\ell k,i} \right) \mathrm{d}S\,\mathrm{d}t + \int_{\tau_{dyn}}^{\infty} \int_{S^2(t)} n^i g^{k\ell} [\ldots]^{\nearrow 0} \mathrm{d}S\,\mathrm{d}t \\ = \mathcal{M}_n + [0] = \mathcal{M}_n, \tag{8}$$

where $n^i = \left(\sqrt{1-\chi(r,t)}, 0, 0 \right)$ is the 3-normal vector to the dynamically varying spherical surface. The second integral vanishes as for $t \ge \tau_{dyn}$, the ambient spacetime contains no matter and therefore the derivatives of the metric coefficients must vanish. On the other hand, during the hadronization phase, *i.e.* $\left[0 \le t \le \tau_{dyn} \right]$, the mater generation rate reads [17]:

$$M^{nor} = 3t - 3t^2 + t^3. \tag{9}$$

In this case, the curvature function increases almost linearly with time, but starts decreasing immediately thereafter as follows:

$$\chi(r,t) = \alpha_{BB} \frac{m(r,t)}{r} \sim \begin{cases} t & t \le \tau_{dyn} \\ \dfrac{1}{1+t} & t > \tau_{dyn} \end{cases} \tag{10}$$

In **Figure 3**, we show a series of snapshots of the time-development of the spacetime topology during the the hardonization phase the thereafter, keeping in mind that the total mass of normal matter remains constant after $t > 1\tau_{dyn}$. Here the gravitational potential starts developing a plateau, which deepens during the hadronization phase, but starts flattening afterwards, *i.e.* $t > 1\tau_{dyn}$. This behavior may be seen from Equation (10), which shows the two cases. Apparently, for $t > 10^{11}\tau_{dyn} \approx$ age of the universe, the curvature function becomes undetectable small, implying therefore that the spacetime at the present time may be considered safely flat.

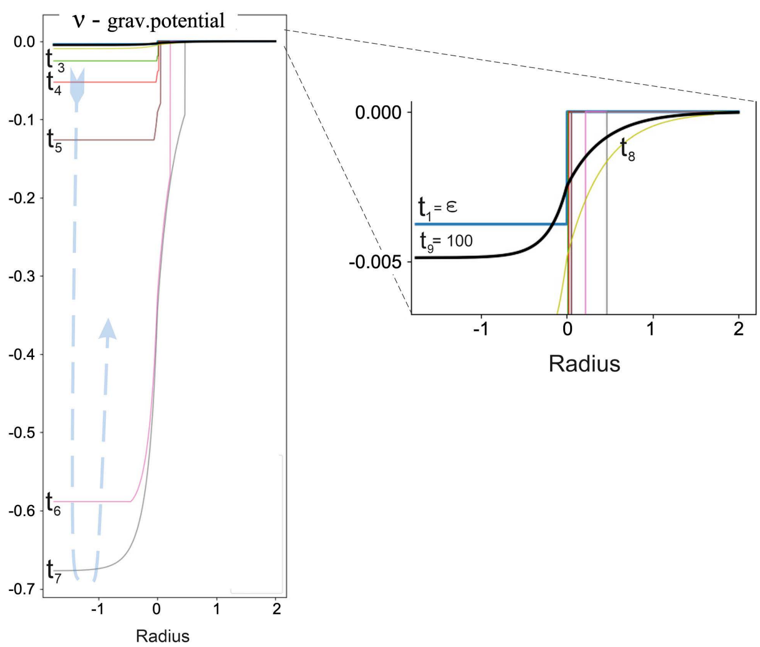

Figure 3. The time-development of the gravitational potential $\mathcal{V}$ shortly after of the hadronization front has taken off and after $t_9 = 100$ dynamical time scale τ_d has elapsed. $\mathcal{V}$ attains its minimum at $t = \tau_d \approx 46$ min, but starts flattening immediately thereafter, due to the finite mass of the progenitor.

