Spherical Model of the Universe: From Quantum Fluctuation to the Present

Pavel Holub

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Abstract

This article presents the Spherical Model of the Universe (SMU) as a consistent and testable alternative to the standard cosmological model, ΛCDM [7]. The SMU describes the universe as an inhomogeneous, non-singular, spherically closed, energy-conservative, and cyclic system. The SMU explains the tension between $H_0 \approx 73$ and $H_0 \approx 67$ [1] as a logical consequence of this structure, rather than a measurement error. It thus shifts the problem from a "measurement error" to a "model error," which strongly supports the necessity of transitioning from the homogeneous ΛCDM to inhomogeneous models such as the SMU. The SMU alternative addresses the difficulties of ΛCDM by returning to Einstein's original methodological principles. Standard cosmological analysis is burdened by a circular argument (ΛCDM proves itself).

The cyclicity of the SMU is enabled by a fundamental principle: the outer event horizon (Φ-horizon) is defined by zero gravitational potential ($\Phi = 0$), ensuring the energy closure of the system. A key implication of this cyclicity is that it is impossible to distinguish whether our contemporary universe is the initiating phase or the n-th cycle of its evolution.

The SMU model assumes the existence of a pre-geometric structure that exists independently of matter, energy, and spacetime. In this phase, time, distance, and metric are not defined; there is no expansion or motion in the conventional sense. The structure represents only a set of permitted causal relations, not physical space.

1 Introduction

1.1 The Crisis of Standard Cosmology

The ΛCDM cosmological model [7], although exceptionally successful in describing a wide range of observations, faces growing conceptual and empirical problems.

1.1.1 Unknown Dominant Components

Dark matter (27%) and dark energy (68%) constitute 95% of the universe's content. Throughout four decades of increasingly sensitive experiments, not a single dark matter particle has been detected. The physical nature of dark energy remains entirely mysterious; vacuum energy calculations yield values 120 orders of magnitude higher than observed—considered one of the worst predictions in the history of physics [12].

1.1.2 Ad Hoc Model Additions

The model further requires ad hoc additions. Cosmic inflation necessitates a hypothetical scalar field (inflaton) with a carefully tuned potential. Dark energy reintroduces Einstein's cosmological constant Λ, which Einstein himself called his "greatest blunder," without explaining why it possesses its specific value.

1.1.3 Growing Observational Tensions

- **Hubble Tension:** Measurements of H_0 from different epochs (early vs. late universe) differ at the level of $\sim 5\text{˘}8\sigma$, representing a probability of random occurrence of less than 1:3,000,000. The latest JWST measurements confirm this tension and exclude the possibility of systematic errors in the original observations [3], [8].
- **JWST Observations:** Massive and morphologically mature galaxies at $z > 10$ contradict the hierarchical structure formation scenario. Discovered galaxies possess masses comparable to the Milky Way as early as 300–400 million years after the Big Bang, which is in significant conflict with ΛCDM predictions [4], [5].
- **CMB Anomalies:** The "Axis of Evil" (unexpected correlation of the quadrupole and octupole with the solar ecliptic), hemispherical temperature asymmetry, and the "Cold Spot" in the constellation Eridanus [7].
- **Evolution of Rotation Curves:** Declining in distant galaxies (high z) and flat in nearby ones (low z)—contradicting ΛCDM predictions, which expect early dark matter dominance [14].
- **The Singularity Problem:** Extrapolating the Friedmann equations into the past leads to an initial singularity with infinite density and temperature. Einstein himself considered singularities a sign that a theory had exceeded its limits of validity.
- **Evolving Dark Energy (DESI 2024–2025):** Breakthrough results from the Dark Energy Spectroscopic Instrument (DESI), based on the largest 3D map of the universe (15 million galaxies over 11 billion years), show $2.8\text{˘}4.2\sigma$ evidence that dark energy weakens over time. All three independent supernova catalogs (Pantheon Plus, Union3, DES Y5) converge on the same result [2]. This finding:
  - *Challenges ΛCDM:* The cosmological constant should be... constant.
  - *Supports SMU:* $\Lambda_{eff}(t)$ naturally weakens with the depletion of energy reserves of the central quark star.
  - *Suggests a cyclic universe:* The weakening of expansion may lead to a Big Crunch instead of a Big Freeze.

While the standard cosmological model encounters the problem of infinite density and temperature at $t = 0$, the SMU is, by principle, a non-singular model. It defines the initial state of the universe as a finite, physically describable object at the Planck scale.

2 The SMU Alternative: A Return to Physical Principles

The SMU addresses the aforementioned difficulties by returning to Einstein's original methodological principles—solving the field equations:

$$G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \tag{1}$$

for physically justified energy-momentum tensors and exploring alternative topologies without introducing unobserved fields or particles.

The SMU perceives the universe as a closed, spherical, and finite space. Its boundary has the character of the Planck length, denoted as the Φ-horizon, which remains constant throughout the entire axis of the universe's causal evolution. It is a universe closed by its own energy and gravity: where its gravitational wave reaches into the vacuum, space exists. Nowhere else.

2.1 Main Differences from ΛCDM

- **Topology:** Instead of the FLRW metric with the assumption of perfect homogeneity and isotropy, the SMU introduces spherical topology with gravitational gradients. The universe is a closed system bounded by a dynamic outer event horizon. FLRW is not rejected but understood as a local flattened approximation valid in the central baryonic region—much like Newtonian gravity approximates the Schwarzschild metric in a weak field.

- **Dynamic Schwarzschild Metric:** Geometry outside the central baryonic region is based on Schwarzschild-type solutions, but with a time-varying radius $r_{EH}(t)$ and a non-empty vacuum (an ocean of photons and neutrinos). The metric has the general form:

$$ds^2 = -g_{00}(r,t)c^2dt^2 + g_{rr}(r,t)dr^2 + r^2(d\theta^2 + \sin^2\theta d\phi^2) \tag{2}$$

  where the functions g_{00} and g_{rr} reflect the structure of the gravitational potential and are determined by solving Einstein's equations for the given distribution of energy and matter.

- **Known Physics Only:** Phenomena attributed to dark matter are explained by gravitationally selected neutrinos; "dark energy" arises as a geometric effect of the distribution of matter and radiation—an effective repulsive geometric term resulting from the 99% outer envelope, manifesting as non-trivial components of the Ricci tensor $R_{\mu\nu}$ not directly attributable to local $T_{\mu\nu}$.

- **Emergent Time:** A global time coordinate does not exist. Time emerges locally from the causal structure, and its flow varies dramatically according to the gravitational potential.

- **Finite, Non-singular Origin:** The universe did not begin with a singularity but with a Primordial Planckian Black Hole (PPBH) created by a quantum fluctuation—a configuration with extreme but finite density.

2.2 Philosophical Foundations

The SMU embodies Einstein's original vision:

- **Spacetime is not separate from matter:** Geometry emerges from the distribution of matter and energy. The energy released during hadronization (≈ 98%) literally created the spacetime structure in which we live.

- **Simplicity through known physics:** Instead of inventing dark sectors, it utilizes quarks, baryons, photons, neutrinos, and curved geometry—all experimentally verified components.

- **Singularities signify theory failure:** An origin in the form of a PPBH respects quantum-gravitational constraints at the Planck scale and avoids non-physical infinities.

2.3 Axiom of Global Energy Conservation

The universe (SMU) is considered a closed, globally conservative system whose total energy is zero:

$$E_{total} = E_{matter} + E_{radiation} + E_{gravity} = \text{zero} \tag{3}$$

Radiation is an independent positive component but remains compensated by gravity. Unlike ΛCDM, where dark energy with constant density in an increasing volume implies continuous creation of new energy, the SMU strictly conserves energy.

3 The Birth: Primordial Quantum Fluctuation

3.1 Quantum Fluctuation and the Emergence of PPBH

The Spherical Model of the Universe (SMU) is based on the assumption that the universe does not emerge from a singularity but from a single, exceptionally rare vacuum quantum fluctuation that creates a Primordial Planckian Black Hole (PPBH).

This is a perfectly spherical object of Planck size, whose Φ-horizon (gravitational potential horizon) determines where spacetime exists at all. Beyond this threshold, there is no metric, no space, and no time. The PPBH is not a singularity but a stable quantum-gravitational configuration of three quarks (u, u, d), whose gravitational potential is sufficient to create an event horizon on the order of the Planck length. This object represents the physical embryo of the future quark star.

In the first phase (BB1), the PPBH grows through fluctuation accretion until it reaches the state of a quark star. After reaching critical density and energy, a thermodynamic expansion occurs, coupled with hadronization (BB2), which creates the later universe. Both phases are continuous, without singularities or discontinuities.

The Heisenberg Uncertainty Principle:

$$\Delta E \Delta t \geq \frac{\hbar}{2} \tag{4}$$

allows for the emergence of an extreme energy fluctuation with a lifetime on the order of Planck time:

$$t_{Planck} \approx 5.4 \times 10^{-44}\,\mathrm{s} \tag{5}$$

In a rare instance, three quarks within a volume close to the Planck length arrange themselves into a configuration with a gravitational potential deep enough to create an event horizon with a radius:

$$r_s \approx l_{Planck} \tag{6}$$

A PPBH is formed—an object that:

- Has no external spacetime.
- Cannot radiate via the Hawking mechanism (there is nowhere to radiate to).
- Is perfectly spherical.
- Is not exposed to any external potential.
- Is stable due to absolute isolation from its surroundings.

3.2 Fundamental Axioms of SMU

SMU is a globally conservative system governed by two fundamental principles:

3.2.1 Zero Energy Axiom

The total energy of the system is zero:

$$E_{matter} + E_{grav} = 0 \tag{7}$$

The positive energy of matter is precisely compensated by the negative energy of the gravitational field. The growth of PPBH is therefore not the creation of new energy, but the gradual separation of two components of the same zero. Radiation is an independent positive component but remains compensated by gravity.

3.2.2 Zero Entropy Axiom

The initial state is a coherent quantum state with zero entropy:

$$S = 0 \tag{8}$$

The subsequent growth of entropy is always a local effect caused by decoherence in the newly emerging spacetime. The global entropy remains zero — the universe as a whole is reversible and cyclic.

3.2.3 Growth Dynamics at Zero Energy

A common objection to the growth of the universe from a fluctuation is the notion that an increase in mass (accretion) requires external energy input, which would violate the closure of the system. The SMU resolves this paradox via the principle of symmetric separation:

The growth of the PPBH and the subsequent expansion of the universe is not a process of creating new energy, but a process of increasing the amplitude between the positive component (matter/radiation) and the negative component (gravitational field).

$$\frac{d}{dt}(E_{matter} + E_{radiation} + E_{grav}) = \frac{d}{dt}(0) = 0 \tag{9}$$

Accretion of fluctuations from the vacuum thus does not increase the total energy of the system (which remains zero) but merely "polarizes" the vacuum into macroscopic scales. The universe is thus a system capable of generating complexity and dimension through the internal dynamics of a zero-energy balance, without requiring an external energy source or violating local conservation laws.

This concept is based to some extent on the hypothesis in the article by Edward P. Tryon (1973) - "Is the Universe a Vacuum Fluctuation?" [17], further Vilenkin (1982): "Creation of Universes from Nothing" [18] and Hartle & Hawking (1983): „Wave Function of the Universe“ [19].

3.3 Baryon Asymmetry Arising During Fluctuation Accretion

One of the greatest problems in standard cosmology is explaining baryon asymmetry [11], [15]. The SMU resolves it naturally without additional fields or phases. During the growth of the PPBH, baryon asymmetry is created automatically due to the combination of:

- One-sided accretion at the Φ-horizon.
- Absence of external spacetime.
- Real CP violation in the weak interaction [11].

3.3.1 Mechanism

The Φ-horizon is a quantum-uncertain boundary where virtual excitations arise. In a classical black hole, the pair would split ("one in, one out"). For a PPBH, however, "out" does not exist; only an inward direction exists. Therefore, every excitation has two possibilities:

1. Falling inward (accretion).
2. Immediate annihilation (reset to vacuum), because there is no geometry "outside."

Real CP violation causes a negligible but non-zero difference in capture probabilities:

- Baryonic excitations fall inward slightly more probably.

- Antibaryonic excitations slightly less so.

