ISSN 2976 - 730X
IPI Letters 2025, Vol 3 (1):7-30
https://doi.org/10.59973/ipil.164

Received: 2025-02-02
Accepted: 2025-02-14
Published: 2025-02-18

Article

Space and Time at Planck's Scale, Carriers of Evolutionary Information, and the Evolution of the Universe

Pronab K Chowdhury [1,*]

[1] National University of Uzbekistan, Department of Theoretical Physics, Tashkent, Uzbekistan

*Corresponding author: pronabkchy@gmail.com

Abstract - The purpose of this paper is to present a detailed description of the Planckian stage of the unified model of natural evolution (UMNE) and the transition from the Einsteinian stage to the Darwinian stage. The model consists of four stages: Planckian, Einsteinian, Darwinian, and Intellectual. Planck's universe is described as a collection of entangled entities called PlanckITs. PlanckITs code the simplest form of existence in space and time. In Planck's universe, existence means entanglement, and entanglement means existence. There are no other physical processes except existence and entanglement. Each event of existence is described in terms of the randomized intervals of separation and duration. The space-time continuum is described as an emergent phenomenon of PlanckITs into an addressable continuum of PlanckYTEs. The definitions of Planck's unit of length, time, and mass are derived from two conditions: the condition for the existence of the randomized spatial and the randomized temporal intervals; the condition for the existence of the space-time continuum. A number called Planck's number is introduced to describe the processes in the Planckian universe. Planck's number N_0 represents the number of PlanckITs in a PlanckYTE. Several expressions are presented that support the hypothesis that the latest generation of the leptons and the quarks carry the information for the evolution of the universe. These expressions give the local and the galactic parameters of the solar systems that support life, the total mass and size of the universe, the critical density, and the Hubble's constant. The beginning moment, the ending moment, and the expansion factor of the initial cosmological expansion are also calculated. A range for the value of the mass of black hole is also derived. This article is a supplementary paper to the research papers: "A Unified Model of Natural Evolution and the Crises in Particle Physics and Cosmology"; "Evolutionary Anthropodynamics: The Evolution of Intellectual Systems" [1,2].

Keywords - Evolution of the universe; Cosmological inflation, Origin of life; Entropy of black hole; Planck's mass; Planck's time; Planck's length

1 Introduction

The unified model of natural evolution (henceforth UMNE)[1] describes the evolution of physical, biological, and social systems using a fundamental principle that incorporates the internal symmetries among evolving objects. In UMNE, natural evolution is described as a multistage process where each stage follows one another in a strict chronological order. The Planckian stage of natural evolution represents the beginning of the universe. The Standard Model of particle physics and the Big Bang theory have achieved brilliant success in describing the evolution of the universe after a fraction of a second from its beginning, but they've failed to describe the very early moment of the universe. There is a general consensus among the theoretical physicists that a new approach is required to describe the events in the Planckian universe. There are many theories, such as loop quantum gravity (LQG), casual set theory (CST), and super string (SS) theory that attempt to combine the quantum mechanics and the general relativity to tackle this problem. Moreover, all these theories face some difficulties in developing a comprehensible description of the space and the time at Planck's scale. Accordingly, a new approach based on the fundamental principles of quantum mechanics, Einstein's theory of gravity, and the UMNE may be helpful to understand the processes at Planck's scale. Additionally, the hypothesis that leptons and quarks carry evolutionary information requires some supporting evidences. In the first paper [1], some conditions relating to the origin of the life and the fate of the universe are discussed. Naturally, a detailed description of the information carried by the leptons and quarks is necessary.

2 Methodological Reductionism

In this section, a method for the deduction of the most fundamental properties of the space and the time is discussed. A top-down reductionist approach is employed to achieve this goal. There are three types of reductionism in philosophy: ontological reductionism, epistomic reductionism, and methodological or scientific reductionism [3]. The methodological reductionism is the best scientific strategy to reduce the explanations of a complex system to the smallest possible entities. This approach is widely used in biology and psychology. For example, all biological processes can be explained in terms of the underlying biochemical and molecular processes within the cell. The Stanford Encyclopedia of Philosophy [4] defines this approach as follows: "The term 'reduction', as used in philosophy, expresses the idea that if an entity 'x' reduces to an entity 'y' then 'y' is a sense prior to x, is more basic than x, is such that x fully depends on it or is constituted by it." According to this definition, a reduced form of the entity can be defined as an entity that appears before or more fundamental than the entity in consideration. A reductionist approach based on the unified model of the natural evolution (UMNE) is discussed in this section. The natural evolution is a process in which evolving objects appear in a strict chronological order. For example, a human being had appeared later than the eukaryotic cell did. On the other hand, the eukaryotic cell is the structural and functional basis of the human body. Following the definition of the reduced entity, the eukaryotic cell is a reduced entity of human beings among the products of the natural evolution. Similarly, we can apply this reductionist approach to understand the nature of the reduced entity for the objects of the physical world, such as atoms and elementary particles.

According to UMNE, an entity of a particular stage of the natural evolution is endowed with a stage specific form of the fundamental interaction [1]. In addition, each entity also possesses all the fundamental interactions of the stages appeared prior to the stage under consideration. For example, a cell belongs to the Darwinian stage of evolution, and it possesses the stage specific interaction mediated through the consciousness. It also possesses the interaction of the Einsteinian and the Planckian stages, i.e., the fundamental interactions of the Standard Model of particle physics and entanglement, respectively. But a cell does not possess the fundamental interaction mediated through the intellect, i.e. the fundamental interaction of the intellectual stage. Additionally, existence in the space-time continuum or the gravitational interaction is common to all evolutionary entities. In other words, as we move back in time from a particular stage of natural evolution to its immediate previous stage in this evolutionary theater, the reductionist approach is applied to strip off the stage specific interaction of the evolving objects of this stage.

The purpose of this section is to deduce the most fundamental properties of the space and time using the methodological reductionist approach. In the first paper [1], the following Fundamental Principle is introduced to describe the natural evolution:

Internal Symmetry of Objects→ Localization of the Symmetry →Interaction Between Objects→ Information Processing

According to this principle, a fundamental interaction is the result of the localization of an internal symmetry of the evolving objects. It means that the reduction of a fundamental interaction is equivalent to the reduction of the internal symmetry of the evolving objects. In other words, when a cell is stripped off the fundamental interaction mediated through the consciousness, the cell simply no longer has the life symmetries: S1, S2, S3, and S4 [1]. Without these life symmetries, a living cell just becomes a collection of atoms and molecules interacting through the fundamental interaction of the Standard Model of particles physics and the gravity. In the case of the de Sitter space-time continuum, the maximum possible symmetry is the Poincaré symmetry. This space-time continuum contains the following symmetry: 4 translations (3 spatial and 1 temporal) and 6 rotations (3 purely spatial rotations and 3 spatio-temporal rotations called boosts). The de Sitter space-time constitutes the space-time continuum for all the stages of the natural evolution except the Planckian stage. During the transition from the Planckian stage to the Einsteinian stage, the space and the time undergo a radical change. Following the reductionist approach, we can conclude that the space and the time of the Planckian stage must have a reduced symmetry in comparison with the de Sitter space-time continuum. It means that if we move backward from the Einsteinian stage to the Planckian stage, the maximal symmetry of the de Sitter space-time continuum must be reduced to some simpler form of the symmetry for the space and the time. The Poincaré group of symmetry has two Casimir invariants: mass and spin. In other words, any physical state in the Poincaré group can be described by the quantum numbers of mass and spin. We can assume that the space and the time in Planck's universe has the skeletal structure of the Poincaré group of symmetry i.e. one spatial translation symmetry and one temporal translation symmetry. This kind of symmetry ensures the emergence of the full set of Poincaré symmetries after the transition into the Eisteinian stage. In its simplest form, the space and the time has no rotational and boost symmetries. It has only the symmetry of one spatial translation and one temporal translation. Furthermore, it has only one Casimir invariant: mass. Accordingly, the mass quantum number can describe any physical state in the Planckian universe. In other words, only linear momentum and energy can be assigned to any physical state of the Planckian space and the Planckian time of the minimum possible symmetry. A PlanckIT represents existence in the Planckian universe; additionally, the physical state of a PlanckIT is described by entanglements with all other PlanckITs. It means that the parameter mass describes the statistical characteristics of these entanglements.