2.1. Explosion versus Implosion of the Progenitor

In normal stars, the negative gradient of the energy density in the radial direction is necessary for ensuring dynamical stability. In the present case, however, the progenitor is made of incompressible SuSu-matter and therefore, the center becomes loosely defined, as $\nabla\mathcal{E}$ vanishes everywhere. For our geometrically preferred observer, $\mathcal{H}_0$, the interior of the progenitor is homogenous and isotropic. Moreover, as SuSu-matter is entropy-free, then the entire content of the progenitor must occupy just one single quantum energy state, which corresponds to the lowest possible one. This implies that the entire content of the progenitor is maximally coupled and behaves collectively as a single quantum entity.

On the other hand, following [6], the density inside the progenitor is constant and equal to the universal maximum density, ρ_{max}^{univ}, beyond which matter becomes purely incompressible and where information between the constituents are communicated with the maximum possible speed: the speed of light. Here, local density perturbations could lead to $\nabla\mathcal{E}\neq 0$ are forbidden, as otherwise, in the vicinity of the corresponding point, there must a point, where $\rho>\rho_{max}^{univ}$, which violates causality.

Recalling that the spacetime inside and outside the progenitor is flat, then both $\nabla\mathcal{E}$ and $\nabla_\mu g_{\mu\nu}$ must vanish everywhere, save at the boundary, where the former becomes almost singular, whereas the latter becomes negligibly small. However, such an imbalance is unlikely, as the superfluid cores in massive NSs would explode rather than glitch. Consequently, the pressure across the surface transforms into a two-dimensional surface tension that confines the ocean of the SuSu-fluid and keeps it hidden from the outside world.

We conjecture that such a configuration may maintain dynamical stability, if the coupling information of all its constituents are mirrored and encoded onto the 2D-like surfaces in a holographic manner as proposed by the holographic principle [24].

Based thereon and in the absence of macroscopic repulsive forces between stellar-mass DEOs, we expect clusters of DEOs to be extraordinarily tight, mimicking thereby the tightly packed nucleons in atomic nuclei. Also, recalling that SuSu-objects occupy the lowest possible energy state, then tightly packed SuSu-objects may merge smoothly without violently hadronizing their contents as it seems to be the case in the NS-merger event GW170817 [14].

Irrespective of whether $10^{24}M_\odot$ massive progenitor was made of tightly packed or merged normal matter objects, the corresponding event horizon, $\mathcal{H}_{BH}$ would be larger than the currently measured cosmic horizon $\mathcal{H}_{Cos}$. This becomes even crasser if the progenitor was made of supranuclear dense normal matter embedded in Schwarzschild spacetime. In the latter case, the radius of the progenitor would be approximately fifteen orders of magnitude smaller than the corresponding event horizon, and therefore there will be no universe to evolve.

In the present case, the Birkhoff theorem has limited applications, as for $t\leq 0$ the progenitor was made of SuSu-matter, and therefore incapable of communicating with or affecting the topology of the ambient spacetime.

This gives rise to the possibility that communications between matter and spacetime may doom to stagnate in entropy-free systems [25] [26]. In the present study, it is important to investigate how the properties of the newly created normal matter could affect the topology of the embedding spacetime and explore the parameter regime, in which the fireball may still collapse into a hypermassive BH. Here both the EOS and the compactness parameter generally play a key role in determining the dynamics of the interiors of astrophysical objects.

In **Figure 4**, a series of snapshots of the radial distribution of the transport velocity, V, the modified Lorentz factor $\bar{\bar{\Gamma}}$, and the gravitational redshift for different EOSs and compactness parameters are displayed. In all these runs, the outward-pointing pressure gradient appears to be extraordinarily strong to jettison the newly created normal matter into the outer spacetime with ultra-relativistic velocities, prohibiting thereby the collapse of the progenitor into a BH, even when the compactness parameter is around one. Unlike normal astrophysical objects, where the surrounding spacetimes have settled into Schwarzschild-like spacetimes, spacetimes embedding expanding fireballs surrounded by infinitely large flat ones are incapable of reversing their collective motions and re-collapse to form point-like objects.