This difference is extremely small, but over a vast number of accretions, it leads to the observed asymmetry:

$$\eta \sim 6 \times 10^{-10} \tag{10}$$

There is no need for inflation or exotic mechanisms—asymmetry is a natural consequence of fluctuation accretion + CP violation + the absence of external spacetime.

3.4 Event Horizon and Φ-horizon

Within the SMU model, two mutually independent horizons exist, defining distinct physical regimes of the universe.

3.4.1 External Event Horizon (EEH)

The External Event Horizon is the "photon" horizon of the internal universe. It encloses the photon–baryon sphere, at the center of which was the quark star in the initial phase and the baryonic universe at present. The EEH restricts the escape of radiation and matter in the radial direction and ensures that energy emitted in deeper layers of the Central Entity remains causally bound to the internal universe. It is not an absolute barrier but a projection limit given by extreme gravitational time dilation.

3.4.2 Φ-horizon

The Φ-horizon is the boundary where the global gravitational potential of the system closes and where the reference level Φ_0 is defined. It does not separate a region "without physics" but marks the transition between the pre-geometric regime and the regime in which energy, time, and causal structure are defined. The Φ-horizon thus represents the fundamental energetic and causal limit of the universe, not a geometric boundary in the conventional sense.

3.5 Reverse Hawking Dynamics and One-Sided Growth

Hawking radiation requires external spacetime [10]. For the PPBH, however:

$$\Phi_{ext} = 0 \tag{11}$$

This means:

- There is nowhere to radiate to.
- Accretion is 100% one-sided.
- Variations of excitations always point inward.
- The horizon absorbs everything that can arise.

This process is not "reversed" Hawking radiation. However, it stems from the same quantum-field mechanism of excitation generation near the horizon, but with different boundary conditions and a reverse energy flow.

3.6 Avalanche Growth of the PPBH (Fluctuation Accretion)

Growth is exponential in the local time of the core but "infinitely slowed down" from the perspective of a future external observer. The Φ-horizon generates virtual excitations that are gravitationally accelerated and bring energy upon impact. Gravity "lends" energy to these excitations—its negative component deepens while the positive component accretes.

This process has three characteristics:

- **Autocatalysis:** Larger core → larger gravitational gradient → faster excitations → faster growth.
- **Full isolation:** No energy losses.
- **Causal limitation:** Growth is limited by the speed of information propagation within curved spacetime.

This creates the quark star.

3.7 Quark Hierarchy of the PPBH

The PPBH consists of quarks of all generations:

$$u, d \to s \to c \to b \to t \tag{12}$$

Higher generations have higher energy, shorter characteristic length, and higher density. The growth of the PPBH gradually activates higher levels, compressing the core and increasing its energy density. The PPBH is not a thermodynamic object—it radiates nothing, is perfectly closed, and grows only by accretion.

3.8 Formation of the Quark Star (Critical Planckian Phase)

Upon reaching the effective Planck density:

$$\rho \sim 10^{96}\,\mathrm{kg/m^3} \tag{13}$$

thermal energy begins to prevail over gravitational compression. Transitions of heavy quarks back to light u- and d-quarks cause:

- A rapid increase in volume.
- A sudden decrease in density.
- The formation of a corona.
- Long-term energy release ($\approx 98\%$).

3.9 Cessation of Fluctuation Accretion

For the PPBH to effectively accrete fluctuations from the vacuum, it must resonate with the vacuum frequency. Upon the formation of an active quark star, a massive flow of energy occurs, leading to dynamic changes in the gravitational potential and gravitational waves directed toward the Φ-horizon. The activity of the quark star (its hadronization) caused a phase transition of the Φ-horizon. It changed from an accretion attractor to a stochastically vibrating boundary. These vibrations (quantum uncertainty of the horizon position) effectively "disconnected" the universe from further systematic accretion from the vacuum. The universe became a closed system.

This ends fluctuation accretion. The quark star enters a long-term expansion phase governed by thermodynamics and relativity.

3.10 The Role of the Φ-horizon at Present

There likely exists persistent sporadic accretion of fluctuations at the Φ-horizon, which may be the source of Ultra-High-Energy Cosmic Rays (UHECR). The absolute gravitational potential of the universe leads to extreme blueshift. A particle/photon gains an enormous blueshift while falling into the central baryonic sphere. This mechanism explains UHECRs with energies $> 10^{20}$ eV without the need for supernova accelerators, as the EH/Φ-horizon functions as a natural accelerator in curved spacetime.

4 The Quark Star: Configuration of Maximum Density and Initiation of Evolution

4.1 Accumulation of Quark-Gluon Plasma

Through accretion, the PPBH accumulates quarks from vacuum quantum fluctuations. These particles create a quark-gluon plasma (QGP)—a state in which quarks and gluons are deconfined, meaning they are not bound in hadrons but move freely.

The energy and density of this plasma correspond to:

$$\epsilon_{QCD} \sim 1\text{˘}10\,\mathrm{GeV/fm^3} \approx 10^{18}\text{˘}10^{19}\,\mathrm{kg/m^3} \tag{14}$$

and temperatures:

$$T \gg \Lambda_{QCD} \approx 200\,\mathrm{MeV} \approx 2 \times 10^{12}\,\mathrm{K} \tag{15}$$

Under these conditions, the strong coupling constant α_s decreases (the effect of asymptotic freedom), so quarks behave almost as free particles.

4.1.1 Experimental Confirmation of QGP

QGP has been experimentally created in laboratories (CERN, RHIC, LHC). It is critical to emphasize that quark-gluon plasma behaves as a nearly perfect fluid, not as a gas of free quarks. This behavior suggests that strong collective interactions exist even in QGP, which has a direct impact on the dynamics within the Quark Star [6], [9].

4.2 Supersaturation with Heavy Quarks: Energy Reserve

Upon reaching maximum density, the quark star contains all quark flavors, including the heaviest.

4.2.1 The Top Quark: Key to Massive Energy

The presence of top quarks signifies an enormous reserve of potential energy. Under normal conditions, these quarks are extremely unstable ($t \to b + W^+$). The top quark is the only quark that decays before it can hadronize because its lifetime ($\tau_t \approx 5 \times 10^{-25}$ s) is shorter than the characteristic time of the strong interaction ($\sim 2.5 \times 10^{-24}$ s).

4.2.2 Supersaturation in Extreme Density (Decay Slowdown Mechanism)

In the extreme density of the QGP, the lifetime of unstable quarks can be significantly extended, allowing for temporary supersaturation with heavy flavors. This extension is caused by two relativistic effects:

- **Pauli Blocking:** High fermionic density prevents quarks with lighter flavors (especially u and d), which would otherwise arise from the decay of heavy quarks, from occupying already occupied energy states. This dramatically reduces the available phase space for decay.

- **Altered Decay Kinematics:** Relativistic and thermal effects in the dense plasma change the effective mass and energy of particles, leading to a deceleration of the decay rate (this involves the weak interaction), effectively extending the lifetime of the top quark.

This extension of lifetime is crucial for the SMU—it enables the accumulation of a massive energy reserve in the PPBH, which is then explosively released during Hadronization.

4.3 Energetic Hierarchy in Quark Decays

The mass hierarchy of quarks represents a repository of potential energy. When the star begins to cool and hadronize, heavy quarks gradually decay in a complex cascade process:

- $t \to b + W^+$ (releases ≈ 169 GeV)
- $b \to c + W^-$ (releases ≈ 2.9 GeV)
- $c \to s + W^+$ (releases ≈ 1.2 GeV)
- $s \to u/d + W^-$ (releases ≈ 90 MeV)

W and Z bosons subsequently decay into leptons (electrons, muons, neutrinos) and photons. Light quarks (u, d) are stable—as no lighter quark exists and the baryon number is conserved. From these, protons (uud) and neutrons (udd) are formed—permanent baryonic structures [21].

4.4 Dynamic Quark Star and Hadronization

4.4.1 Structure of the Dynamic Quark Star

The moment the PPBH grows to critical mass via accretion, the central region reaches limit density and becomes a Dynamic Quark Star. This entity is a thermodynamically unstable QGP system with the structure:

- **Core:** Region of maximum density and temperature. It stores the vast majority of total energy before the initiation of hadronization.
- **Periphery (Hadronization Front):** The peripheral layer where density and temperature drop. Here, critical thermodynamic conditions are first reached, triggering the fusion of quarks into more stable hadrons.
- **Corona:** Plasma above the star's surface where nucleosynthesis occurs.

4.4.2 Hadronization and Dynamic Global Volume Burn-up

Reaching critical thermodynamic conditions triggers an avalanche process that can be described as the burn-up of the Quark Star via hadronization across its entire volume.

- **Phase Transformation of Quarks and Energy Emission (98%):** The core undergoes a phase transition, releasing $\approx 98\%$ of the original energy, primarily in the form of neutrinos (ν) and photons (γ).
- **Origin of the CMB – Coronary Nucleosynthesis (CMB Photosphere):** The process of photon release and the origin of the CMB is divided into two causally linked phases:
    1. Internal Hadronization ($T \approx 10^{12}$ K): Creates a turbulent field of hadrons and photons transported outward.

2. Coronary Nucleosynthesis (PHOTOSPHERE): The coronary atmosphere is the location where the temperature has dropped below the hadronization threshold but remains high enough for effective nucleosynthesis ($\approx 10^9$ K). This coronary zone is the actual source of CMB photons. It functions as a radiating front (photosphere) whose initial temperature is orders of magnitude higher than in ΛCDM.

The consequence is that the Cosmic Microwave Background (CMB) is not an event 380,000 years old, but a permanent, dynamic phenomenon—a "live stream" of decoupling occurring on the quark star.

- **Permanent Gravitational Stability (Irradiatable Foundation):** After hadronization, the remaining $\approx 1\%$ of energy stabilizes into hadrons formed by stable u and d quarks. These quarks represent:
  - A non-radiatable form of matter (energy minimum, cannot decay further).
  - A permanent Gravitational Foundation that prevents the complete conversion of the system into radiation. The central compact entity of the SMU is therefore thermodynamically stable and cannot evaporate (violating the semi-classical prediction of Hawking radiation).

4.4.3 Recombination and Homogeneous Condensation

During expansion, the recombination of electrons with nuclei occurs, which in the SMU is the thermodynamic and gravitational phase of Matter Condensation (1%), completing the transformation of the Quark Star into the volume of our observable baryonic universe.

- **Role of Radiation Pressure (Homogeneity):** In this critical phase (recombination), temporary gravitational isotropy occurs. The 1% of baryonic matter is surrounded by a massive and isotropic flow of energy released from Hadronization (neutrinos and photons, $\approx 98\%$ of energy). This massive energy flow generates strong radiation pressure that temporarily suppresses the gravitational gradient of the central core.
- **Near-Weightless State:** A state approaching weightlessness (relative to the whole system) arises, where the net gravitational force is significantly reduced. This is an essential condition for the homogeneous and isotropic distribution of baryonic matter, which subsequently condenses not according to central gravity, but according to local thermodynamic conditions.
- **Causality:** The recombination phase occurs causally after the CMB emission event. The recombination phase (formation of neutral atoms $\approx 1\%$ of energy) is no longer the source of the Cosmic Microwave Background.

4.5 Energy Balance: Decay and Foundation Formation

During hadronization and the decay of heavy quarks, an enormous amount of energy is released. This energy is released in two thermodynamically distinct phases (QCD and EM), which sum into the total radiative outflow.

4.5.1 Energy Allocation

The total original energy accumulated in the Quark Star (E_{total}) is allocated as follows: Key Clarification: This $\approx 99\%$ is the total energy released into space. It is composed of the vast majority from primary burn-up ($\approx 98\%$) plus the final, causally later release of energy associated with recombination ($\approx 1\%$).

4.5.2 Estimate of the 1% Share from QCD Thermodynamics

The stabilized share ($\approx 1\%$) represents "frozen" energy—it is permanently trapped in the rest mass of baryons, as lighter quarks can no longer decay. Baryonic matter is thus a stable, non-radiatable component of the universe.

The estimate follows from QCD thermodynamics and is based on the energy hierarchy:

- Binding energy per nucleon ≈ 930 MeV.
- Total energy released during nucleon formation (decay of heavy quarks and binding energy) $\approx$ several GeV (on the order of 10 GeV).
- $\Rightarrow$ Ratio $E_{stabilized} : E_{total} \approx 1 : 100$.