3 Mathematical Model of the Space and the Time at Planck's Scale

3.1 The Equation of State for the Planckian Universe

In the previous section, we see that the most fundamental entities of nature are mutually entangled PlanckITs. According to quantum mechanics, the phenomenon of entanglement is a consequence of the superposition of the states of a physical system. In the Planckian universe, there are no other processes except the existence and the entanglement. In other words, in the Planckian universe, existence means entanglement, and entanglement means existence. The physical description of the Planckian stage is the description of the mutual entanglements among the PlanckITs. Suppose, there are N PlanckITs in the Planckian universe. It means that any PlanckIT is in a state of entanglement with all of the remaining N - 1 PlanckITs. An entanglement between two PlanckITs is characterized by two parameters: the spatial separation and temporal interval between two events of existence. We denote the spatial separation and the temporal intervals by l_i and t_i respectively. The existence and entanglement of each of the PlanckITs are characterized by the distributions of N-1 spatial separations and N-1 temporal intervals. Suppose, the probability of a particular spatial separation l_i is given by:

$$P(l_i) = \ A \ l_i \ exp(-l_i/\alpha) \tag{1}$$

where A and α are two non-zero constants. The value of A can be obtained from the conditions $\sum_{n=1}^{N-1} P(l_i) = 1$. For very large N, (N is about 10^{69}) the sum $\sum_{i=1}^{N-1}$ can be replaced by the integral $\int_0^{\infty} dl$. The value of A is α^{-2}. Suppose, the mean and the standard deviation of this distribution are $\bar{L}$ and σ_L respectively. Then we get:

$$\text{Mean:} \quad \bar{L} = \int_0^\infty l_i \, P(l_i) \, dl = 2\alpha \tag{2}$$

$$\text{Variance:} \quad \sigma_L^2 = \int_0^\infty l_i^2 \, P(l_i) \, dl - (\bar{L})^2 = 2\alpha^2 \tag{3}$$

$$\text{Standard Deviation:} \quad \sigma_L = \sqrt{2}\alpha \tag{4}$$

Similarly, the probability of a particular temporal interval t_i is given by:

$$P(t_i) = B \; t_i \; exp(-t_i/\beta) \tag{5}$$

where B and β are two non-zero constants. Suppose, the mean and the standard deviation of this distribution are $\bar{T}$ and σ_T respectively. Then, we get $\bar{T} = 2\beta$ and $\sigma_T = \sqrt{2}\beta$. From equations (2) and (4) we get:

$$\bar{L} = \sqrt{2}\sigma_L \tag{6}$$

Similarly , we have

$$\bar{T} = \sqrt{2}\sigma_T \tag{7}$$

This means that the standard deviation of L can never be zero unless the mean value of L is zero. In other words, there would be no distribution of constant spatial separations for which $\bar{L} \neq 0$ and $\sigma_L = 0$. If $\sigma_L = 0$, then $\bar{L} = 0$. This condition guarantees the existence of a random distribution of spatial separations with non-zero mean and variations. Similarly, the same conclusions can be made for the temporal intervals.

The most important feature of these distributions is that all characteristics of space and time are defined by two non-zero constants α and β. Consequently, these two constants define the following fundamental properties of the space and the time: the homogeneity of the space and the homogeneity of the time.

The Planckian universe consists of N mutually entangled PlanckITs. The mean and the standard deviation describe the statistical characteristics of the entanglements of a single PlanckIT with the remaining PlanckITs. It means that these statistical parameters describe the existence of an individual PlanckIT. We can assume that all PlanckITs are equivalent. This assumption reflects the fact that Planckian universe represents the simplest form of existence in space and time. We can also assume that there is a simple correlation between the distribution of l_i and t_i of a particular PlanckIT. Based on the property of space and time derived from special relativity, we can define this correlation for any PlanckIT as:

$$\bar{L} = c \, \bar{T} \tag{8}$$

Using relations (6), (7), and (8), we get:

$$\sigma_L = c \, \sigma_T \tag{9}$$

where c is a constant. The constant c plays the same role as the ideal gas constant R does in thermodynamics. But our experience with the macro-world beyond Planckian universe tells us that c is the speed of light in a vacuum. This means that the value of c is determined by the properties of the space and the time at Planck's scale. We can call equation (8) as the equation of state of PlanckITs in the Planckian universe. This equation of the state reflects the fact that greater the average spatial separation between any two events of existence represented by two PlanckITs, greater the average time interval between them.

3.2 Conditions for the Existence of the Randomized Space and the Randomized Time

The standard deviation of the distribution of the space intervals σ_L gives the uncertainty in position of an individual PlanckIT. Similarly, the standard deviation of the distribution of the time intervals σ_T gives the uncertainty in the duration of any entanglements of an individual PlanckIT. The equation of state of the Planckian universe does not guarantee that σ_L and σ_T do not reduce to zero.

In the previous section, we discussed that the non-zero mean value of the spatial separation and the temporal intervals can be guaranteed by the non-zero value of their variances or standard deviations. In other words, if the values of σ_L and σ_T are zero, then the distributions of the intervals of the space and the time become trivially zero respectively. To ensure the existence of the randomized distribution of the intervals of the space and the time, we must define conditions for the randomization of the intervals of the space and the intervals of the time independently from each other. We call these conditions as the condition for the existence of the randomized space and the condition for the existence of the randomized time respectively. Using if AB = C, then C$\neq 0 \Rightarrow A \neq 0, B \neq 0$.

These conditions can be achieved by the following equations:

$$\sigma_L \pi_L = \hbar/2 \tag{10}$$

$$\sigma_T \epsilon_T = \hbar/2 \tag{11}$$

where π_L and ϵ_T are two parameters that describe properties of the space and the time respectively, and $\hbar$ is a non-zero constant. π_L is called the spatial existential conjugate parameter and ϵ_T is called the temporal existential conjugate parameter. If we compare these equations with the Heisenberg's uncertainty conditions, then $\hbar$ is Planck's constant. Additionally, π_L and ϵ_T are identified as uncertainties in linear momentum and energy respectively. It becomes obvious that $\hbar$ is also defined by the properties of the space and time at Planck's scale. The most interesting feature of the Planckian universe is that the conditions of existence guarantee the non-zero value of $\bar{L}$, $\bar{T}$, α and β.

Since σ_T represents the uncertainty of the duration of entanglement events, we can assign the parameter ϵ_T the meaning of uncertainty in energy. Then, comparing with the Heisenberg uncertainty relation and using the well known mass-energy relation of special relativity, we get:

$$\epsilon_T = mc^2 \tag{12}$$

Using the relations (9), (10), and (11), we get:

$$\pi_L = mc \tag{13}$$

It is noteworthy that we are using the well known relation from our known physical world such as Heisenberg's uncertainty principle and Einstein's mass energy relation to derive the fundamental properties of the space and the time. This is reasonable because these relations are derived from the principles that reflect the basic properties of the physical world and the space-time continuum.