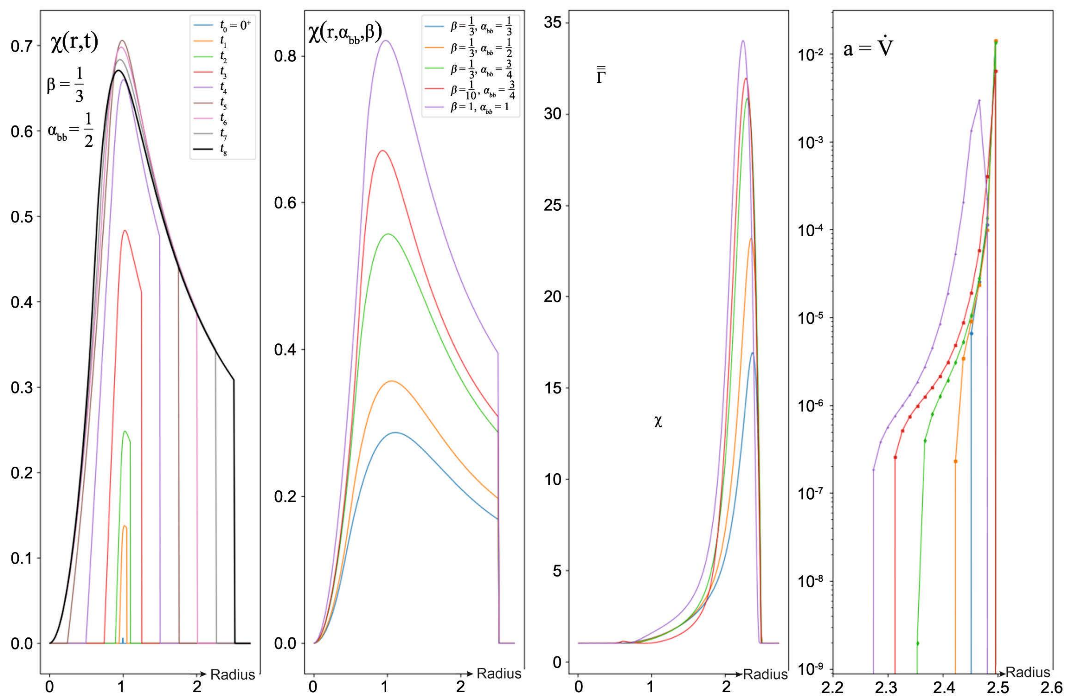

Figure 4. Snapshots of the curvature function $\chi(r,t)$ are shown at different times during the hydrodynamical expansion of the fireball, using the EOS $P = \beta\varepsilon$, where $\beta = 1/3$ (right panel). In the second panel, the curvature function is shown for different values of $\beta = 1/3$ and compactness parameter α_{bb}. In the third and fourth panels, the modified Lorentz factor $\bar{\bar{\Gamma}}$ and the time-variability of the shock velocity are shown.

2.2. The Origin of Power and Acceleration of High-Redshift Galaxies

According to the here-presented scenario, BBs are actually local events that take off from time to time sequentially or in parallel at the same and/or in different locations of an infinitely large, flat, homogeneous, and isotropic universe.

Based thereon, it is tempting to explore how such giant explosions could affect the activities and dynamics of distant galaxies.

Consider an old and inactive galaxy, G, at a distance $r_G = 10^{28}$ cm from the $\mathcal{H}_0$ observer. Without loss of generality, let the mass and size of G be $\mathcal{M}_G = 10^{10} M_\odot$ and volume $V_G^{vol} = \ell_G^3 = kpc^3$ and consisting of 10^{10} old and faint stars (see **Figure 5**).

Prior the BB-explosion, the partial mass of the progenitor enclosed inside the cone confining G reads:

$$\mathcal{M}_P^G = \frac{M_p}{16}\left(\frac{\ell_G}{r_G}\right)^2 \approx 10^9 M_\odot, \tag{11}$$

where $M_p = 10^{24} M_\odot$.