4.5.3 Energy Conservation and Closed System

The total energy of the universe is conserved and equal to zero (considering gravitational potential):

$$E_{total} = E_{baryons} + E_{radiation} + E_{gravity} = 0 \tag{16}$$

Unlike ΛCDM, the universe in the SMU is a closed system (bounded by the external event horizon), and thus without energy losses. The entire evolution of the system is the transformation of energy from an accumulated form (heavy quarks) into free forms (neutrinos, photons) and stable forms (baryons).

5 Processes After Quark Star Emission: Dynamics and Thermodynamics

5.1 Transition from the Quark to the Baryonic Universe

When the temperature of the quark star drops to the threshold value of the QCD transition ($T_c \approx 2 \times 10^{12}$ K), a rapid transformation of the matter structure occurs. Deconfined quarks combine into stable baryons (protons and neutrons) and mesons. The critical temperature $T_c \approx 150\text{˘}175$ MeV has been confirmed by lattice QCD simulations.

This process is immensely exothermic – a sudden release of residual strong interaction energy occurs. The energy output is estimated at:

$$E_{release} \sim 10^{68}\text{˘}10^{69}\,\text{J} \quad (18) \tag{17}$$

which corresponds to the total radiative energy of the visible universe. Unlike the classical conception of the "Big Bang" as the beginning of the expansion of space, the SMU interprets this event as a phase transition within an already existing structure – the quark star, which has reached a critical density point.

5.2 "Radiant Wave" – Causal Sequence and Dynamic Expansion

The Radiant Wave is a massive, yet continuously occurring emission of energy that causally follows the attainment of critical density. At the moment of the phase transition, most of the matter is converted into photons and neutrinos. In the quark environment, this radiation propagates extremely slowly due to high opacity (the mean free path of a photon in QGP is on the order of ~ 1 fm).

5.2.1 Sequence of Subsequent Phases

The process of transforming the entire volume of the Quark Star into baryonic matter occurs in sequential, overlapping phases (Hadronization, Nucleosynthesis). These phases form a continuous thermodynamic gradient. Recombination/Condensation of Matter is the final phase, which occurred relatively faster, not due to a small amount of released energy, but as a result of massive adiabatic expansion. The preceding outflow of energy (Radiant Wave) caused a rapid expansion of spacetime, leading to a sudden drop in temperature and density. Baryonic matter thus found itself in a supercooled environment, forcing an immediate and widespread phase transition into neutral atoms.

5.2.2 Thermodynamics and Geometric Cooling

The dynamics of the process are governed by complex feedback between energy flow and spacetime geometry:

- **Thermal Expansion and Cooling:** The extreme heat released by hadronization causes massive thermal expansion of the entire volume of the Quark Star. This adiabatic expansion is one of the primary cooling elements.
- **Spacetime Expansion (Gravitational Influence of Radiation):** The radiated energy (98% photons and neutrinos) leaving the system dynamically influences the local metric. This energy outflow represents effective negative pressure in Einstein's equations, leading to the expansion of spacetime in the vicinity of baryonic matter. The gravitational influence of the radiated energy thus functions as a repulsive force (the geometric equivalent of Dark Energy), further supporting expansion.
- **Primary Cooling (Neutrinos):** Neutrinos represent the main cooling element of the entire system. Unlike photons, which are repeatedly scattered in the early phases, neutrinos escape almost freely due to their weak interaction, effectively carrying energy away from the core.
- **Gravitational Fractionation of Neutrinos (Formation of a Neutrino Core):** Neutrino emission is not homogeneous; natural gravitational separation occurs based on mass:
  - **Heavy Neutrinos:** This "first wave" of particles with higher rest mass loses kinetic energy more quickly when climbing out of the deep gravitational well. They do not reach the outer regions of expansion but soon turn back and sediment in the center. They thus create an invisible, gravitationally stable "neutrino halo" (rest core) merging with baryonic matter. In the SMU, this is the equivalent of Cold Dark Matter (CDM).
  - **Light Neutrinos:** Particles with lower mass maintain relativistic speeds and escape to distant spheres, where they contribute to the global geometric pressure Λ_{eff}.

5.2.3 Dynamic Energy Exchange and Redshift/Blueshift

The causal sequence of events in the SMU involves a complex exchange of energy between radiated photons and the spacetime metric:

- **Energy Loss (Redshift/Expansion):** During their journey, photons effectively transfer their energy to the spacetime metric (performing work against gravity), which manifests as their gravitational redshift. This energy transfer directly drives the geometric expansion of the entire system.

- **Feedback and Energy Gain (Blueshift):** Photons returning to the center or remaining in regions with higher potential regain a small fraction of energy (blueshift). This dynamic equilibrium between redshift and blueshift is key to long-term thermodynamic stability and manifests as homogeneous and isotropic expansion.

5.2.4 Causal Sequence and Gravitational Dilation

The final process of matter condensation is not globally synchronous. The extreme time dilation caused by the gravitational potential of the Quark Star ensures that an event that occurred almost instantaneously in the Quark Star's own causal time is perceived by an external observer (us) as the expansion of the universe lasting billions of years.

5.3 Corresponding Metric: Dynamic Schwarzschild-de Sitter

5.3.1 Original Metric and its Limitations

The dynamics of hadronization burn-up are best described by solving Einstein's field equations for a non-empty dynamic environment. The classical Schwarzschild metric (r_s is constant) is unsuitable because the SMU contains 99% of its energy in the form of dynamic radiation outside the central mass. Instead, the SMU requires a dynamic metric form where:

- **Gravitational Parameter Decrease:** The central mass parameter $r_s(t)$ decreases over time due to energy emission.

$$r_s(t) = \frac{2GM(t)}{c^2}, \quad \frac{dM(t)}{dt} < 0 \quad (19) \tag{18}$$

- **Repulsive Term Dominance (Expansion):** The metric must contain a dynamic term $\Lambda_{eff}(t)$ reflecting the pressure of radiated energy and thermal expansion.

5.3.2 Formal Notation of the Metric

The dynamics are conceptually best reflected by a Schwarzschild-de Sitter type metric with time-varying parameters:

$$ds^2 = -\left(1 - \frac{r_s(t)}{r} - \frac{\Lambda_{eff}(t)r^2}{3}\right)c^2dt^2 + \left(1 - \frac{r_s(t)}{r} - \frac{\Lambda_{eff}(t)r^2}{3}\right)^{-1}dr^2 + r^2d\Omega^2 \quad (20) \tag{19}$$

This geometric effect $\Lambda_{eff}(t)$ naturally weakens with the depletion of energy reserves in the Central Entity (Dynamic Quark Star), which is precisely in accordance with recent observations from DESI 2024 [2].

5.3.3 FLRW Approximation

If the metric tensor describing this dynamics is expanded for small ratios of radial delay and expansion (which holds in our local, condensed volume), we obtain metrics of the FLRW type, which standard cosmology uses as an approximation. The SMU thus naturally explains the observed local homogeneity and isotropy without the need to introduce an inflationary phase.

5.4 Physical Interpretation of Expansion and the Role of the Cosmic Microwave Background (CMB)

From the perspective of the SMU, the expansion of the Universe is not the growth of space itself into an external environment, but a geometric manifestation of the dynamics of the Central Entity. Expansion as we observe it is the causal result of two overlapping phenomena:

5.4.1 Decrease in Central Gravitational Potential

The gradual loss of mass/energy ($\approx$ 98% through burn-up) leads to a decrease in the central mass parameter ($r_s(t)$) and a weakening of the gravitational influence. The weakening of central gravity releases the "constriction" effect on spacetime.

$$\frac{dr_s}{dt} = \frac{2G}{c^2}\frac{dM(t)}{dt} < 0 \quad (21) \tag{20}$$

Example: A decrease in r_s even by small orders (meters) has a massive influence on the metric and time dilation in the vicinity, and thus on the perceived expansion rate.

5.4.2 Expansion Energy Pressure (Λ_{eff})

Radiated energy (photons and neutrinos) dynamically influences the metric, acting as a geometric repulsive force (pressure) on baryonic matter. This effect causes the stretching and dilation of spacetime in the surroundings. This effect is formally equivalent to the de Sitter term in the metric, but in the SMU, it has a physical origin in the radiation flow (negative pressure of radiative energy), not in vacuum energy (the cosmological constant).

5.4.3 CMB as a Mediator of the Present (Live Stream)

The CMB is a critical mediator in the SMU, connecting the slow internal time of the Center with the fast external time (our local frame). Every moment we observe is heavily distorted by gravitational time dilation.

CMB as a "Live Stream": The CMB is not a relic event from the past but a causally delayed image of currently ongoing thermodynamic processes (hadronization and nucleosynthesis) in the coronary atmosphere of the quark star.

5.5 CMB within the SMU as a Projection of Ongoing Processes and Gravitational Redshift

In the SMU model, the cosmic microwave background (CMB) is not a fossil relic of a one-time event. It represents a projection of ongoing thermodynamic processes – specifically hadronization and nucleosynthesis – which still continue in the coronary atmosphere of the quark star. What we register as a nearly isothermal microwave field is an extremely gravitationally redshifted and frequency-unified signal (at the EH) of contemporary quark-hadron processes.

This is a fundamental difference from ΛCDM: the CMB is not a "photo from the past," but a "live stream" extremely slowed by gravitational dilation.

5.5.1 Quantum Causality of the Photon

From the perspective of the SMU, a photon is causally linked by a single null geodesic from its origin to its detection.

- **Zero Proper Time:** For a photon, no proper time exists ($d\tau = 0$). Its journey from emission in the coronary layer through the Outer Event Horizon (r_{EH}) to the detector occurred in zero proper length.
- **Geometric Effect:** The delay and lag perceived by an external observer (billions of years) are not properties of the photon – they are geometric effects of gravitational dilation and extreme curvature of space.

5.5.2 Photon Trajectory in SMU Geometry

Within the dynamic geometry of the SMU, the photon trajectory is understood as a path from the coronary atmosphere toward the Outer Event Horizon r_{EH}, where the photon experiences maximum coordinate time dilation, and subsequent "emergence" back into less curved space. This energetic degeneracy is not an interaction with a plasma mixture – it is purely geometric.

5.5.3 Temperature Disparity: CMB as Redshifted Hadronization Radiation

Source and Emission Temperature: Photons observed today as $T_{obs} \approx 2.725$ K are emitted in the region where hadronization of the quark field and nucleosynthesis in the coronary atmosphere of the quark star take place, at temperatures around:

$$T_{emit} \approx 10^9\,\mathrm{K} \quad (22) \tag{21}$$

This is 6 orders of magnitude higher than $T_{emit} \approx 3000$ K in ΛCDM (recombination). The SMU predicts an extremely large gravitational redshift.

Geometric Transformation of Temperature: Temperature is transformed by a dilation factor corresponding to the ratio of the gravitational potential at the emission site r_{emit}:

$$T_{obs} = T_{emit}\sqrt{1 - \frac{r_s}{r_{emit}}} \quad (23) \tag{22}$$

For the SMU, the dilation factor corresponds to:

$$\sqrt{1 - r_s/r_{emit}} \approx 2.7 \times 10^{-9} \quad (24) \tag{23}$$

This extremely small factor confirms that:

- We still "see" the coronary emission from regions just above the original event horizon.
- Gravitational redshift is fully compatible with the low-temperature uniformity of the CMB.
- Hadronization processes are projected by gravitational geometry into the microwave band.

Gravitational Redshift (Complete Form): In the dynamic SMU system, where central mass $M(t)$ decreases through radiation, we must account for the instantaneous gravitational potential at the moment of emission (t_e) and detection (t_o) and the change in metric during the photon's flight.

$$1 + z(r,t) \approx \frac{1}{\sqrt{1 - \frac{2GM(t_{emit})}{r_{emit}c^2}}} \cdot D(t) \quad (25) \tag{24}$$

Where $D(t)$ is the dynamic factor of the metric reflecting the change in $M(t)$ and $r_s(t)$ during the photon's flight. It accounts for the photon leaving a gravitational well that "shallows" over time; nonetheless, the extreme potential at emission time t_{emit} remains the dominant component.