As stated earlier, any physical state of PlanckITs is described by the parameter mass. Accordingly, m represents the mass of a PlanckIT. The meaning of the parameter m in the context of Planckian universe would be clear in the next section.

3.3 Condition for the Existence of the Space-Time Continuum and Planck's Units

According to UMNE, the Planckian universe of the randomized space and the randomized time evolves into an addressable manifold of continuous space-time at the moment of transition to the Einsteinian stage. At Planck's scale, the space and the time describe the entanglement of the PlanckITs among themselves. Each entanglement is characterized by the random values of spatial and temporal intervals. But in the Einsteinian stage, the randomly existing space and randomly existing time transform into a continuum or manifold called de Sitter space-time with maximal symmetry of the Poincaré group or de Sitter vacuum. The properties of the de Sitter vacuum is described by the theory of general relativity. The theory of general relativity asserts that any two objects can have individual existence in the space-time continuum if the spatial separation between them is equal or greater than the Schwarzchild's radius (r_s) of the greater mass. It means that a collection of PlanckITs emerge into a continuum if only if all PlanckITs satisfy the criteria for the existence in de Sitter space-time continuum. If we imagine two PlanckITs of equal mass M exists in a de Sitter space-time continuum, then their minimum separation must be:

$$d_{min} = r_s = 2GM/c^2 \tag{14}$$

On the other hand, the spatial uncertainty of the position of any individual PlanckIT in the Planckian universe is equal to σ_L. For any two PlanckITs, the uncertainty between their spatial positions is given by the rule of propagation of uncertainties. For two variables with Gaussian or normal distribution, the uncertainty is given by the square root of the sum of their variances.

$$\sigma_{12} = \sqrt{\sigma_1^2 + \sigma_2^2} \tag{15}$$

But the distribution of l_i is not Gaussian in nature. From equation (2) and (4), it is clear that the mean and the standard deviation is proportional to each other. This means we can assume that the rule of propagation for l_i uncertainty is different from (15). The distribution for the difference for l_i for two PlanckITs has the mean $\bar{L_1}$ -$\bar{L_2}$ and the standard deviation $\sigma_1 + \sigma_2$. Accordingly, the rule for propagation for the uncertainty is given by simple rule of propagation of uncertainty. The simple rule states that the uncertainties of quantities are always added for the sum or difference of any two random quantities. Thus, the uncertainty in separation for two PlanckITs is:

$$\sigma_{12} = \sigma_1 + \sigma_2 \tag{16}$$

Since all the PlanckITs have the same mean and standard deviation, the total uncertainty in the spatial distribution of any two PlanckITs is $2\sigma_L$. Accordingly, the equations (10), (14), and (16) give the condition for the existence of the space-time continuum:

$$2\sigma_L = d_{min} \tag{17}$$

$$2\hbar/(2Mc) = 2GM/c^2 \tag{18}$$

$$M = \sqrt{\hbar c/2G} \tag{19}$$

The quantity M is called Planck's unit of mass and denoted by M_P. Physicists usually prefer the expression M = $\sqrt{\hbar c/G}$ for Planck's mass [5]. But the factor 2 in the denominator is very important as it becomes clear later in this paper.

We set the Planck's unit of length and time equal to σ_L and σ_T respectively. This is because the standard deviation of spatial separation and temporal duration is identical to the uncertainties of the corresponding variables. Using the equations (12) and (13) we can write $\pi = M_P$c and $\epsilon_T = M_P c^2$.

Finally, we have the Planck's units using equations (8), (10) and (11) as expressed below:

$$\text{Planck's Mass:} \quad M_P = \sqrt{\hbar c/2G} = 1.53897148 \times 10^{-8}\ \text{kg} \tag{20}$$

$$\text{Planck's Length:} \quad L_P = \sigma_L = \sqrt{\hbar G/2c^3} = 1.14286489 \times 10^{-35}\ \text{m} \tag{21}$$

$$\text{Planck's Time:} \quad T_P = \sigma_T = \sqrt{\hbar G/2c^5} = 3.81218693 \times 10^{-44}\ \text{s} \tag{22}$$

The Planck's units play an important role in the evolution of the universe. There are many ways to deduce the Planck's units [5]. All methods except the one proposed in this paper are empirical in nature. However, in this paper, fundamental principles of physics are used to derive these units. The constant $\hbar$ and c have different meanings than their traditional ones. Usually, the constant c represents the speed of light in vacuum or maximum speed of propagation of information as postulated in special relativity; however, here, it represents the coefficient of correlation between the randomly varied intervals of spatial separations and temporal intervals in equation (9). Additionally, the constant $\hbar$ guarantees the existence of non-zero intervals for the randomized space and the randomized time. As a result, the structure of the space and the time at Planck's scale is determined by only two fundamental constants: $\hbar$ and c. Importantly, at Planck's scale, the space and the time constitute a continuum when the condition of existence (17) is satisfied. This condition requires that the PlanckITs must satisfy the condition for existence in a manifold given by the Schwarzchild's radius. A new constant G is introduced to define this condition. Naturally, the constant G appears to be the gravitational constant. The equations (10) and (11) resemble the Heisenberg uncertainty relations of quantum mechanics that limits the uncertainties of measurement of position and duration. In this way, the space-time continuum acquires the features of special relativity, general relativity, and quantum mechanics. In short, this approach for the derivation of the Planck's unit of length, time, and mass is fundamentally different from the existing ones.

3.4 Alternative Derivation of Planck's Units and a Comparative Evaluation

The derivation of the Planck's unit in the previous section employs a new approach. It is useful to compare it with the existing methods of derivation. The existence of the natural units of length, time, and mass was first suggested by Johnstone Stoney in 1874 [5]. He showed that these 3 natural units can be expressed in terms of elementary charge, Newtonian gravitational constant, and the speed of light. In modern scientific terms, Stoney's units can be written as:

$$\text{Mass:} \quad M_S = \sqrt{e^2/4\pi\epsilon_0 G} = 1.86 \times 10^{-9}\,\text{kg} \tag{23}$$

$$\text{Length:} \quad L_S = \sqrt{e^2 G/4\pi\epsilon_0 c^4} = 1.37 \times 10^{-36}\,\text{m} \tag{24}$$

$$\text{Time:} \quad T_S = \sqrt{e^2 G/4\pi\epsilon_0 c^6} = 4.59 \times 10^{-45}\,\text{s} \tag{25}$$

At the time of Stoney's proposal, there were no electrons, no quantum mechanics, and no special theory of relativity. Later, Planck proposed a set of units using only three fundamental constants $\hbar$, c, and G.

We discuss the derivation of the Planck's units using Bridgman's theorem of dimensional analysis. Bridgman's theorem states that any physical quantity Q can be expressed in the form:

$$Q = C q_1^{\alpha} q_2^{\beta} q_3^{\gamma} \tag{26}$$

where C is a dimensionless quantity; q_1, q_2, and q_3 are base physical quantities, and α, β and γ are rational numbers.
Using the three fundamental constants $\hbar$, c and G for q_1, q_2, and q_3 respectively, we can deduce the following values for Planck's constants

$$\text{Planck's Mass:} \quad M_P = A_1 \sqrt{\hbar c/2G} \tag{27}$$

$$\text{Planck's Length:} \quad L_P = A_2 \sqrt{\hbar G/2c^3} \tag{28}$$

$$\text{Planck's Time:} \quad T_P = A_3 \sqrt{\hbar G/2c^5} \tag{29}$$

where $A_1, A_2, and\ A_3$ are dimensionless numbers.