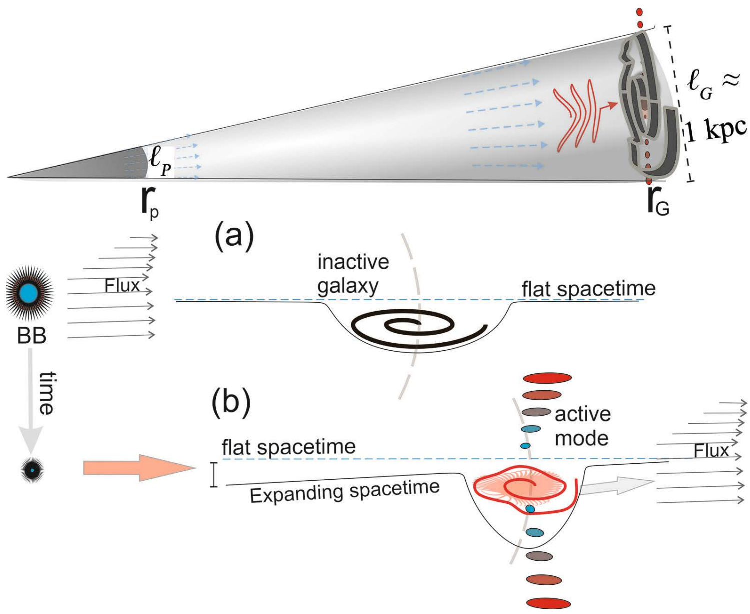

Figure 5. In the upper panel, we show the geometry of the interaction of the normal matter of the fireball with a galaxy inside a spherical cone. The Su-Su-matter that is set to collide with the galaxy "G" is confined to a spherical cone of radius r_p and a cross-section with the diameter ℓ_p. The galaxy "G" is set to be at a distance r_G from the center and confined to the frustum of the cone having 1 kpc height and a cross-section of 1 kpc^2. In the lower panel, we show a schematic description of the collision between the fireball with an old and distant galaxy (a). The expansion of the normal matter of the fireball together with the embedding curved spacetime collides with a motionless galaxy surrounded by a flat spacetime. The transfer of mass and momentum together with the expanding spacetime of the fireball turn the galaxy into an active mode, but also sets the galaxy into an outward accelerating motion (b).

Note that if $\mathcal{M}_p^G$ were the only source of normal matter, then, due to the verified homogeneity and isotropy of the observable universe, no galaxy with $\mathcal{M} > 10^9 M_\odot$ would ever form inside the G-cone, contrary to observations. This may justify our assertion, which these old inactive galaxies were behind the particle horizon, but got re-activated through the collision with the matter of the expanding fireball. Similar to spherical accretion, let A_{cap} be the effective capturing area of particles originating from the fireball. In the present case, A_{cap} should dramatically decrease, as the incoming velocity of particles from the fireball propagates with ultra-relativistic speeds. Hence A_{cap} may become comparable to the sum of the cross-sections of the objects of *G*, *i.e.* only those particles that collide face-to-face with the objects would be captured. In this case, we may generously set the average capturing area of an individual object to be:

$$\left\langle A_{cap}\right\rangle = \frac{\sum_i^N A_{i,cap}}{N} = \pi\left\langle R_{cap}\right\rangle^2 \approx 10^{22}\ \text{cm}^2 \tag{12}$$

where $N = 10^{10}$ is the number of objects of G. This yields a total capturing area of approximately $A_{cap}^G = 10^{10}\times\left\langle A_{cap}\right\rangle = 10^{32}\ \text{cm}^2$, which is roughly ten orders of magnitude less than the cross-section of the galaxy $A_{cs} \sim \ell_G^2 = 10^{42}\ \text{cm}^2$.

To estimate the amount of normal matter and momentum transferred to the galaxy, we integrate the continuity and momentum equations over the volume of the galaxy confined by the cone with the solid angle $\text{d}\Omega = \sin\theta\,\text{d}\theta\,\text{d}\varphi$, where θ runs from zero to ℓ_G/r_G. *i.e.*:

$$\int_{Vol}\left(\frac{1}{\sqrt{-g}}\frac{\partial}{\partial t}\left(\sqrt{-g}\mathcal{D}\right)+\frac{1}{\sqrt{-g}}\frac{\partial}{\partial r}\sqrt{-g}\left(\mathcal{D}V\right)\right)\text{d}Vol = 0, \tag{13}$$

and where $V,\mathcal{D}$ are the transport velocity and relativistic density, *i.e.* the normal rest density times the Lorentz factor $u^t = 1/\left(g_{tt}+V^2 g_{rr}\right)$. Here $\sqrt{-g}\left(= r^2R^3\sin(\theta)/\sqrt{GW}\right)$ is the determinant of the metric.