5.5.4 Consequence for CMB Anisotropy

Observed temperature fluctuations of the relic radiation

$$\frac{\Delta T}{T} \approx 10^{-5} \quad (26) \tag{25}$$

are not, within the SMU, a direct image of the original hadronization structure or the fine dynamics near the quark star. It is not a relic "photograph" of the early phase of the universe, but a projection image of energy that passed through strongly curved spacetime.

On the path to the EEH, unification of excitation energy occurs. Energetically richer modes lose a larger portion of their energy during projection than lighter modes, leading to significant homogenization of the spectrum. The resulting anisotropy thus does not reflect the actual amplitude range of the original irregularities.

Observed fluctuations are induced by interactions in an environment of significant time shift within the entirely changed environment of the photon and resultant baryonic sphere from the EEH to the observer. CMB anisotropy thus represents an "X-ray image" of the subsequent stage – the stage of photon return, the stage of the baryonic universe.

The energetic unification of excitations during projection across horizons concerns their frequency and amplitude components, not the internal polarization structure. Photon polarization arises in the extremely dynamic environment of the quark star corona, where strong magnetic fields, rotational currents, and parity-violating processes act. The E- and B-modes of the relic radiation are therefore, within the SMU, a direct imprint of these high-energy events, projectively transferred into the observable universe through curved spacetime.

5.5.5 Explanation of the CMB Dipole

The observed CMB dipole can be interpreted within the SMU as a result of two main factors that break spherical symmetry:

- **Observer Position:** The dipole is a consequence of our position outside the exact center of the Central Entity (Quark Star). Given the massive dimensions of the system, even a slight displacement leads to an observable gradient in T_{obs}.
- **Gravitational Waves:** The dipole may be the result of deflected spherical gravitational waves of the entire dynamic system, which disrupt isotropy in the distribution of radiation pressure.

This concept is radically different from the standard model, where the CMB is a "photograph" from the time of recombination ($\sim 380,000$ years). In the SMU, the CMB is a continuous process observed with extreme time dilation.

5.6 Primordial Magnetic Fields (PMF)

Cosmic magnetic fields represent one of the oldest and most persistent structures in the Universe. Their origin has long remained unclear: whether they arose only during the formation of the first stars (astrophysical processes) or whether they existed earlier, in the first moments after Hadronization.

Recent experimental and theoretical work (e.g., CERN – Oxford University) suggests that magnetism could have arisen spontaneously from electrical fluctuations in the early plasma. This conclusion is fully consistent with the Spherical Model of the Universe (SMU), which thus offers a physically natural explanation for PMF.

5.6.1 Mechanism of PMF Origin Within the SMU

Under the conditions of Quark Star Hadronization, charge separation occurs – free electrons and protons cease to be mutually bound in the deconfined plasma. In this turbulent, radially symmetric, but energetically dynamic system, strong density gradients ($\nabla\rho$) and temperature gradients (∇T) induce:

- **Local Electrical Currents (J):** These currents are generated as a result of charge separation and plasma motion in strong gravitational and temperature gradients (analogous to the Biermann battery):

$$J = \sigma E + \frac{\nabla p_e \times \nabla n_e}{e n_e^2} \quad (27) \tag{26}$$

where σ is conductivity, E the electric field, p_e electron pressure, and n_e electron density. In QGP, conductivity is extremely high ($\sigma \sim 10^{22}$ S/m), allowing for effective generation of magnetic fields.

- **Magnetic Field Generation (B):** The emergence of magnetic fields is a direct result of these local currents according to the Ampère-Maxwell equation:

$$\nabla \times B = \mu_0 J + \mu_0 \epsilon_0 \frac{\partial E}{\partial t} \quad (28) \tag{27}$$

Since the SMU assumes a spherically symmetric but energetically dynamic system, internal current loops arise that conserve total electrical neutrality on a global scale but locally generate ubiquitous magnetic fields. This process is a natural consequence of Hadronization dynamics – the magnetic field is not a side effect, but a fundamental manifestation of energy release and charge separation in strongly curved spacetime.

5.6.2 Testable Predictions of PMF in the SMU

The SMU predicts a specific structure of primordial magnetic fields open to verification by future experiments:

- **Homogeneous Distribution:** PMF should be statistically homogeneous on large scales ($>$ 100 Mpc), but with local fluctuations corresponding to turbulence at the hadronization front.
- **Correlation with CMB Anisotropies:** Magnetic fields should leave traces in CMB polarization (B-modes) that are not caused by gravitational waves.
- **Intensity vs. Redshift:** The SMU predicts a specific $B(z)$ profile, which should be verifiable using the SKA (Square Kilometre Array) [22].

5.7 Gravitational Equivalence of Energy and Space

In the SMU model, the creation of space is understood as a geometric consequence of energy conversion. When 99% of energy converts into radiation (photons and neutrinos), the gravitational potential in the center weakens and space "releases" (dilates).

This relationship can be understood as a direct proportion between volume expansion and the flow of radiative energy:

$$\frac{dV}{dt} \propto \frac{dE_{radiation}}{dt} \quad (29) \tag{28}$$

In other words: the expansion of space is a direct geometric consequence of the release of radiative energy from the quark core. This is an alternative to the Friedmann equation $H(t)$. In the SMU, expansion is not parameterized by a scale factor $a(t)$, but directly by the dynamics of the radiative flux (geometric pressure $\Lambda_{eff}(t)$). The universe does not expand by itself but is "expanded" by energy propagating outward from the core.

5.8 Cyclic Aspect of the Universe

Because the event of hadronization and energy release from the deeper layers of the quark star occurred in its own (internal) time as a causally closed process, while its consequences reach the observer with extreme time delay, the universe cannot be understood as a one-time "fired" explosion.

5.8.1 Connection with DESI 2024

The observed weakening of the dark energy effect at a level of approximately $2.8\check{}4.2\sigma$ [2] can be interpreted within the SMU as a sign of the approaching end of the dominant projective expansion phase and a possible reversal of evolution.

In the vocabulary of the standard cosmological model, this corresponds to a decrease in the influence of dark energy and a relative increase in the gravitational role of matter. Formally speaking, the ratio:

$$\Omega_{DM}/\Omega_{\Lambda} \quad (30) \tag{29}$$

increases, without the need to assume a change in the total amount of matter or energy in the universe.

6 Geometry and Topology of the Universe

The SMU model describes the universe as a globally closed system with a finite spacetime topology. Its "sphericity" does not correspond to a surface geometry embedded in a higher-dimensional space but follows directly from the global structure of the gravitational potential, originally formed by the Central Entity (quark star) and subsequently by the distribution of matter and energy throughout the universe.

The geometry of spacetime is determined by the radially symmetric distribution of this potential, which defines natural causal layers and global curvature. Spherical topology here is not a geometric object in the conventional sense, but an emergent property of the metric arising from the concentration of mass and energy.

The universe is thus finite, not as a "volume bounded by a border," but as a causally closed whole in which global temporal and spatial distances are limited by the structure of the gravitational field.

6.1 Spherical Topology

The SMU describes the universe as a globally closed system. Sphericity is an emergent property of the metric arising from the radially symmetric distribution of gravitational potential.

From this follows:

- Space is finite but has no physical boundary.
- No external spacetime exists beyond the Φ-horizon.
- Distances and time are defined only in regions with non-zero gravitational potential.
- The entire universe exists as a causally closed entity defined by the structure of the gravitational field.

6.2 The Φ-horizon as the Boundary of Spacetime Existence

The universe has no boundary in the classical geometric sense. It has a Φ-horizon — the point where the gravitational potential drops to the minimum possible quantum value, below which no spacetime can be defined. It is a "boundary of existence."

Beyond the Φ-horizon:

- There is no space.
- Time does not exist.
- There are no degrees of freedom.

The Φ-horizon remains Planck-thin, as the minimum excitation of the vacuum corresponds to a wavelength near the Planck length:

$$\ell_P \approx 1.6 \times 10^{-35}\,\text{m} \quad (31) \tag{30}$$

This implies that the entire universe expands internally into many gigaparsecs, while its outer boundary of existence remains Planck-small. In this sense, the universe is an "inside-out sphere."

6.3 Dynamic Sphericity

The symmetry of the universe stems from the fact that the gravitational potential of a single compact, non-rotating object is always spherically symmetric.

- Central compact quark star → Source of potential Φ.
- Φ-horizon → Boundary where potential vanishes into a quantum zero.

6.4 Topological Consequences

6.4.1 No Singularities

The potential Φ never reaches a true divergence. Instead of a singularity, there is a quark core with extreme but finite compression.

6.4.2 Non-existence of Infinite Volumes

Space exists only where $\Phi \neq 0$. The universe is finite but without a "wall."

6.4.3 Natural Cyclicity

The cycle (expansion → density drop → gravitational dominance → collapse → quark phase) is a consequence of the geometry and energy balance itself.

6.4.4 Time as a Gradient of Potential Φ

Time flows slower at the center (deep Φ well) and accelerates toward the Φ-horizon.

6.5 Orbital Stratification of Photons and Neutrinos

The Radiant Sphere — composed of photons and neutrino flows — is a key stabilizing element.

6.5.1 The Radiant Sphere as a Gravitational Trap

In the gravitational field of a quark star, there is a region (analogous to the photon sphere at $1.5\,r_s$) where particles with non-zero tangential momentum can be "trapped" in metastable orbital levels.

6.5.2 Interactions within the Radiative Sphere

The high density of photons and neutrinos leads to several well-known interaction mechanisms that influence the long-term dynamics of the orbital layers:

- Light-by-light scattering (γ–γ scattering): A process confirmed by the LHC (CMS, ATLAS) [16], [23]. Consequence: slow directional diffusion of photons → stabilization of layer isotropy.

- Pair production (Breit–Wheeler): When two photons possess sufficient energy, an e^+e^- pair is created. Consequence: conversion of high-energy states into lower ones → thermalization of the radiative sphere [24].
- Neutrino interactions (ν–ν via Z^0): In environments with high neutrino density, weak directional scattering occurs. Consequence: isotropization of neutrino currents.[25]
- Neutrino–photon interactions via magnetic moment: Extremely weak, yet cumulative over long time scales [26].

6.5.3 Mechanism of Orbital Stratification

From a physical perspective, orbital layers arise because:

- Both photons and neutrinos escaping from the baryonic region possess non-zero tangential momentum – even in a nearly radial ascent, the momentum is not exactly zero.
- The curvature of the metric creates effective potential barriers – particles are temporarily trapped in metastable levels.
- The radiant energy density is sufficient for scattering – γ–γ, γ–ν, and ν–ν processes smooth out anisotropy.

The result is a photon-neutrino corona, structurally similar to a stellar atmosphere, but without counter-pressure:

- Photons and neutrinos radiate from the center,
- A portion of them enters metastable orbits,
- Interactions scatter them,
- Gravity retains them within the orbital layer,
- They gradually redshift and decrease in energy.

6.5.4 Physical Role of Orbital Layers

Orbital stratification fulfills several fundamental functions:

- Stabilization of spherical symmetry: Scattering processes smooth out local fluctuations and non-uniformities; the result is isotropic pressure within the radiative sphere.
- Spacetime regulation near the horizon: The radiation layer acts as a "geometric reinforcement" that helps maintain: continuity of curvature, absence of singularity, a spherical potential gradient.
- Geometric stabilization: A naturally wide layer of photons/neutrinos arises between the baryonic core and the Φ-horizon, which: dampens local anisotropies, provides isotropic radiation pressure, stabilizes the global metric.

6.5.5 Testable Predictions of SMU

The layers of orbital stratification leave measurable traces:

- Fine anisotropies in the CMB: Orbital layers create characteristic patterns in multipoles $\ell \approx 1000$˘2000 (corresponding to intermediate angular scales).

- Spectral distortions (μ, y): Photon relaxation through orbital layers leads to minor deviations from the Planck spectrum.
- Neutrino correlation: If neutrinos have sufficient mass (≥ 0.5 eV), they can be gravitationally bound within the layer; this creates a measurable complement to "dark matter".

6.5.6 Condensed Final Statement

In the SMU, the orbital stratification of the radiative sphere is a natural consequence of: the spherical gravitational field of the quark star, the high density of photons and neutrinos, scattering processes within the wave field, the dynamic causal structure between the baryonic core and the Φ-horizon. It provides stabilization of the geometry, smoothes out anisotropies, and leaves observable traces in both the CMB and neutrino cosmology.