We can establish a relation between Stoney's and Planck's unit by using the fine structure constant of electromagnetic interaction $\alpha_{EM}= e^2/(4\pi\epsilon_0\hbar c)$. The relation is Stoney's Unit = $\sqrt{\alpha_{EM}}$ Planck's Unit.

If we compare the expression for the Planck's unit derived by Stoney and Planck with the units that are derived in this paper, we see that there are lot of ambiguities in the former case. The dimensionless constants must be determined from the experiments which are impossible at the Planck's dimension. Additionally, we can use any of the following fine structure constants for the three types of interaction of the Standard Model of particle physics: α_{EM} = 0.00729, α_{Weak} = 0.03383, α_{Strong} = 0.1184 [5]. In short, the existing methods of the derivation of the Planck's unit are not fundamental in nature. So we can't use ambiguous values as the bases of the unified model of natural evolution. On the contrary, the Planck's unit derived in this paper have no ambiguities in their values. Comparison shows that the values of the dimensional constants are $A_1 = A_2 = A_3 = 1$. In this paper, the Planck's unit of mass, length, and time are derived from the fundamental properties of space and time defined by special relativity, general relativity, and quantum mechanics. Furthermore, the factor 2 in the formulas is very important as we see later.

3.5 An Important Number in the Universe

In nature, some numbers generate curiosity about what they mean. One of these numbers is the Avogadro's number. Why does it exist? We know that the macroscopic properties of a substance are usually expressed in terms of moles. For example, the specific heat capacity of a substance is expressed in Joules/(Kelvin · moles). This means that we can't apply the idea of the specific heat capacity to a single atom or molecule. Rather, we always refer it to a certain number of atoms, molecules or other particles. Similarly, we can't apply the concepts of heat and temperature to individual particles. On the contrary, we can assign a certain amount of kinetic energy and mass to a single particle. The reason is that the concepts of the heat and temperature are related to the thermodynamic properties of an ensemble of particles. The thermodynamic properties are defined by the statistical parameters such as average value of a quantity taken over an ensemble. The fluctuation of any statistical parameter from its average value depends on the number of the particles in the ensemble. In other words, the greater the number of the particles in an ensemble the greater the accuracy of its thermodynamic properties. In this sense, we can get an idea of what the Avogadro's number means. This number shows how accurately the thermodynamic properties of a system are described. If the number of particles in a system is greater than a significant fraction of a mole i.e 6.02×10^{23}, then the values of the parameters describing thermodynamic properties are well defined. This is why the Avogadro's number plays an important role in the description of nature.

The properties of the Planckian universe are described by the statistical parameters such as mean and standard deviation of the distributions of intervals of the space and the intervals of time. We assume that the Planckian universe has N PlanckITs, and each event of entanglement is described by a pair of the intervals of the randomized space and the randomized time respectively. It means that there are N-1 events of entanglement associated with a particular PlanckIT. The question is: Is there any number like the Avogadro's number in the Planckian universe? Luckily, nature has such a number. We can call this number as Planck's number N_0. The Planck's number determines the minimum number of entanglements which must be considered to make the description of the Planckian universe statistically reliable. Later in this paper, we see that N_0 plays an important role in the evolution of the universe and the origin of life on Earth. It also plays a role in the emergence of the space-time continuum of the Einsteinian universe from the Planckian universe of the randomized space and the randomized time. Consequently, it becomes undoubtedly evident that N_0 is one of the important numbers in the universe.

3.6 A Description of the Planckian Universe

In the preceding sections, the basic properties of the Planckian universe are discussed. The Planckian universe represents the initial state of our universe. It consists of N PlanckITs where every PlanckIT is entangled with all the remaining PlanckITs. Each entanglement is described by a pair of variables: an interval of space l_i and an interval of time t_i. These intervals are randomly generated and have a Maxwellian like distribution (1) and (5). The equation of the state of the Planckian universe is given by (8). The conditions (10) and (11) are necessary and sufficient conditions of the existence for these distributions. These conditions guarantee that the standard deviations of the distribution of space and time intervals must have non-zero values.

We suppose that every event of existence can be described by a wave function ϕ (l_i, t_i). The square of the amplitude of this wave function gives the probability of events of existence with separation l_i and duration t_i. We can define a Hilbert space with a basis for every event of existence. We can also express any wave function as a linear combination of the basis vectors.

From the discussion in the previous section, it is clear that the Planck's number N_0 plays a role in describing the processes of the Planckian universe as the Avogadro numbers does in describing the state of ideal gas. The Planck's unit of length and time relates the Planckian universe with our known universe. They represents the smallest intervals of the space and time that can be defined in the space-time continuum. The Planck's unit of length plays an important role in other contemporary candidates for the theory of quantum gravity: loop quantum gravity, black hole theory, and string theory. For example, in the loop quantum gravity, Planck's area and Planck's volume play an important role. Similarly, in cosmology, the entropy of black hole is expressed in terms of the Planck's area. In light of the previous discussion, we can assume that the Planck's dimensions are key to the description of the processes in the Planckian universe.

For this purpose we use the idea of a PlanckYTE - a collection of N_0 PlanckITs - as the basis of the description of the Planckian universe. We assume that the state of a PlanckYTE is described by a wave function ψ. The Hilbert space of the wave function ψ can be written as a direct product of Hilbert spaces of a individual PlanckITs ϕ.

$$\psi = |\phi_1\rangle \otimes |\phi_2\rangle \otimes |\phi_3\rangle \otimes |\phi_4\rangle \otimes \cdots \tag{30}$$

The square of the amplitude of the wave function ψ gives the probability of the particular configuration of a PlanckYTE — a collection of N_0 events of existence. Since Planckian events of existence are distinguishable from one another because of their differences in values of spatial and temporal intervals, a different arrangement corresponds to a different macro-state. For example, if we take three PlanckITs (events of existence) represented by the wave functions ϕ_1, ϕ_2, and ϕ_3, then there are six macroscopic states of existence:

$$|\phi_1\rangle|\phi_2\rangle|\phi_3\rangle,\ |\phi_1\rangle|\phi_3\rangle|\phi_2\rangle,\ |\phi_2\rangle|\phi_1\rangle|\phi_3\rangle,\ |\phi_2\rangle|\phi_3\rangle|\phi_1\rangle,\ |\phi_3\rangle|\phi_2\rangle|\phi_1\rangle,\ \text{and}\ |\phi_3\rangle|\phi_1\rangle|\phi_2\rangle.$$

The number of macro-states is given by 3!. Any wave function representing the macro-state containing three events is given by the superposition of six macro-states of different arrangements as follows:

$$\begin{aligned}\psi = &c_1|\phi_1\rangle|\phi_2\rangle|\phi_3\rangle + c_2|\phi_1\rangle|\phi_3\rangle|\phi_2\rangle + c_3|\phi_2\rangle|\phi_1\rangle|\phi_3\rangle \\ &+c_4|\phi_2\rangle|\phi_3\rangle|\phi_1\rangle + c_5|\phi_3\rangle|\phi_2\rangle|\phi_1\rangle + c_6|\phi_3\rangle|\phi_1\rangle|\phi_2\rangle.\end{aligned} \tag{31}$$

where the square of the coefficients c_i give the probability of the particular arrangements of the events.