The integration yields:

$$\frac{\delta\mathcal{M}}{\delta t}+\left(\dot{\mathcal{M}}_o-\dot{\mathcal{M}}_{in}\right)=0, \tag{14}$$

where $\delta\mathcal{M}, \dot{\mathcal{M}}_{in}\left(= A_{cone}^G\mathcal{D}V\right)$ and $\dot{\mathcal{M}}_o$ stand for the total mass absorbed by the galaxy, mass injection, and ejection rates, respectively. Note that as $r_G \gg r_p$, the spacetime surrounding G may be safely considered as flat.

Let us assume $\dot{\mathcal{M}}_o = \alpha\dot{\mathcal{M}}_{in}$, where $\alpha < 1$. For the above-mentioned galaxy with $A_{cap}^G/A_{cs} = 10^{-10}$, we obtain: $\alpha = 1-10^{-10}$.

In this case, the mass growth of the galaxy due to capturing of normal matter from the fireball reads:

$$\delta\mathcal{M} = \frac{(1-\alpha)\beta}{\sqrt{1-\beta^2}}\times t, \tag{15}$$

where $\beta = V/c$. Mass and time here are in units of $\mathcal{M}_p^{cone}$ and $\tau_d = r_p/c$, respectively.

Note that $\delta\mathcal{M} \le 1$, as the supply of normal matter is upper-limited by the progenitor's mass content inside the cone.

Prior to hitting by the fireball's matter, the galaxy with its locally curved spacetime, is assumed to be motionless with respect to $\mathcal{H}_0$, though embedded in an infinitely large flat spacetime. When the ultra-relativistically propagating matter from the fireball hits the galaxy, the transferred momentum is expected to set the galaxy into an outwardly accelerating motion.

Noting that the topology of the expanding spacetime embedding the fireball doesn't allow velocity-crossover of normal matter, *i.e.* $\nabla \cdot V > 0$, which also implies that the normal matter's particles may be considered as non-interacting or dust, and therefore the pressure gradient, $|\nabla P|$ may be safely neglected. In this case, the collision between the motionless galaxy and the incoming and captured matter of the fireball can be treated as an inelastic collision in a two-body system. Under these conditions, we may volume-integrate the momentum equation:

$$\begin{aligned} &\frac{1}{\sqrt{-g}}\frac{\partial}{\partial t}\left(\sqrt{-g}\mathcal{M}^r\right)+\frac{1}{R}\frac{1}{\sqrt{-g}}\frac{\partial}{\partial r}\left(\sqrt{-g}\mathcal{M}^r V\right) \\ &= -\frac{1}{R}\frac{\partial P}{\partial r}+\frac{\mathcal{M}^t}{2R}\left(g_{tt,r}+V^2 g_{rr,r}\right), \end{aligned} \tag{16}$$

where $\mathcal{M}^\sigma \left(\doteq \mathcal{D}hu^\sigma\right)$ and u^σ stand for the four-momenta and four-velocity in $\sigma = \{t, r, \theta, \varphi\}$ coordinates, respectively. h here is the enthalpy.

Requiring conservation of momentum and setting the second terms on the LHS and RHS to be equal, we obtain:

$$\begin{aligned} &\delta\mathcal{M}\beta_{in} + M_G \beta_G \overset{\nearrow 0}{} = \left(\delta\mathcal{M} + M_G\right)\beta_f \\ &\Rightarrow \beta_f = \left(\frac{\delta\mathcal{M}}{M_G + \delta\mathcal{M}}\right)\beta_{in}, \end{aligned} \tag{17}$$

where $\beta_{in}, \beta_G, \beta_f$ are the inflow velocity of normal matter through the left boundary of the galaxy (see Figure 5), the velocity of the galaxy prior collision, which is set to vanish, and the final combined velocity of the galaxy together with the captured matter. Inserting $\delta\mathcal{M}$ obtained from the equation of mass conservation, Equation (15), then the final expression of the escape velocity of the galaxy reads:

$$\frac{\beta_f}{\beta_{in}} = \frac{(1-\alpha)\dfrac{\beta}{\sqrt{1-\beta^2}}t}{M_G + (1-\alpha)\dfrac{\beta}{\sqrt{1-\beta^2}}t}. \tag{18}$$

Obviously, for any positive mass of a galaxy, $M_G > 0$, the causality condition is safely satisfied.