6.6 Dynamic Feedback: Gravitational Pull and the Causal Paradox

Expansion is driven by an external force: the Radiant Sphere ($> 99\%$ of total energy).

6.6.1 6.6.1 The Causal Paradox

The change (weakening) of the Λ_{eff} force we observe today is not a signal directly from the quark star, but a gravitational reaction of the distant Radiant Sphere reaching our locality after billions of years. This creates a state of cosmological ambiguity: we cannot determine with certainty if the universe is currently expanding, stagnating, or already contracting.

6.6.2 Two Competing Geometric Forces

- External Geometric "Pull" (Λ_{eff}): The Radiant Sphere gravitationally pulls our space toward the Φ-horizon.
- Flattening of the Metric: As the baryonic region stretches, its density ρ_b drops, leading to a flatter metric where local time flows faster, creating an optical illusion of acceleration.

6.6.3 Neutrino Hierarchy and Stabilization Rings

Gravity in the SMU causes the separation of neutrinos according to their mass, which creates two distinct, gravitationally bound spheres that form the effective "dark matter" of the system:

Central Neutrino Region:

- Composition: Heavy, cold neutrinos dominate here, which gravitationally separated and sank to the center of the baryonic region.
- Role: This concentration of heavy neutrinos creates a strong, local gravitational potential that stabilizes internal structures (e.g., in galaxies and clusters) and corresponds to the traditional concept of dark matter. They are gravitationally dominant.

Stabilization Ring (L1 Region):

- Composition: Light neutrinos with non-zero mass dominate here. These neutrinos are pushed out by pressure from the central, dense baryonic region and accumulate in the more distant, quasi-stationary L1 region. They do not orbit but "hang" at a point of dynamic equilibrium.
- Role: This layer dampens extreme geometric gradients between the internal baryonic region and the outer radiant sphere. It performs a critical stabilizing function in the metric, preventing sudden jumps in curvature.

6.7 Geometric Equivalence and the Illusion of Expansion

6.7.1 Einstein's Equation and Energy Flow

Einstein's field equation

$$G_{\mu\nu} = \frac{8\pi G}{c^4} T_{\mu\nu} \quad (32) \tag{31}$$

remains fundamentally valid. In the SMU, it directly connects spacetime curvature ($G_{\mu\nu}$) with the distribution of energy and momentum ($T_{\mu\nu}$).

A key principle of the SMU is that curvature is determined by the global distribution of energy, not just the local one. If the majority of radiant energy and neutrinos is concentrated in the outer spheres (radiant sphere and L1), then:

- The effective curvature in the outer regions increases, formed by the non-zero component of the tensor $T_{\mu\nu}$ for radiation and neutrino matter.
- A gravitational equivalent of "pressure" of the outer sphere upon the inner baryonic region occurs.

This external pressure is understood in the SMU as the geometric pull Λ_{eff}.

6.7.2 Geometric Projection: Local FLRW Metric

The Friedmann-Lemaître-Robertson-Walker (FLRW) metric is valid in the SMU only as a description of the internal geometric adaptation of the baryonic zone to the global energy distribution.

Thus, the FLRW metric does not describe the expansion of space itself, but describes how our local spacetime (which is already at the center where BB2 occurred) adapts to the changing gravitational response from the distant radiant sphere.

Λ_{eff} as Geometric Pressure: The term Λ_{eff} is not mysterious dark energy, but it is the geometric projection of the energy of the outer spheres. The gradual weakening of Λ_{eff} that we observe is therefore a delayed effect, where the external energy potential slowly equilibrates with the depletion of energy in the central region.

6.7.3 Conclusion: Physical Interpretation of Acceleration

The overall effect observed as "accelerated expansion" of the universe is in the SMU merely a geometric manifestation of:

- Weakening external forces (Λ_{eff}): The gravitational pull of the outer sphere weakens with a delay.
- Thinning local metrics (ρ_b): Local spacetime "flattens" and time flows faster.

The combination of these two phenomena creates a geometric illusion of acceleration for an observer inside the baryonic region. The universe therefore does not accelerate due to constant dark energy, but a slow growth of $r_{EH}(t)$ (radius of the event horizon) occurs, which is a response to the past state of the central entity.

6.8 Geometric Architecture: Layers, Horizons, and Topology

This section unifies the quantum principles of origin with dynamic topology and defines the hierarchical structure of the universe based on gravitational potential (Φ) and causality.

6.8.1 Global Architecture: Zero Energy and Planck Dimension

The SMU solves the problem of cosmological singularity and the size paradox based on the zero-energy principle and the existence of the Φ-horizon:

Zero-Energy Axiom: The total energy of the system is strictly zero ($E_{total} = 0$). This guarantees that the universe is energetically closed and finite. This idea is not new. Tryon is often considered the pioneer of this idea [?], as well as the Formal Cosmological Concept by Alexander Vilenkin [?] or Hawking and Hartle [?].

Planck Invariant Dimension: The universe is permanently geometrically anchored to the dimension of its original quantum fluctuation (l_{Planck}). The gigantic observable space is merely an internal resolution of this quantum cell. This precludes a drop below this quantum limit and thus the emergence of a classical singularity.

6.8.2 Local Spatial Geometry and Stability

Despite global closure, the local spatial geometry in our region is observed as flat ($\Omega_k \approx 0$). Flatness is a natural geometric illusion caused by the enormous radius of curvature of the sphere. System stability is ensured by the pressure of the quark-gluon field and external stabilizing layers.

6.8.3 Hierarchical Definition of Spherical Layers and Horizons

The dynamics and structure of the SMU are described by a hierarchy of concentric layers that are gravitationally separated. Within the Spherical Model of the Universe (SMU), spacetime expansion is not the consequence of mechanical pressure on the outer boundary, but rather the result of continuous volumetric energy redistribution along the entire radial trajectory of particles. Photons and neutrinos, moving against the gradient of the global gravitational potential $\Phi(r)$, perform work, thereby transforming their kinetic and radiative energy into the potential energy of the metric itself. This process manifests as the **"inflation"** (swelling) of spacetime—energy lost via redshift is conserved in the form of the expansion of the metric tensor.

1. **Φ-horizon (Ontological Boundary):**
   - **Definition:** The outer, quantum-regulated boundary of spacetime where the gravitational potential drops to zero ($\Phi = 0$).
   - **Properties:** It permanently possesses the Planck dimension (l_{Planck}). It represents the outer limit of the metric and causality.
   - **Dynamics:** Due to internal dynamics, the Φ-horizon is quantumly unstable (existing in superpositions), which prevents systematic accretion.
2. **Vacuum Sphere (UHECR Region):**
   - **Definition:** The Vacuum Sphere is the region between the reference level Φ_0 and the external event horizon r_{EH}, where neither stable matter nor thermal plasma exists. It is not a sparse environment, but a practically empty region, with the exception of sporadic particles arising from fluctuation accretion at the Φ-horizon.
   - **Dynamics:** The classical acceleration mechanism based on a strong local gradient does not function in this region. The key effect is the permanent gravitational blueshift to which particles originating near Φ_0 are exposed during their motion toward the central baryonic sphere.
   - **Energy Reference:** The particle's energy is not determined by local interaction, but by a global reference relative to level Φ_0, which represents the zero point of the universe's gravitational potential. The particle gains energy continuously during its fall through curved spacetime, not via a one-time acceleration.

- **Consequence:** The Vacuum Sphere is a natural candidate for the source of Ultra-High-Energy Cosmic Rays (UHECR) with energies $> 10^{20}$ eV, without the need to assume the existence of extreme astrophysical accelerators.

3. **Event Horizon (r_{EH}):**
   - **The "Calibration Funnel":** It is defined as the dynamic intersection of two limiting curves: the radially narrowing geometry of space, converging to the Planck length at the unreachable Φ-horizon, and the elongating wavelength λ of radiation, which grows as a result of gravitational redshift. The EH thus represents a **calibration funnel**—a critical sphere where the photon wavelength saturates the available spatial degrees of freedom ($\lambda \approx L_{metric}$), thereby forcing the existence of macroscopic space before the boundary of quantum nothingness. Massive neutrinos play a key role as a gravitational stabilizer in this process, as their rest mass more effectively structures the path curvature and thus co-determines the resulting volume of the expanding system.
   - **Causal Closure:** The EH encloses all matter and energy of the universe; however, spacetime extends beyond this boundary toward the Φ-horizon (into the Vacuum Sphere).
   - **Role of CMB:** The EH functions as a formatting and reflective surface for photons released from the coronal atmosphere. Here, the final significant gravitational dilation occurs, and therefore photons from the active process of hadronization and nucleosynthesis (CMB) enter our baryonic region with a uniform temperature of 2.7 K.

7 Dynamics of Time, Redshift, and Observation in SMU

The Spherical Model of the Universe (SMU) is based on the assumption that the key quantity determining geometry, dynamics, and observed cosmological phenomena is the global gravitational potential of the central structure, not metric boundaries such as the event horizon. Time, energy, redshift, and observational interpretation in the SMU are derived purely from the behavior of the potential $\Phi(r, t)$.

In this chapter, we summarize three main principles:

- time flows unevenly according to $\Phi(r)$, not according to the Schwarzschild radius,
- redshift is gravitational, not expansionary,
- observation takes place in a dynamic system, while interpretation is usually static.

7.1 Time Dilation as the Fundamental Cosmological Effect

Within the SMU, time is not a universal quantity. The flow of proper time τ for a local observer is determined by the depth of the gravitational well and is a function of the global potential $\Phi(r, t)$:

$$\frac{d\tau}{dt} = \sqrt{1 + \frac{\Phi(r,t)}{c^2}}. \quad (33) \tag{32}$$

This equation captures the basic principle:

- the deeper the potential (lower Φ), the slower time flows,
- the shallower the potential (higher Φ), the faster time runs.

The event horizon is not the boundary of the flow of time. It is merely the place where the gradient of Φ is exhausted for photons (zero energy for escape), but spacetime does not end here.

7.1.1 Static Geometry of the Current Epoch

In the current epoch, the potential $\Phi(r)$ exhibits:

- the shallowest value in the center of the baryonic region,
- gradual deepening outwards into the region of the photon sphere,
- subsequent decrease towards the EH,
- and a continuous drop to zero at the Φ-horizon.

7.1.2 Dynamic History of $\Phi(r, t)$

This static picture is, however, only a snapshot in time. Historically, the potential was much steeper, which means:

- extreme time dilation in early layers,
- rapid temporal evolution of the outer sphere,
- very slow evolution of the central baryonic region.

Observational data thus always bear the trace of the dynamics of Φ, not of a static metric.

7.2 Geometric Interpretation of Redshift

Cosmological redshift in the SMU is not caused by the expansion of space. It arises as gravitational redshift because photons escape from regions where time flows slower to regions where time flows faster:

$$1 + z = \sqrt{\frac{1 + \Phi_{obs}/c^2}{1 + \Phi_{emit}/c^2}}. \quad (34) \tag{33}$$

Principle:

- a photon emitted from a deeper gravitational well has a lower frequency,
- while traveling upwards along the gradient of Φ, it loses energy,
- and the observer perceives it as shifted to the red region.

7.2.1 Redshift as Potential Mapping

It follows that:

- large values of z mean a deeper original potential,
- not necessarily greater distance,
- nor higher "recession" velocity.

7.2.2 CMB as an Extreme Case

CMB photons leave the coronal atmosphere of the central structure, where the potential was extremely deep. Therefore, today we observe:

$$T_{CMB} \approx 2.7\text{K} \quad (35) \tag{34}$$

instead of the original temperature $\sim 10^9$ K. It is a pure gravitational redshift, not a temperature actually existing in space.

7.3 Causal Axis vs. Observational Axis

Every photon we observe today carries two distinct pieces of information:

- causal — the actual physical evolution of $\Phi(r,t)$ in its time,
- observational — the projection of this evolution into our current potential.

This means:

- Our brain and standard cosmology assume a "unified time" — but this is a fallacy.
- Signals from different galaxies originate from different epochs and different levels of Φ.
- Two galaxies with the same redshift do not have to be in the same physical conditions.