Similarly, we can apply the same argument for the number of macro-states of a PlanckYTE. There are N_0! macro-states in the ensemble of a PlanckYTE. This means a PlanckYTE can exist in any one of N_0! macro-states.

One of the fundamental property of a quantum system is the superposition of states. So, any state of the PlanckYTE should be in a superposition of $N_0!$ macro-states. Another fundamental property of quantum system is entanglement. Quantum entanglement is the consequence of the superposition principle. Moreover, we must consider that the entanglements between PlanckITs are quantum in nature. It means that the Planckian universe has entanglement entropy. Like Planck's unit of length, time, and mass, we can also define the Planck's unit of entanglement entropy.

The formula for the entanglement entropy is as follows [6]:

$$S = -k \sum_{n=1}^{N_0!} p_i log(p_i) \tag{32}$$

where p_i is the probability of particular macro-state and k is the Boltzmann constant.

There are two extreme cases for entanglement entropy. In the first case, the wave function of the ensemble consists of pure states corresponding to the individual wave functions. There is only one macro-state. There is no superposition of states. In this situation $p_i = \delta_{ik}$. In this case of complete certainty, the probability of a macro-state is either 1 or zero. Hence, the entanglement entropy of the ensemble of PlanckYTEs is zero because either log 1 = 0 or $p_i log(p_i) = 0$ in the the limiting case of p_i tends to zero. In the second case, there is complete uncertainty when a macro-state is a superposition of all available macro-states; the N_0 events of existence are maximally entangled among themselves. In this case, all macro-states are equally probable, and each state has a equal probability of $1/N_0!$. The entanglement entropy is

$$S = -k \sum_{n=1}^{N_0!} (1/N_0!)\ log(1/N_0!) = \ k\ log((N_0!) \tag{33}$$

Therefore, the entanglement entropy of an ensemble consisting of N_0 PlanckITs has a value in the range from 0 to k log($N_0!$). Furthermore, the principle of maximum entropy [7] states that the probability distribution which best represents the current state of knowledge about a system is the one with largest entropy. Using this principle and the Sterling's formula for large N, $\log(N!) = N(logN - 1)$, we can define the Planck's unit of entropy as follows:

$$\begin{aligned} \text{Planck's unit of entropy} \quad S_P &= k \log(N_0!) \\ &= kN_0(\log N_0 - 1) \end{aligned} \tag{34}$$

Additionally, we can calculate the total mass, total entropy, and temperature of the Planckian universe.

$$\begin{aligned} \text{Total mass} \quad & M_{tot} = NM_P \\ \text{Total entropy} \quad & S_{tot} = (N/N_0)S_P = kN(\log N_0 - 1) \\ \text{Temperature} \quad & \theta_P = M_P c^2/k \end{aligned} \tag{35}$$

where N is the total number of PlanckITs in Planck's universe.

The Planckian universe has very low entanglement entropy. The transition of the Planckian stage into the Einsteinian stage is associated with many fold increase of the entropy of the universe. Thus, the law of increasing entropy is a fundamental law of nature; the increase in entropy is the primary cause for evolution. This huge increase in entanglement entropy is resulted from the creation of space-time continuum.

4 Carriers of the Evolutionary Information

4.1 Down-quark: The Eternal Prisoner and the Secret of Life

The idea of the 'quark' was introduced by Murray Gell-Mann and George Zweig in 1964 to explain the hierarchy in the multitude of the elementary particles called hadrons. Hadrons are numbered over hundreds; they could be categorized in groups of eights and tens called octet and decaplets respectively. The introduction of the quarks dramatically reduced the number of truly elementary particles. According to the quark hypothesis, the baryons are made of three quarks, and the mesons are made of a quark and an anti-quark. The quark structure of the baryons had faced another challenge. It happens that some baryons, for example, the Omega baryon (sss), has three identical strange quarks in the same state. This fact explicitly contradicts the Pauli exclusion principle or spin statistics that states: no two fermions can occupy the same state. Yochiro Nambu and M.Y. Han, independently A. Tavkhelidze and Y. Miyamoto proposed the color quantum number to save the correct spin-statistics for the quarks. Three colors - Red, Green, and Blue - actually describe three different species of quarks. Thus, we have three extra species for each of the six flavor of quarks. The introduction of color quantum number for quarks increased the number of fundamental elementary particles by a considerable margin; however, it helped to unify the whole particle physics under one standard theory called Standard Model of particle physics. Surprisingly, the introduction of quarks does not increase the number of hadrons. The number of hadrons remains unchanged because the quark model implies that any hadron must be colorless or white, a term to denote a special combination of colors that resulted into a white color. For example, a certain amount of red, green, and blue colors or a red and anti-red combines to form the white color. Scientists can build a colorless state from quarks in many ways. But there are restrictions on the number of quarks and anti-quarks that can comprise a composite particle. In reality, we usually have the system of three quarks or anti-quarks called baryon and anti-baryons respectively. Additionally, a system of quark and anti-quark is called mesons. This is because these composite systems of quarks fulfill the requirement of a colorless combination. For example, a system of two quarks or four quarks cannot be made colorless.

The quark model of hadrons has presented the physicists with a new challenge. There are a lot of indirect experimental evidences of the existence of the quarks within baryons, such as the proton or neutron. But scientists are not yet successful in separating an individual quark or anti-quark from a baryon or meson. In other words, quarks are eternally confined within the bounds of baryons or mesons. The quantum chromodynamics or the field theory of the strong interaction has achieved significant success in explaining the confinement of the quarks within baryons or mesons [8]. According to the quantum chromodynamics (QCD), eight gluons carry the strong interaction in the same way as the photon carries the electromagnetic interaction. But unlike photons, the gluons themselves carry the color quantum number and interact with one another. As a result, two new phenomena - the asymptotic freedom and the infrared slavery - characterize the strong interaction between quarks. The asymptotic freedom asserts the fact that the strength of the interaction between two quarks decreases to almost zero as they approach each other at very high energy. The infrared slavery states that the strength of the interaction between two quarks increases continuously or remains constant as the distance between the quarks increases. As a result, the bond between two quarks at large distance becomes so energetic that a pair of a quark and anti-quark replaces the bond; the process of separation of quarks results into formation of additional mesons. In other words, any attempt to disintegrate a baryon or meson into individual quarks produces more baryons and mesons but no free quarks. It means that a baryon or meson serves the role of an eternal prison for the quarks. A proton is composed of two up-quarks and one down-quarks, and a neutron has one up-quark and two down-quarks. Consequently, it can be assumed that the up- and down-quarks are eternal prisoners within the bounds of the proton or neutron.

In 1989, the author found that the down-quark (d-quark) contains information about the origin of life on the Earth. It alone contains the information about the mass of the planet, the mass of the central star of the solar system harboring life, and the temperature of the surface where life originated [9]. Using the information contained in the d-quark and other particles of first generation, we can formulate the necessary conditions for the origin of life and its sustainable future in the course of the evolution of the universe after the Big Bang. This research work is a direct product of the scientific inquiry that was initiated by the discovery of the role of the d-quark in the coding of evolutionary information three decades ago.