Based thereon, we show in Figure 6 the time-development of the velocity of the galaxy for different mass injection rates $\dot{\mathcal{F}} = (1-\alpha)\dfrac{\beta}{\sqrt{1-\beta^2}}$. With $(1-\alpha) \approx 10^{-10}$

in the present case, incident matter with high Lorentz factor sets the galaxy into an accelerating mode relatively early compared to those with low Lorentz factors, though the acceleration rate for such a distant galaxy remains almost constant. The duration of the rapid acceleration here is approximately $10^{10}\tau_{dyn} \approx 10^{6}$ yr, but it may even last much longer.

Consequently, motionless galaxies are capable of accelerating their outward-oriented motions from rest up to ultrarelativistic velocities, depending on the amount and duration of the injection rate.

3. Summary and Discussion

By means of GR-numerical calculations, the newly proposed $\mathcal{H}$-metric has been employed to study the time-evolution of the topology of spacetime embedding the progenitor of the BB. Prior to the explosion, the progenitor was levitating in an infinitely large spacetime.

The hypothesis here is that incompressible superconducting gluon-quark superfluids (SuSu-matter) with zero entropy are incapable of affecting the curvature of the embedding spacetime. Spacetime-matter coupling is established only in the presence of normal matter, *i.e.* compressible and dissipative one. In our case, this matter is created via a hadronization process through which SuSu-matter is converted into hadrons.

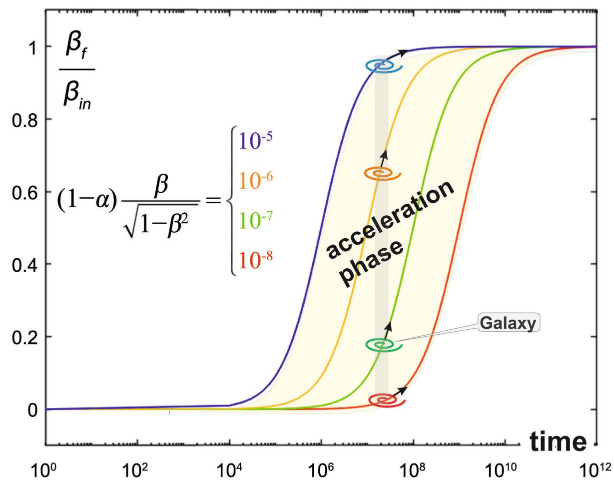

Figure 6. The time-development of the relative receding velocity, β_G of a remote, inactive, and motionless galaxy during the collision with normal matter from the expanding fireball having an ultrarelativistic incident velocity β_{in}. During the collision, mass and momentum are transferred to the galaxy, thereby triggering its outward acceleration, which in turn depends on the ejection rate of mass $\dot{\mathcal{F}} = (1-\alpha)\frac{\beta}{\sqrt{1-\beta^2}}$. Large $\dot{\mathcal{F}}$-values enforce the galaxy to start accelerating at relatively early times compared to low the $\dot{\mathcal{F}}$-values, though the rate of acceleration itself is constant for remote galaxies.

Our calculations confirm that during the hadronization process, the fireball forms a curved spacetime, whilst the newly created normal matter is jettisoned into the surrounding flat spacetime with ultrarelativistic velocities. The driving force here is ∇P, which remains constant during the hadronization process. ∇P is effective at the hadronization front only. The background of the here-calculated varying spacetime dictates that the velocity of outflowing particles satisfies $\nabla V > 0$, which forbids crossing over of particles, and therefore may be treated as non-interacting.

Our calculations also confirm that due to the finite mass of the progenitor, the spacetime embedding the fireball expands, and the enclosed spacetime flattens, thereby asymptotically converging into a flat spacetime.

We have argued that the surface of the progenitor is most appropriate for the hadron flash to run away and reach its center after roughly 46 minutes.

It is also shown that incompressibility in general relativity requires this type of matter to be embedded in flat spacetime, making the progenitor immune to collapse into a supermassive BH, even when the compactness parameter of order one. On the other hand, incompressibility and flatness ensure that the interior of the progenitor is perfectly homogenous and isotropic and that these properties must hold for at least 13.8 Gyr later.