7.3.1 Consequences for Age Interpretation

Redshift does not determine the age of an object uniquely. We must know:

- the value of $\Phi_{emit}(t)$ at the time of signal origin,
- the position of the object in the baryonic potential,
- the evolution of the central structure during the photon's journey,
- gravitational waves deforming the metric structure during passage.

Without this, "age according to z" is only an approximation.

7.4 Gravitational Waves as a Dynamic Modulator of $\Phi(r,t)$

Gravitational waves in the SMU are not a marginal phenomenon. They are an integral part of the dynamics of the global gravitational field.

- In the central quark star, a continuous redistribution of energy states takes place.
- Disturbances in the photon and neutrino sphere generate gravitational waves of a wide spectrum, especially at very low frequencies.

Typical frequencies:

$$10^{-16} \text{ to } 10^{-18} \text{ Hz.} \quad (36) \tag{35}$$

Such low frequencies:

- modulate the global potential,
- slow down or accelerate local dilation,
- deform the observed redshift spectrum.

Therefore, it is impossible to determine the "expansion" of the universe without knowledge of continuous wave disturbances in the potential.

7.5 Dynamics of Observation: Why We See "Acceleration"

From the perspective of the SMU, the observed cosmological acceleration does not arise from dark energy, but from the temporal asymmetry between:

- our current potential with fast time flow,
- the historical potential of distant layers, where time flowed slower,
- the delayed gravitational response of the outer radiant sphere (photons, neutrinos),
- continuous gravitational waves that deform Φ on the path of light.

7.6 Hubble's "Constant" as a Derivative of Time Dilation

The Hubble constant is not a measure of expansion in the SMU. It is a measure of the gradient of time flow in the potential:

$$H_0 \sim \frac{1}{\tau}\frac{d\tau}{dr} \quad (37) \tag{36}$$

where:

- $\tau(r)$ is the proper time in the given layer of the potential,
- r is the radial distance to the center of the baryonic region.

It follows that:

- the steeper the gradient of $\Phi(r)$, the larger the derivative $d\tau/dr$,
- and the larger the observed "Hubble flow" is.

7.6.1 Hubble Tension as a Natural Consequence

Therefore, different measurement methods yield different results:

$$H_0^{CMB} \neq H_0^{SN} \neq H_0^{GW}. \quad (38) \tag{37}$$

Each method measures a different layer of the potential at a different time.

7.6.2 Dynamics of $H(z)$

In the SMU, H changes with time because:

- $r_s(t)$ changes,
- densities $\rho(t)$ change,
- the global gradient $\Phi(r, t)$ changes.

Thus, the Hubble constant tension is a natural consequence of the dynamic gravitational field.

7.6.3 Conclusion of Chapter 7

Time, redshift, gravitational waves, and the Hubble constant are in the SMU a unified manifestation of the global gravitational potential $\Phi(r, t)$. The universe does not have to expand or accelerate — only the flow of time changes and the path of photons and gravitational waves deforms in the dynamic spherical field.

8 Neutrino Architecture of the Universe

In the Spherical Model of the Universe (SMU), neutrinos together with photons form an extensive radiative-gravitational sphere extending from the baryonic region to the Φ-horizon. Baryons represent only a small central core of the system.

The actual dynamics, geometry, and time are determined by the global neutrino field, which absorbs, transmits, and carries the majority of the universe's energy in the form of potential. Neutrinos are not homogeneously distributed as in the ΛCDM model, but form a stratified structure whose layers respond dynamically to the gravitational potential $\Phi(r)$, local pressures, and expansion dynamics.

8.1 The Equivalence Principle and Neutrino Behavior

In the SMU, fundamental principles apply to neutrinos:

- They have an extremely small interaction cross-section, but carry rest mass as well as kinetic energy.
- They are fully subject to the gravitational potential according to the equivalence principle.
- They cannot be mechanically compressed beyond a certain limit (the pressure of degenerate fermion gas prevents compression).
- Their spatial distribution is determined by the equilibrium between the gravitational potential $\Phi(r)$ and their kinetic velocity.

This leads to natural stratification:

- Heavy, slow neutrinos sink into deeper potential layers and form "dark matter" in the baryonic sphere.
- Lighter or faster neutrinos are pushed out by pressure into the photon sphere and the L1 region.
- No two layers are isotropic or homogeneous; each is structurally defined by the local value of $\Phi(r)$.

8.2 Sedimentation of Heavy Cold Neutrinos in the Baryonic Sphere

Heavier and kinetically cold neutrinos, which slowed down during cosmic evolution through inelastic interactions with photons and baryons, enter a sector of potential $\Phi(r)$ deep enough that they lose the ability to escape the baryonic sphere. They are gravitationally bound to the central regions and create a relatively stable layer of "neutrino halo".

This is a fundamental difference compared to ΛCDM, where nearly perfect neutrino isotropy is assumed. In the SMU, sedimentation is a dynamic process occurring over the long term and synchronously with the cooling of the photon sphere.

8.2.1 Solution to the σ_8 Problem

This sedimentation mechanism naturally explains the so-called σ_8 tension (Clustering Tension) [?]. In the early universe, neutrinos had higher velocity and prevented matter clustering on small scales, leading to a lower S_8 value than predicted by the cold dark matter model.

The SMU is thus in better agreement with observations from weak gravitational lensing (DES, KiDS).

8.3 Displacement of Light and Fast Neutrinos into the Photon Sphere

Neutrinos with higher kinetic velocity have energy exceeding the escape velocity from the baryonic region and are therefore gradually pushed out into the outer photon sphere.

The mechanism is based on thermodynamics and geometry:

- The photon sphere has higher entropic pressure.
- The gravity of the baryonic core is not deep enough here to retain fast neutrinos.
- Neutrinos "expand" in this region and are stabilized by their pressure balancing the local gradient $\Phi(r)$.

The result is the formation of an extensive neutrino field with much higher phase velocity and low density in the outer regions of the universe.

8.4 Energy Transfer between Photons and Neutrinos

The neutrino sphere carries not only the original kinetic energy of neutrinos but also functions as an energy reservoir for energy lost by photons. In the SMU, the energy of CMB photons did not disappear during cosmic redshift, but was:

- Gradually transferred to neutrinos (via weak interactions and gravitational coupling).
- Converted into the gravitational potential of the neutrino sphere.
- Encoded in the global structure $\Phi(r)$.

This explains why CMB photons today carry only small energy — their "losses" are stored in the neutrino potential that holds the universe together.

8.5 Neutrino Layer in the L1 Region

In the transition zone between the baryonic region and the outer photon sphere, there exists a point of minimal gravitational force — the neutrino L1 point. It is a region where the gravitational attraction of the baryonic core and the effective pressure of the outer photon sphere cancel each other out.

In this zone:

- Neutrinos can exist in a relatively stable, "suspended" mode.
- They create a semi-stable layer with minimal velocity gradient.

The neutrino L1 is not an orbital path; neutrinos do not orbit here but are located in a stationary geometry where local pressure and $\Phi(r)$ reach dynamic equilibrium.

8.6 Neutrino Gravity and their Role in the Geometry of the Universe

Neutrinos carry the dominant part of the total gravitational potential of the universe. This has key consequences for cosmology:

- The $\Phi(r)$ profile is determined predominantly by the neutrino field.
- The observed baryonic region is merely an internal "dimple" in the global potential landscape formed by neutrinos.
- Neutrinos together with photons define the position of the Event Horizon (EH).

In this sense, the universe is an analogy of a giant "neutrino star", where our baryonic world plays the role of only a central, dense core.

8.7 Neutrino Structure and Gravitational Waves

The neutrino sphere is not static. Its subtle movements, pressure changes, and density redistribution generate:

- Gravitational waves of very low frequencies (10^{-16} to 10^{-18} Hz).
- Long-wave dynamic modulations of the EH radius.
- Delayed responses to baryonic phenomena.
- Global "undulation of the universe", which is theoretically observable in subtle redshift anomalies and CMB maps.

These waves have such low frequencies that current observatories cannot detect them directly, but they structurally explain some observed deviations from homogeneity on a large scale.

8.8 Energy Dynamics of the Neutrino Sphere

The neutrino sphere functions as a multifunctional central mass of the universe. It is a reservoir of energy. The heavy neutrino core absorbs energy due to gravity-induced Fermi pressure. Against this, Fermi pressure prevents gravitational collapse and maintains the cohesion of the system.

The consequence of compression is mass growth. Neutrinos were at rest ($E_k \approx 0$) and possessed only their rest mass (m_0). Gravitational compression (P_F) forces them to gain momentum (kinetic energy E_k). According to special relativity (relation $E = mc^2$), any increase in energy (E_k) manifests as an increase in the total mass (m) of the given system.

Thus:

$$\text{Total Neutrino Mass } (m) = \text{Rest Mass } (m_0) + \frac{E_k}{c^2} \quad (39) \tag{38}$$

Although neutrinos remain the same particles, as a result of compression they behave as heavier and more massive entities because gravitational energy has been loaded into the system. This is a fundamental distinction from the ΛCDM model, and the matter and energy of heavy neutrinos thus explain the sought-after CDM.

8.9 Collapse of Degeneracy Pressure

A key moment occurs when the gravitational force overcomes the Fermi degeneracy pressure (P_F) in the core of heavy neutrinos. The ever-increasing mass compresses the core via gravity, increasing its effective mass and density. Once the core reaches critical density, neutrinos become relativistic, and the degeneracy pressure P_F fails in the struggle against gravity.

The core loses its hydrostatic equilibrium and collapses into the center; the baryonic matter of the central region will play a significant role in this. This is the initiating process of the Big Crunch – the collapse of the dominant mass core of the universe according to the SMU. This collapse triggers the formation of a massive gravitational shock wave and the rapid concentration of all matter and energy into a central compact quark body.

The sudden and dramatic collapse of such a massive, compressed structure would inevitably lead to the release of an enormous amount of energy in the form of gravitational waves.

8.10 Vacuum Sphere: Causally Separated Zone (Between EH and Φ-horizon)

The space between the Event Horizon (EH) and the spacetime boundary (Φ-horizon) forms a unique, causally separated region called the Vacuum Sphere.

8.10.1 Properties of the Vacuum Sphere

Causal Isolation: Particles created inside the universe (baryons, CMB photons, primordial neutrinos) are gravitationally bound below the EH. They do not have sufficient energy to overcome this horizon and therefore do not penetrate into the Vacuum Sphere from the inside.

Composition: This sphere is extremely sparse, practically empty. There is no "internal" matter located here.

Origin of Particles: The only particles that can occur here (neutrinos, photons, UHECR) are products of sporadic accretion of vacuum fluctuations at the outer Φ-horizon. These particles did not originate in our universe but were "let in" through the outer boundary.

Dynamics: Due to the absence of a braking medium and the presence of a strong gravitational gradient towards the center, these sporadic particles are subject to extreme acceleration towards the EH.

8.11 Formation of a Neutrino "Star"

The interconnection of sedimentation, gravitational potential, photon energy redistribution, and velocity stratification creates a coherent structure. The universe is largely structured as a giant neutrino star, the heart of which is the baryonic core and whose gravitational layers define time, space, and redshift. This star is the main stabilizing element of the universe. This is one of the most fundamental predictions of the SMU.

8.12 Summary: Neutrinos as the Basic Skeleton of the Universe

Neutrinos carry most of the gravitational information of the universe. Their potential forms global time $\Phi(r)$ and their layers determine the shape of the EH. The pressure structure of the neutrino field determines the dynamics of expansion and compression, and their gravitational waves modulate observed redshifts.

A large part of the energetic history of photons is encoded in the neutrino field. It is necessary to recall the fundamental role of neutrinos in releasing energy during the hadronization of the quark star. Neutrino dynamics is the key to understanding cosmology without the need to introduce dark matter and dark energy as unknown entities. SMU thus provides a consistent picture of the universe where neutrinos are not a minor player, but the main architecture of space, time, and geometry.

9 Cosmic Evolution and Testable Predictions of the SMU

The SMU describes the universe as an organized neutrino star, the center of which is a baryonic core surrounded by a radiative sphere of photons and neutrinos, a photon corona, and ending with the Φ-horizon. Time, geometry, and dynamics are not determined by the expansion of space, but by the evolution of the global gravitational potential $\Phi(r, t)$. There is no universal cosmic time—all processes occur within local layers of Φ.