4.2 Neutrino : A Mysterious Particle of Nature

The neutrino is a mysterious particle of the universe. In 1930, Wolfgang Pauli proposed the existence of the neutrino to avoid the violation of the law of conservation of energy, linear momentum, and angular momentum during the beta decay of a nucleus. The role of these laws of conservation is so powerful in physics that the existence of the neutrino was immediately accepted by the scientific community without any experimental evidence for its existence. The experimental evidence of the existence of the neutrino came after 27 years. The reason for its elusiveness is the fact that the neutrino has no electric charge and no color, and it interacts only through weak nuclear and gravitational interactions. In the Standard Model of particle physics, neutrinos behave as an odd member of the community of fundamental particles. For example, all fermions of the Standard Model except neutrinos are ambidextrous. It means that they can exist in both left handed and right handed versions but neutrinos exist only in the left handed versions. There are no right-handed neutrinos in nature. This property of neutrinos makes them unable to interact with the Higgs boson because an interaction between a fermion and a Higgs boson changes the handedness of the former from left to right and vice versa. As a result, all fermions except neutrinos in the Standard Model acquired rest mass through the interaction with the Higgs boson after the spontaneous breakdown of electroweak symmetry had taken place. This is why physicists considered neutrinos as massless for a long time. But in 1998, scientists made another discovery that changed their minds about the mass of neutrinos. Neutrinos exist in three flavor belonging to the three generations. They are known as electron neutrino, muon neutrino, and tau neutrino. Scientists observed that the ratios of the different flavors of neutrino in a neutrino beam oscillate as the beam travels through space. For example, if we begin with a beam of pure electron neutrinos, the neutrinos of other two flavors will appear as the beam travels through space. The scientists concluded that such oscillation between flavors is only possible if the neutrinos have nonzero rest mass [10]. Moreover, the origin of the mass of neutrinos remains mysterious because the Standard Model of particle physics does not allow neutrino to have mass. Another mystery with neutrinos within the Standard Model is that the decay of muon or tauon is always associated with its own species of neutrino. For example, the decay of muon is always associated with the production of the mu-neutrino, or a decay of tauon is associated with the production of the tau-neutrino. A tauon can not decay into a mu-neutrino, electron-neutrino, and muon even though such a process is not prohibited by the laws of conservation of the particle physics. Though some scientists consider the right handed version of neutrinos as its antiparticle, many scientists don't agree on how a true anti-particle to neutrino looks like.

The purpose of this discussion is to investigate what is the role of the neutrino in the information system coded by elementary particles. One of the fundamental features of the neutrino as information carrier is that it codes the information about the initial inflationary phase of the Big Bang theory. According to the Big Bang theory, all quarks and leptons appeared during the particle era after the initial inflation had stopped. But the calculation shows that the parameters of the neutrino define the expansion factor of initial cosmological inflation and the final size of the universe at the end of the initial inflation. These two facts support the hypothesis that the neutrino's mass has a primordial origin, and neutrinos appeared earlier than the other members of the family of information carriers did. The information carried by neutrino is weakly related to the origin of life since it determines only the galactic habitable zone. The immediate conditions for the origin of life like information about life carrying solar systems are not directly coded by the neutrinos. Thus, the neutrino is a mysterious particle because of its origin and the role it plays in the evolution.

4.3 Proton : The Storehouse of Evolutionary Information

Prior to the hypothesis of the quark, all hadrons were considered elementary particles or fundamental constituents of the universe. Although all the members of the hadron family have been stripped off this honor, the proton becomes an exceptional case. It behaves as a fundamental constituent in all respects despite the fact that proton is composed of more fundamental particles called quarks. The lifetime of proton decay is more than 10^{34} years, whereas the other baryons except the neutron has a life time of less than 10^{-10}s. In this perspective, because the proton's life time is at least 10^{23} times longer than the age of the universe, the proton can be considered as a fundamental particle of the universe. Even the proton's counterpart the neutron doesn't live so long. A free neutron decays in 920 seconds, but it's almost as stable as proton when it exists in association with proton inside a nucleus. According to particle physics, if we switched off the electromagnetic interaction, the neutron and proton could be considered as two states of the same particle called the nucleon. In other words, the proton and neutron can be considered two charge states of the nucleon with charge +1e and 0e respectively, where e is the elementary charge. The stability of the neutron is the result of the switching charge states by exchanging charged pi-mesons. For this reason, the proton and neutron play the same role as a carriers of the evolutionary information.

The analysis of the structure of evolutionary information systems of the universe sheds some light on the fact why the proton has a theoretically infinite life time in contrast to all other composite elementary particles. The proton consists of two up quarks and one down quarks; however, the information is coded in only the down quark and the proton as a whole. No evolutionary information is coded by the two up quarks. This is because it would mean the existence of two particles carrying the same information in a system. On the other hand, two down quarks in a neutron carry duplicate evolutionary information. This duplication of evolutionary information explains the cause of the instability of a neutron in a free state. In a bound state inside a nucleus, the neutron can avoid this duplicity of information by exchanging pi-meson with the proton and becoming a proton. In this sense, the proton is more fundamental than neutron. Another important fact is that evolutionary information can be coded by a single quark or lepton as well as by any pair of the these particles. But in most cases, d-quark or proton as a whole takes part in coding the information. Based on these facts, we can consider the proton as the main storehouse of the evolutionary information for the evolution of the universe.

5 The Evolution of the Universe and the Origin of Life

5.1 The Structure of the Information System for the Evolution of the Universe

What physical quantities do we need to define the structure of the information system for the evolution of the universe? There are two types of physical quantities that we can employ to formulate the information coded by the first generation of quarks and leptons: the mass and charge of the leptons and quarks. Before listing these quantities, it is necessary to discuss the inclusion of the proton instead of the up-quark into the information system. As discussed in section 4.3, the proton can be considered as a fundamental particle despite being composed of two up quarks and one down-quark. The proton is the final evolutionary product of the particle era of Big Bang; its parameters are determined by the strong and weak nuclear forces acting among all the generations of quarks and leptons. The inclusion of proton in lieu of up and down quark as an information carrier makes the contribution of strong and weak nuclear interaction into the structure of evolutionary information system redundant. In other words, the proton itself accounts for the contributions of all sub-nuclear processes that resulted into its formation. The further evolution of the universe beyond the particle era is guided by evolutionary information coded by electron, electron neutrino, d-quark, and proton.

Further analysis of the structure of the information system for the evolution of the universe will be done in the framework of the UMNE. The purpose of this analysis is to identify the main events in the course of the evolution of the universe and define the parameters describing these events in terms of the information coded by the particles: proton, d-quark, electron and electron neutrino. In section 3, the description of the Planckian stage of the evolution of the universe is presented, and we defined the Planck's units of length(L_P), mass(M_P), time(T_P), and entropy(S_P) in terms of the fundamental constants $\hbar$, c, G, k and N_0. It means that these physical constants must be included in the list of the physical quantities that define the information system. We also can use only the fine structure constant of electromagnetic interaction instead of three coupling constants of Standard Model of particle physics.i.e. the strong coupling constant, the weak coupling constant, and the electromagnetic coupling constant. If we add to the list the masses of proton, d-quark, electron, and electron neutrino then we get the complete list of 10 physical quantities that define the set of evolutionary information for the universe. In summary, we need only 10 physical quantities and fundamental physical constants. The list below contains the physical constants and parameters of elementary particles with their values [11]:

- **Speed of light** $c = 2.99792458 \times 10^{8}\,\mathrm{m\,s^{-1}}$
- **Planck's constant** $\hbar = 1.05457182 \times 10^{-34}\,\mathrm{J\,s}$
- **Gravitational constant** $G = 6.67430 \times 10^{-11}\,\mathrm{m^3\,kg^{-1}\,s^{-2}}$
- **Planck's number** $N_0 = 4.1075 \times 10^{8}$
- **Boltzmann constant** $k = 1.380649 \times 10^{-23}\,\mathrm{J\,K^{-1}}$
- **Fine structure constant** $\alpha = 7.29735256 \times 10^{-3}$
- **Effective mass of proton** $m_p = \frac{m_p+m_n}{2} = \frac{1.67262193+1.67492750}{2} \times 10^{-27}\,\mathrm{kg} = 1.67377472 \times 10^{-27}\,\mathrm{kg} = 938.9\,\mathrm{MeV}$
- **Effective mass of d-quark** $m_d = 2.00853854 \times 10^{-29}\,\mathrm{kg} = 11.28\,\mathrm{MeV}$
- **Mass of electron** $m_e = 9.10938371 \times 10^{-31}\,\mathrm{kg} = 0.511\,\mathrm{MeV}$
- **Effective mass of electron neutrino** $m_\nu = 1.9609 \times 10^{-36}\,\mathrm{kg} = 1.1\,\mathrm{eV}$

All the values of the physical quantities and constants except the masses of d-quark and electron neutrino used in this paper are well accepted and experimentally verified. The values of the masses of the d-quark and electron neutrino have some discrepancies with the accepted values. The accepted values of masses of the d-quark is in the range 4.7 - 5.8 MeV [12], and the value of the electron neutrino is less than 1 eV [13]. The value of the effective mass of d-quark used in this paper is fixed by the parameters of the life harboring solar systems such as the mass of Earth, the mass of Sun and the temperature of the surface where life first originated. For example, the masses of the life-harboring planet and central star are uniquely determined by the mass of the d-quark alone. Since the mass of the Earth and the Sun are well determined physical quantities, there is no reason to change the value of the mass of d-quark. Furthermore, the mass of the electron neutrino lies within the upper boundary of the experimental values .

For further analysis, it is noteworthy that the value of the rest mass of d-quark and electron neutrino are uncertain by their nature. The rest mass of free d-work can't be directly measured because of the fact that quark cannot be separated from the baryon or meson. All calculations of the masses of quarks are done indirectly. For example, a neutron consists of 2 d-quark and 1 u-quark and weighs 947 Mev. It is obvious that the first approximation for the rest mass of the quark would be about 300 MeV. The small value of the rest mass of the d-quark is the consequence of the chiral symmetry or axial flavor transformation among up and down quarks. The masses of quarks are calculated in the model of lattice gauge theory of quantum chromodynamics. Additionally, in the electroweak theory, the mixing of the states of d-quark, s-quark and b-quark is required to explain the decay of baryons and mesons into the stable leptons and quarks of the first generation [14]. In other words, the value of the mass of the d-quark used in this paper can be considered as the effective mass of three generations of quarks i.e. d-quark, s-quark, b-quark. In this case, the effective rest mass of d-quark must be greater than accepted value of 4.7 Mev. In the context of the interpretation as an information carrier, we can assume that information carried by the d-quark is a superposition of information carried by all three generations of quarks. In the case of the neutrino, three different flavors of neutrino can mix to produce neutrino oscillation - an experimentally observed phenomenon [15]. According to particle physics, the three different states of the neutrino are three distinct super-positions of the three states of different masses. It means that the mass of the electron neutrino is a linear combination of all three types of the neutrinos. So the mass of electron neutrino used in this paper may be taken as the effective mass of a neutrino as a result of their mixing. As in the case of the d-quark, the information carried by the electron neutrino is a superposition of the information carried by three generations of neutrinos. In other words, the evolutionary information carried by all generations of lepton and quarks in some sense contribute to the final set of information.

5.2 Important Events During the Evolution of the Universe

The questions are: What events do we consider as very important in the natural evolution? How do we explain these events using the information coded by the latest set of fundamental particles? It is obvious that the beginning and ending moments of the initial inflation, should be coded by the information system of the elementary particles. At the end of the inflation, the universe gets all the characteristics of our observable universe including its flatness and the structure of the ordinary matter. It means that the expansion parameters as well as the total mass and size of the universe should be coded by the elementary particles. According to the inflationary paradigm, the density of the universe at the end of inflation must be fine tuned to the critical density observed today. Obviously, the next important event in the universe is the origin of life. In UMNE, the origin of prokaryotic cell denotes the beginning of the Darwinian stage in the same way as the emergence of ordinary matter denotes the beginning of the Einsteinian stage. The origin and sustainability of life require the fulfillment of many local and galactic conditions. Finally, the ultimate fate of the universe is also an important event that must be a part of evolutionary information system coded by elementary particles. According to the Standard Model of cosmology, the ultimate fate of the universe is determined by the total amount of all types of matter and energy present in the universe, and also by the current value of the Hubble's constant. In the following sections, some quantitative information for these events are presented in terms of 10 physical quantities listed in section 5.1.

5.2.1 Cosmological Inflation

The inflationary era constitutes the period of transition from the Planckian stage to the Einsteinian stage. In UMNE, the transition of the Planckian stage to the Einsteinian stage begins at Planck's time 3.8×10^{-44} s. The PlanckITs are the most primitive raw material for the natural evolution. The very first physical process in this universe is the phase change in which the PlanckITs are organized into primordial PlanckYTEs. The duration of this reorganization is determined by the Planck's number N_0. A PlanckYTE contains N_0 number of PlanckITs. Consequently, the time required for the reorganization into a PlanckYTE is $N_0 T_P$ or 1.6×10^{-35} s. In other words, this is the smallest duration of time during which any physical process can happen in the de Sitter space-time continuum. Consequently, the earliest possible moment for the beginning of the initial cosmological inflation should be equal to $N_0 T_P$. Similarly, the inflation cannot end before the appearance of the information carriers for the Eisteinian stages, such as leptons and quarks.

In this section, some formulas related to the inflationary period of Big Bang are derived using the set of constants and physical quantities listed before.

The moment of the beginning of the inflationary era is given by:

$$\tau_1 = N_0 T_P = N_0 \sqrt{\frac{\hbar.G}{2c^5}} = 1.5656 \times 10^{-35} s \tag{36}$$

The moment of ending of the inflation using (38), (50), and (51) is:

$$\tau_3 = 44\ ln10/(3.4 \times 10^{33}) = 2.9798 \times 10^{-32} s \tag{37}$$

The calculation of the moment for the ending of inflation in the expression (37) is obtained from final size of the universe and the expansion factor during inflation. The total size and total mass of the universe is calculated in the section 5.2.3 "The Fate of The Universe".

The expansion factor of the initial inflation is coded by neutrino and given by expression below:

$$S = S_0\ exp(\frac{2c^2}{\hbar} \sqrt[4]{\frac{\hbar c}{2G}} \sqrt{\frac{N_0 m_\nu}{3}}\ t) \tag{38}$$

where the S_0 is the size of the Planckian universe (see (50)) at the beginning of inflation and the S is size of the universe at the end of the initial cosmological inflation. With values of t given by (37), we found that the size of the universe is increases by a factor 10^{44} at the end of the inflation. The values obtained in this paper for the parameters of the initial inflation are in good agreement with the current estimate for these cosmological parameters.

From the equation (38), it is evident that the information carried by the neutrino is primordial than those carried by the electron and proton. It supports the fact that the origin and nature of neutrino is different from other fermions of the ordinary matter.

5.2.2 The Origin of Life

The origin of life is the most significant event in the course of the evolution of the universe after the inflationary era. The existence of life in this universe requires many conditions to be satisfied [1]. Solar systems with the characteristics similar to our own satisfy these requirements. It means that the evolutionary information system must code the parameters of our own solar system.