It is also shown that in the absence of theoretical mechanisms, such as inflation, hadronizing the progenitor through a runaway hadron flash that starts precisely at the center of a $10^{24} M_{\odot}$ and not at $r = 0 \mp \varepsilon$, is a vague assertion that cannot be supported by observations. Among others, this approach implicitly prioritizes $r = 0$ as a special location, which must be imposed by an already existing spacetime of unknown topology, which embeds an object made of quantum matter of an unknown energy state.

Our scenario predicts the progenitor to have a measurable size and its explosion should have taken off in our neighborhood. Both the formation and explosion of a progenitor are neither invoked by extra forces nor singular events, but rather: they are vital parts in a universal life-cycle that occur from time to time sequentially or in parallel at the same and/or in different locations in our infinitely large, flat, homogeneous, and isotropic parent universe. In this life cycle, massive pulsars are born with embryonic SuSu-cores, which are set to grow in mass and dimension as pulsars cool down on the cosmic time scale and become old NSs. These in turn continue to cool down to finally metamorphose entirely into invisible Dark Energy Objects (DEOs). In our parent universe, DEOs have ample time to conglomerate into tight clusters, where they merge to form giant progenitors. At certain times, these progenitors decay and hadronize promptly enter promptly and end up forming fireballs. These in turn cool down via expansion, thereby giving rise to the formation of the first generation of stars, which subsequently collapse to form massive pulsars, and so the cosmic life cycle starts anew (see **Figure 7**).

In this paper, a new model for powering and accelerating high-redshift galaxies has been presented. Accordingly, through the collision of the BB-matter with

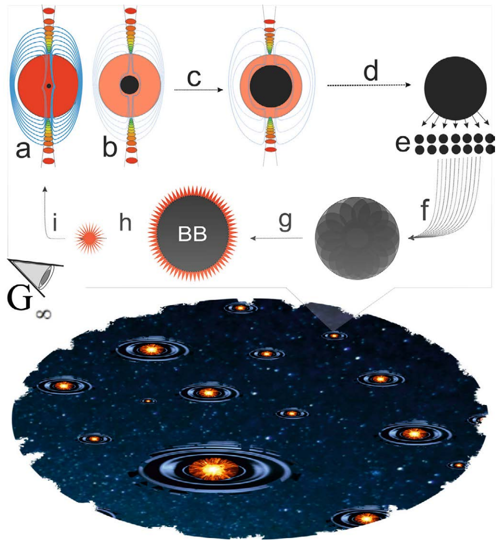

Figure 7. A schematic description of BB-life cycles in the multiverse scenario as seen by the supra-observer $\mathbf{G}_{\infty}$. Pulsars are born with embryonic cores made of incompressible SuSu-matter (a), they cool and grow in mass and dimension on the cosmic time (b, c), become invisible (d), conglomerate into clusters (e), merge and form BB-progenitors (f), they hadronize (g), new massive stars are generated (h), which then they collapse to form pulsars (i) and a new cycle starts anew.

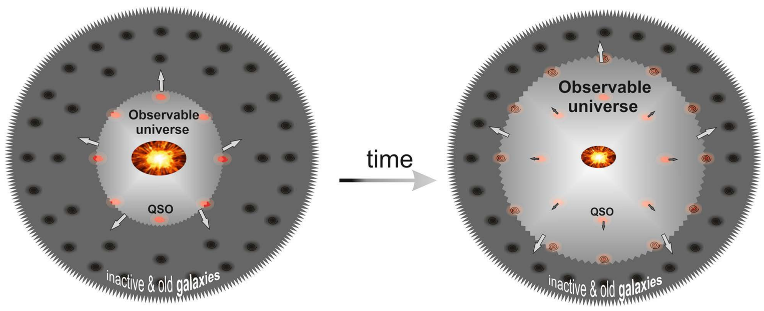

Figure 8. A schematic description of the time-development of the observable universe. When both the expanding fireball and the embedding spacetime hit old and inactive galaxies residing in the surrounding infinitely large and flat universe, they turn them o active modes, while the transferred mass and momentum set them into outward accelerating motions.

high-redshift galaxies, matter and momentum are transferred to the galaxy, which appears to be capable of turning these galaxies into active mode and setting them into outward accelerating motions. As a consequence, the distance between two arbitrary galaxies on the same line of sight relative to the observer $\mathcal{H}_0$, must increase with cosmic time (see **Figure 8**).

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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