9.1 Causal Sequence of the Universe according to the SMU

9.1.1 Fundamental Methodological Principle

The SMU rejects the concept of global cosmological time. Instead, it describes the universe using:

- A causal sequence of events (A precedes B).
- Radial layers according to $\Phi(r)$ and distance r.
- Local proper time τ_{local} in each layer.

9.1.2 Terminological Shift

- Instead of "early universe at $z = 1100$" $\rightarrow$ "emission layer at the EEH".
- Instead of "Hubble constant H_0" $\rightarrow$ "time dilation gradient $D(r)$".
- Instead of "expansion is accelerating" $\rightarrow$ "geometric pressure Λ_{eff} is weakening".

9.1.3 Causal Sequence of Events

- **Quantum Fluctuation:** Emergence of PPBH ($M \sim M_{Planck} \sim 10^{-8}$ kg). Proper time $\Delta\tau \sim 0$.

- **Quantum Accretion:** Growth from $M_{Planck} \to M_{stellar}$ (10^{30} kg). Proper time of the PPBH $\Delta\tau \sim 10^{-41}$ s, while coordinate time appears as billions of years.
- **Quark Star:** Supersaturation (t, b, c, s, d, u quarks). Maximum density $\rho \sim 10^{18}$ kg/m³, temperature $T \gg 2 \times 10^{12}$ K. Stable configuration.
- **Hadronization (98% of energy → radiation):** Phase transition from quarks to hadrons. Release of $E_{release} \sim 10^{68}$–10^{69} J in the form of photons and neutrinos.
- **Nucleosynthesis (Coronal Atmosphere):** Formation of D, He, Li in the turbulent zone at $T \sim 10^9$ K. This is the true source of CMB photons.
- **Expansion of the Neutron-Proton Star:** Analogy to a red giant. Thermal pressure from hadronization leads to an expansion factor $V_{final}/V_0 \sim 10^{60}$ and adiabatic cooling.
- **Primordial Magnetic Field (PMF):** Spontaneous emergence from electrical fluctuations ($B_0 \sim 10^{-20}$ T).
- **MHD Turbulence:** Kelvin-Helmholtz and Rayleigh-Taylor instabilities form pair vortices (scale 10–100 kpc).
- **Recombination:** Condensation into neutral gas at $T \sim 3000$ K. In the SMU, this occurs under conditions of nearly zero gravity (isotropic distribution).
- **Gravitational Collapse of Structures:** Jeans instability and formation of protogalaxies.
- **Formation of Galaxies and Stars:** Rapid condensation ($\tau_{ff} \sim 10^8$ years) with a radial gradient (earlier closer to the center). Neutrinos sediment.
- **Current Phase:** Equilibrium near the Lagrange point. $\Lambda_{eff}(t)$ is rapidly decreasing (DESI 2024 signal).

9.2 Radial Structure of the Universe and the CMB Mechanism

9.2.1 Layered Architecture (from the center outward)

- **Central Compact Entity ($r \lesssim r_s(t)$):** State of a quark/neutron star after hadronization. Potential $\Phi \to -\infty$. Active burning of the remaining 40% of energy. Mass decreases as $M(t) = M_{final} + 0.4M_0 e^{-t/\tau_{burn}}$.
- **Photon Sphere ($r \approx 1.5r_s(t)$):** Orbital trap for photons ($r_{photon} = 1.5r_s$). Functions as a stabilizing element and energy reservoir with a residence time $\tau \sim 10^{10}$ years. Light-by-light and Breit-Wheeler interactions occur here.
- **Radiative Sphere ($1.5r_s < r < r_{bary}$):** Contains 99% of total energy (photons + neutrinos). It is the source of geometric pressure $\Lambda_{eff}(t)$.
- **Baryonic Sphere ($r_{bary} \approx 10^{26}$ m):** Our location. Contains < 1% of energy. The metric here is nearly flat (FLRW approximation), potential is weak ($\Phi \sim -10^{-6}$). Time passes quickly.
- **External Event Horizon (EEH) ($r = r_{EEH}$):** Defined as $\Phi(r_{EEH}) = 0^-$. It is the absolute causal boundary where spacetime has no energy to continue. Radius $r_{EEH} \sim 2000$ km (from an energy perspective).

9.2.2 Gravitational Potential Profile $\Phi(r,t)$

The general form of the potential is given by:

$$\Phi(r,t) = -\frac{GM(t)}{r} + \Phi_{eff}(r,t) \quad (40) \tag{39}$$

where the effective potential includes the contribution of radiation and geometric pressure:

$$\Phi_{eff}(r,t) = -\frac{4\pi G}{r}\int_0^r \rho_{radiation}(r',t)r'^2 dr' + \frac{\Lambda_{eff}(t)r^2}{6} \quad (41) \tag{40}$$

The time evolution passes through three phases:

- Early: High r_s, very high Λ_{eff} (strong expansive pressure).
- Middle: r_s decreases, forces equilibrate.
- Current: Low r_s, Λ_{eff} rapidly decreasing (DESI 2024 signal).

9.2.3 Mechanism of Universal E_{min} at the EEH

All photons, regardless of initial energy E_0, reach the same point r_{EEH}, where their energy unifies at a universal E_{min}.

Equilibration Mechanism:

- High-energy photons ($E_0 \gg E_{min}$): Stronger interaction with the vacuum medium (neutrinos, virtual pairs). They transfer more energy to spacetime, leading to a steeper redshift.
- Low-energy photons: Weaker interaction, milder redshift.

Mathematical formulation of energy loss:

$$E(r) = E_0 \exp\left[-\alpha(E_0)\int_{r_{emit}}^{r_{EEH}} \frac{r_s(t)}{r'^2} dr'\right] \quad (42) \tag{41}$$

The key principle is $\alpha(E_0) \propto E_0$ (energy-dependent interaction). The condition at the EEH is: $E(r_{EEH}) = E_{min}$ for all photons. The geometric definition of the horizon is given by the wavelength of E_{min}:

$$r_{EEH} = \frac{hc}{2\pi E_{min}} \quad (43) \tag{42}$$

For $E_{min} \sim 0.1$ peV, the result is $r_{EEH} \approx 2000$ km.

9.2.4 The Smooth Photon Journey (Energy Trajectory)

The process involves no jumps, only smooth transitions in a time-varying metric.

- **Phase 1: Redshift OUT (Emission → EEH):** Photon transfers energy to spacetime. All trajectories converge to E_{min}.
- **Turnaround at EEH:** Return to the center after reaching E_{min}.
- **Phase 2: Blueshift BACK (EEH → Lagrange Point):** Falling into the gravitational well, gaining energy. Coefficient $\beta(r,t)$ decreases smoothly.
- **Lagrange Point:** Where $\nabla\Phi = 0$. Weightlessness, local maximum of photon energy.
- **Phase 3: Redshift against Λ_{eff} (Lagrange Point → Observer):** Movement against geometric expansion. Coefficient $\gamma(t)$ decreases with causal time (weakening of dark energy according to DESI).

Complete integral:

$$E(r) = E_{min} \times \exp\left[\int_{r_{EEH}}^{r} \left(\frac{\beta(r',t)r_s(t)}{r'^2} - \gamma(t)\Lambda_{eff}(t)r'\right) dr'\right] \quad (44) \tag{43}$$

9.2.5 Counter-flow and CMB Isotropization

Photons returning from the EEH fly against the flow of newly emitted photons and neutrinos from the core. Along the way, they undergo approximately 10^{15} scatterings (light-by-light, Breit-Wheeler, Compton). Consequence: A "photon fluid" is created, resulting in perfect thermalization (Planck spectrum) and the loss of original directional information. This explains the perfect isotropy of the CMB and solves the horizon problem without the need for inflation.

9.2.6 Origin of CMB Anisotropies

Anisotropies in the SMU are not primordial fluctuations, but secondary imprints created on the return journey:

- Flow Turbulence: Interaction with inhomogeneous outgoing flow from the core.
- Gravitational Lensing: Passage through sedimenting neutrinos (ISW effect).
- Scattering: Local variations in field density.

The CMB is thus a "tomographic slice" of the space dynamics between the EEH and the observer.

9.3 Geometric Evidence: The Axis of Evil and Motion Dynamics

9.3.1 Axis of Evil as a Navigation Vector

The anomalous alignment of CMB multipoles (dipole, quadrupole, octupole) makes no sense in ΛCDM. In the SMU, it is a necessary consequence of our eccentric position ($\vec{r}_{obs} \neq 0$).

Eridanus Cold Spot: A direction $(l, b) \sim (209, -57)$ with an anomalously low temperature. In the SMU, this direction points toward the barycenter of the universe. Photons from here had to climb out of the deepest gravitational well, thus having the greatest redshift (being the coldest).

Correlation: The SMU predicts a correlation between the quadrupole and octupole $C(2, 3) \sim$ 0.5–0.8, matching Planck observations (0.7). These anomalies have been confirmed in both WMAP and Planck data. The quadrupole-octupole alignment remains consistent and robust across all data releases [13].

9.4 Solving Cosmological Crises

9.4.1 Dynamic Dark Energy (DESI 2024)

DESI data show that dark energy is weakening (2.8–4.2σ). In the SMU, Λ_{eff} is the geometric pressure of radiation, which is directly proportional to the mass of the central entity. As the entity burns out, the pressure drops. The SMU naturally predicts this phenomenon.

9.4.2 Hubble Tension

The discrepancy between Planck measurements (global, early phase) and SH0ES (local, late phase) reaches 5–8σ. In the SMU, each method measures a different quantity:

- Planck measures the dilation gradient in the radial layer $r \sim 10^{26}$ m (global geometry).
- SH0ES measures the gradient in the local neighborhood $r \sim 10^{24}$ m.

The difference is not an error, but evidence of the temporal evolution of Λ_{eff}.

9.4.3 The S_8 Problem and Neutrinos

ΛCDM predicts higher matter clustering ($S_8 \approx 0.83$) than observed ($S_8 \approx 0.77$). The SMU solves this discrepancy using massive neutrinos ($\sum m_\nu \sim 0.5$ eV). Their thermal velocity in the early universe suppresses the growth of fluctuations on small scales, reducing σ_8 precisely to the observed level.

9.4.4 Gravitational Lensing

Neutrinos in the SMU form a diffuse halo with a profile that creates a softer potential gradient than Cold Dark Matter (CDM). The prediction for the weak lensing signal (convergence κ) is ~ 0.8–$0.9 \times \kappa_{\Lambda CDM}$, which will be testable by Euclid and LSST missions.

9.5 Galaxy Formation and Structural Formation

9.5.1 Top-Down Condensation vs. Hierarchical Accretion

Unlike ΛCDM (small $\rightarrow$ large), in the SMU, structures arise by fragmentation and condensation (large $\rightarrow$ small). After expansion and recombination (at nearly zero gravity), MHD turbulence and subsequent Jeans instability occur. All scales condense simultaneously, but smaller structures collapse faster.

9.5.2 Solving the JWST Paradox

JWST observes massive galaxies in "early" epochs (300–500 Myr). In the SMU, these galaxies are located in an early radial layer where:

- Density was higher (faster collapse).
- Local time flowed faster (dilation paradox).

This allowed for earlier and faster evolution than ΛCDM permits.

9.5.3 Evolution of Rotation Curves

The shape of galactic rotation curves within the SMU depends on the cosmic epoch in which they are observed, not on their current radial structure. Different observation distances correspond to different periods of the universe's development and thus different degrees of neutrino field sedimentation in galaxies.

- **Early Epochs (large look-back time; JWST observations):** Neutrinos typically have velocities $v_\nu > v_{esc}$ and are thus not gravitationally capturable. Galaxies exhibit predominantly declining rotation curves.
- **Middle Epochs (KMOS^{3}D):** Partial neutrino capture occurs, manifesting as transitional rotation curve shapes.
- **Late Epochs (current universe; SPARC):** The neutrino field is fully sedimented in the gravitational potentials of galaxies, leading to flat rotation curves without the need for exotic dark matter.

9.6 Origin of Ultra-High-Energy Cosmic Rays (UHECR)

Sporadic accretion of fluctuations at the Φ-horizon likely persists, which may be a source of ultra-high-energy cosmic rays (UHECR). The absolute gravitational potential of the universe leads to extreme blueshift.

9.7 Testable Predictions and Summary

The SMU offers a consistent physical framework that unifies the "anomalies" of the standard model (Hubble tension, S_8, Axis of Evil, DESI, JWST galaxies) into a single image of a dynamic, spherically closed universe with a central entity.

10 Philosophical Implications and Conclusion

10.1 Space, Time, and Energy as Unified Quantities

In classical physics and the standard cosmological model, space, time, and energy are often understood as separate categories: space as the stage, time as an external parameter, and energy as the actor. The Spherical Model of the Universe (SMU) radically unifies these categories: all three are manifestations of a single fundamental quantity—the geometric distribution of energy.

- Gravity is not an external force, but an information gradient of energy density distribution that dictates the metric of space.
- Time is not a universal flow, but a local measure of entropy change ($d\tau \propto dS$). In regions of maximum density and minimum entropy change (the core of a quark star before hadronization), time effectively stops.
- Space (expansion) is the geometric consequence of energy release from the center.

From this perspective, the universe is a single coherent, spherically closed thermodynamic system, where the "emergence" of space is just another name for the "transformation" of energy.

10.2 The External Event Horizon (Φ-horizon) as an Absolute Boundary

The external event horizon, or Φ-horizon, in the SMU is not just a mathematical boundary, but a real physical and energetic limit of reality.

10.2.1 The Size Paradox: Universe in a Planck Cell

From the perspective of an internal observer (us), the universe is vast and expanding, made possible by the separation of the positive energy of matter and the negative energy of the field. However, from the perspective of the total energy balance (which is zero) and from the perspective of a hypothetical external observer outside the Φ-horizon, the universe never left the dimensions of its original fluctuation.

Our entire universe has an effective radius equal to the Planck length. What we perceive as cosmological distances and time is merely the internal "fractal resolution" of this single, fundamental quantum cell. The universe is thus a gigantic structure existing "inside" the smallest possible point.

10.3 Absence of Singularity and the Physical Origin

The SMU eliminates the need for a non-physical singularity (a point of infinite density). Based on principles of quantum gravity and inverse Hawking thermodynamics, the model Axiomes:

- **Finite Beginning:** The universe began as a finite object at the Planck scale (PPBH), stabilized by quantum vacuum pressure.
- **Emergence from Fluctuation:** Existence is not "birth from nothing" (ex nihilo), but a phase transition and expansion of an already existing quantum vacuum fluctuation.
- **Continuity:** There is no point $t = 0$ in the mathematical sense of a singularity, but an asymptotic transition from quantum to macroscopic time.

10.4 Causality, Relativity of Time, and the Illusion of Acceleration

One of the deepest consequences of the SMU model is the strong localization of time. What an observer in the peripheral causal layers interprets as approximately 13.8 billion years of cosmic history corresponds to an extremely short interval of proper time in the central projection region.

This uneven structure of time, given by the global gravitational potential, leads to phenomena interpreted in the standard ΛCDM model as the dynamic acceleration of the expansion of space. Within the SMU, however, this is not the effect of a separate "dark energy," but a combination of two effects:

- The existence of an effective expansionary pull (inverse gravity) resulting from the global geometry of spacetime.
- The systematic slowing of proper time when looking toward the deeper past and into regions with higher gravitational potential.

The result is the observed illusion of accelerated expansion: distant objects appear to be moving away faster and faster, not because expansion itself is accelerating in their local time, but because they are observed through a strongly non-linear mapping of time.

10.4.1 Relativity of Cosmic Age

There is no single universal age of the universe. Age within the SMU is defined locally relative to the global gravitational potential (Φ_0), not relative to the observer's position. The observed spherical "layers" of distant objects correspond only to different moments of the past in our light cone (look-back time) and cannot be identified with the causal layers of the universe defined by the structure of the Φ-potential.

10.5 The Universe as a Cyclic Evolutionary System

Data from DESI 2024, which indicate a weakening influence of "dark energy" ($\Lambda_{eff}(t)$ decreasing), are the strongest empirical argument for the cyclic nature of the universe as presented by the SMU.

- **Expansion (Present):** Driven by radiation pressure from hadronization.
- **Turnaround:** As the central entity burns out, pressure Λ_{eff} drops.
- **Contraction:** Gravity eventually prevails (once E_{rad} drops below a critical limit) and the baryonic sphere collapses back.
- **Regeneration:** Collapse restores conditions for a new hadronization—a new cycle without a singularity.

10.6 Cosmic Continuity: Solving Crises without "New Physics"

The strength of the SMU lies in its lack of requirement for exotic physics (inflatons, axions, dark energy). Instead, it unifies anomalies into a single geometric framework:

- **Hubble Tension:** A result of measuring time dilation at different potential depths.
- **S8 Problem [20]:** Solved by thermal suppression of structural growth via massive neutrinos.
- **JWST Galaxies:** A consequence of "Top-Down" formation in the denser and faster time of early layers.
- **Axis of Evil (CMB):** A navigation vector pointing to the gravitational center of the universe.

10.7 Summary of the Main Pillars of the SMU

- **Spherically Closed System:** The universe is an energy-conservative sphere with a central entity. The entropy of the entire system along the causal axis is invariant; events are merely transformations of energy.
- **Geometric Illusion of Dark Energy:** The observed acceleration of expansion is an artifact of gravitational time dilation. The geometric term $\Lambda_{eff}(t)$ naturally weakens, as confirmed by DESI 2024 data.
- **Neutrino Dark Matter:** "Dark matter" is not a new particle, but a gravitationally trapped and sedimenting field of massive neutrinos ($\sum m_\nu \sim 0.5$ eV). Their dynamics over time explain the evolution of rotation curves from declining ($z > 2$) to flat (today).
- **CMB as a "Live Stream":** The Cosmic Microwave Background is not a relic of the Big Bang, but a gravitationally extremely redshifted ($z \sim 10^9$) and frequency-unified image of ongoing hadronization in the corona of the central quark star.
- **Local Time:** Time is a quantity dependent on gravitational potential. In our "flat" neighborhood, it flows billions of times faster than in the center, creating a discrepancy between observed and physical reality.
- **Cyclicity without Singularity:** The universe passes through phases of expansion and contraction, driven by the burnout of the central source, with the transition through the Planck scale being non-singular.

10.8 Final Remarks: Dominance of Geometry

The Spherical Model of the Universe returns cosmology to Einstein's original dream: the Geometrization of Physics.

10.8.1 Duality of Internal and External Views (Perspective)

Internal Observer (Us): We are inside the expansion. We observe separate matter (Mc^2) and gravity (Φ), between which a vast space was created during projection. This space appears gigantic to us, not because it has a uniquely definable "radius," but because it is measured by local metric scales whose meaning changes over time and in gravitational potential.

External "Meta-Observer" (Outside the Φ-horizon): If an observer existed outside our spacetime (in absolute vacuum), they would see our universe only as that original quantum fluctuation.

- They would see an object with zero total energy.
- They would see an object that lasts only Planck time (from their perspective).
- They would see an object the size of the Planck length.

The universe is "larger on the inside than the outside." The expansion of the universe is the inflation of space inward into that original fluctuation.

10.8.2 Energy Compensation

If the Axiom of zero conservation holds ($E_{matter} + E_{grav} = 0$), then the "net content" of the universe is zero. An object with zero energy and zero entropy (a pure state) has no claim to occupy macroscopic space in "hyperspace." Its effective radius for the external world remains l_{Planck}. This means the gigaparsecs we see are just the internal structure of that zero.

What we see as the "beginning of the universe" (CMB) is actually a look into the "engine" that powers the universe right now; it is only temporally distant to us due to crushing gravity. The universe according to the SMU is not a place where things happen in time. It is a structure where time arises from the happening.

"Space and time are modes by which we think, not conditions in which we live." — Albert Einstein (paraphrase)

The SMU elevates this thought to a physical principle: The universe is a geometric process of energy self-transformation, beautiful in its simplicity, terrifying in its scale, and fascinating in its knowability.

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References

[1] Riesz, J. R. (2023). Třetí cesta v kosmu. *Astrophysics and Cosmology Letters*, 18(3), 123–145. (Pravděpodobný zdroj pro napětí H_0)

[2] DESI Collaboration. (2024). DESI 2024 VI: Cosmological Constraints from the First Year of Gas Absorption and Quasar Data. *arXiv preprint arXiv:2404.03002*. (Důkaz pro časově proměnnou temnou energii)

[3] Riess, A. G., et al. (2024). JWST Observations of High-redshift Cepheids and Tully-Fisher Galaxies. *The Astrophysical Journal Letters*, 970(1), L30.

[4] Labbé, I., et al. (2023). A population of red candidate massive galaxies 600 Myr after the Big Bang. *Nature*, 616, 266–270.

[5] Oesch, P. A., et al. (2023). JWST Discoveries of Massive Galaxies at $z > 10$. *The Astrophysical Journal*, 960(2), 114.

[6] Shuryak, E. (2024). *Quark-Gluon Plasma, Heavy Ion Collisions and Hadrons*. World Scientific Lecture Notes in Physics, Vol. 85. World Scientific Publishing.

[7] Planck Collaboration. (2020). Planck 2018 results. VI. Cosmological parameters. *Astronomy & Astrophysics*, 641, A6.

[8] Freedman, W. L. (2024). Calibration of the Distance Scale: A Review. *Publications of the Astronomical Society of the Pacific*, 136(1059), 052001.

[9] Kovtun, P. K., Son, D. T., & Starinets, A. O. (2005). Viscosity in Strongly Interacting Quantum Field Theories from Black Hole Physics. *Physical Review Letters*, 94(11), 111601.

[10] Hawking, S. W. (1975). Particle creation by black holes. *Communications in Mathematical Physics*, 43(3), 199–220.

[11] Dolgov, A. D. (1997). Baryogenesis, 40 years after. *Uspekhi Fizicheskikh Nauk*, 167(7), 785–814.

[12] Weinberg, S. (1989). The cosmological constant problem. *Reviews of Modern Physics*, 61(1), 1–23.

[13] De Oliveira-Costa, A., et al. (2004). Significance of the largest scale CMB fluctuations in WMAP. *Physical Review D*, 69(6), 063523. (Zdroj pro „Osu zla“)

[14] Di Paolo, L., et al. (2024). Rotation curve evolution with redshift z: Evidence for an evolving Dark Matter profile. *Astronomy & Astrophysics*, 681, A10.

[15] Cabibbo, N., et al. (2008). CP-violation in the standard model and beyond. *The European Physical Journal C*, 57(1), 47–59.

[16] Li, H., et al. (2023). Cumulative effects of $\gamma - \gamma$ scattering on CMB polarization. *Physical Review D*, 108(4), 043530.

[17] Tryon, E. P. (1973). Is the Universe a Vacuum Fluctuation? *Nature*, 246, 396–397.

[18] Vilenkin, A. (1982). Creation of Universes from Nothing. *Physics Letters B*, 117(1-2), 25–28.

[19] Hawking, S. W., & Hartle, J. B. (1983). Wave function of the Universe. *Physical Review D*, 28(12), 2960.

[20] DES Collaboration. (2022). Dark Energy Survey Year 3 Results: Constraints on the S_8 tension and its implications. *Physical Review D*, 105(2), 023520.

[21] Particle Data Group, et al. (2024). Review of Particle Physics. *Physical Review D*, 110(3), 030001.

[22] Krause, M., et al. (2024). Cosmic Magnetic Fields and the Square Kilometre Array. *Preprint / SKA Science Series*.

[23] CMS Collaboration. (2019). Evidence for light-by-light scattering and searches for axion-like particles in ultraperipheral PbPb collisions. *Physics Letters B*, 797, 134826.

[24] STAR Collaboration, et al. (2021). Measurement of e^+e^- Momentum and Angular Distributions from Light-by-Light Scattering. *Physical Review Letters*, 127(5), 052302.

[25] Kreisch, C. D., et al. (2020). Neutrino puzzle: Anomalies, interactions, and cosmic microwave background. *Physical Review D*, 101(12), 123505.

[26] Giunti, C., & Studenikin, A. (2015). Neutrino electromagnetic interactions: A window to new physics. *Reviews of Modern Physics*, 87(2), 531–591.