The mass of the planet is given by:

$$M_E = \frac{9\hbar c N_0}{2\alpha m_d G} = 5.9737 \times 10^{24}\,\text{kg} \tag{39}$$

The mass of the central star is given by:

$$M_S = \frac{N_0^2 \hbar c}{2 m_d G} = 1.9895 \times 10^{30}\,\text{kg} \tag{40}$$

The temperature at which life might originate is:

$$T_E = \frac{m_d c^2}{k N_0} = 318.32\,\text{K} = 45.3°\text{C} \tag{41}$$

The expression (39), (40), and (41) show that the d-quark alone carries the most important information about the origin of life in this universe.

The planetary habitable zone is given by the following expressions:

The nearest distance of the life bearing planet from the central star:

$$R_{Emin} = \frac{2\hbar}{\alpha^2\, m_p\, m_e}\sqrt{\frac{\hbar}{2\,G\,c}} = 1.3335 \times 10^{11} m = 0.89 AU \tag{42}$$

The farthest distance of the life bearing planet from the central star:

$$R_{Emax} = \frac{9\hbar}{2\,\alpha\, m_d\, m_e}\sqrt{\frac{\hbar}{2\,G\,c}} = 1.8246 \times 10^{11} m = 1.22 AU \tag{43}$$

There is a good agreement of the obtained values for the parameters of the life harboring solar systems with the observed values. Because the masses and charges of three atomic particles are used in the above formulas, this shows that the parameters of a life harboring solar system are actually coded by the d-quark, proton and electron. The contribution of the evolutionary information coded by any flavor of neutrinos is totally absent in determining the local conditions for the origin of life.

The diameter of the inner boundary of the galactic habitable zone

$$d_{Gmin} = \frac{N_0\,\hbar}{2\, m_p\, m_\nu}\sqrt{\frac{\hbar}{2\,G\,c}} = 3.3875 \times 10^{20} m = 35,811\ ly \tag{44}$$

The diameter of the outer boundary of the galactic habitable zone:

$$d_{Gmax} = \frac{N_0\,\hbar}{2\,m_d\,m_\nu}\sqrt{\frac{\hbar}{2\,G\,c}} = 2.8229\times 10^{22} m = 2.9842\times 10^{6}\ ly \tag{45}$$

It is obvious from the above formulas that information coded by neutrino plays an important role in coding the galactic condition for the origin and sustainability of life in the universe.

The local and galactic conditions determine the place where life could originate and develop. But the universe was not always hospitable for the origin of life and its subsequent evolution. For example, the universe was very hot for few hundred thousand years after the Big Bang. Consequently, there should be some temporal conditions that restrict the earliest possible moments for some events related with the origin of life.

The earliest moment of the origin of the sun like stars (G2 spectral type) is given by:

$$T_{Smin} = \frac{9\,N_0^2\,\hbar}{2\,\alpha m_p\,m_d\,c}\sqrt{\frac{\hbar}{2\,G\,c}} = 5.5884\times 10^{16} s = 1.7709\times 10^{9}\ years \tag{46}$$

The earliest moment of the origin of the life in the universe is given by:

$$T_{Lmin} = \frac{N_0^2\,\hbar}{2\,\alpha m_p\,m_e\,c}\sqrt{\frac{\hbar}{2\,G\,c}} = 1.3691\times 10^{17} s = 4.3385\times 10^{9}\ years \tag{47}$$

The values of the temporal limits obtained above are in good agreement with the present knowledge about the origin of life. According to modern cosmology, there are three types stars formed after the Big Bang: population I, population II, and population III. Population III stars are the first stars that appeared about 200 to 300 million years after the recombination era of Big Bang (378,000 years after Big Bang). Population III stars do not contain metal heavier than lithium. They had very large mass and very short life. The population II stars are the product of the debris of the explosion of short lived population III stars. They are also heavy metal poor (less than 0.01%). The population I star are formed from the debris of the supernovae explosions of the population II stars with comparatively longer life span. The sun is a population I star with about 2% of heavy metal in its composition. According to modern cosmology, life can appear only in the heavy metal rich stars of population I. Though the first stars of population III appear between 200 million and 300 million years after the Big Bang [16], the value of 1.77 billion years for the moment of the earliest possible origin of sunlike (G2) stars is in good agreement with the Big Bang theory. The value of 4.34 billion years for the earliest possible moment of origin of life is also in good agreement if we consider the fact that life in our solar system originated about 3.7 billion years ago, i.e., 10 billion years after the Big Bang.

5.2.3 The Fate of the Universe

According to the Standard Model of cosmology (also known as the Big Bang theory), the ultimate fate of the expansion of the universe depends on the ratio of the current density of the universe to a critical value of density which is determined by the parameter of expansion called Hubble's constant H_0. After the initial inflationary expansion had ended, the rate of the expansion was determined by the type of substance that dominated in the universe. There are three types of evolutionary stuff in the universe: matter (dark and ordinary), radiation, and dark energy. During the post inflationary expansion, the radiation dominated at the beginning period, and matter dominated at the later periods. Both the matter and radiation produced a decelerated expansion in which the rate of expansion was decreasing with time. But the latest astronomical observations confirmed the fact that the expansion of the universe began to accelerate about 5 billion years ago. It means that the domination of matter and radiation was replaced by some agents that produce an accelerated expansion. According to the

Standard Model or Lambda CDM model, this expansion is due to the dark energy, a quintessential form of matter that creates the negative pressure for the exponential expansion.

The ultimate fate of the universe depends on the density of all forms of stuff in the universe including the dark matter and the dark energy. The large scale astronomical observations supports the fact that the universe is almost flat with great certainty. So we need the total size and total stuff of the universe to calculate the density of all matter in the universe. In a flat universe, this density must be equal to the critical density defined by the measured value of the Hubble's constant. It is already mentioned that our calculation would be based on the information coded by the latest generation of leptons and quarks. Using the 10 parameters described in section 5.1, we get the following expression for the ultimate fate of the universe.

The total mass and energy (mass equivalent) is given by:

$$M_{tot} = \frac{N_0^3}{m_d m_e}\left(\frac{\hbar c}{2G}\right)^{\frac{3}{2}} = 1.3806 \times 10^{61}\ \mathrm{kg} \tag{48}$$

The total number of PlanckYTEs is given by:

$$N_{PL} = \frac{N_0^2}{m_d m_e}\left(\frac{\hbar c}{2G}\right) = 2.1840 \times 10^{60} \tag{49}$$

The size of Planck's universe before inflation is:

$$S_0 = \sqrt[3]{N_{PL}\left(\frac{\hbar G}{2c^3}\right)^{\frac{3}{2}}} = 1.4829 \times 10^{-15}\ \mathrm{m} \tag{50}$$

The size of the universe at the end of the initial cosmological inflation is:

$$L_{tot} = \frac{N_0^2 \hbar}{2m_p m_\nu}\sqrt{\frac{\hbar}{2Gc}} = 1.3914 \times 10^{29}\ \mathrm{m} = 1.4709 \times 10^{13}\ \mathrm{ly} \tag{51}$$

According to modern cosmological observations, the observable universe is about 93 billion light years or 8.8 x10^{26} m in diameter; it has an amount of ordinary matter about 1.5 x 10^{53} kg. There is a general consensus among cosmologists that the size of the entire universe is at least 150 times more than the observable universe or 1.32 x10^{29} or 14 trillion light years in diameter. The obtained value for the size of the entire universe in (51) is in good agreement with the assumptions of contemporary cosmologists. The total matter of the universe could be also calculated from the assumed value of 1.5x10^{53} kg for the total ordinary matter of the observable universe. If we take that there are 5% ordinary matter in the observable universe then the total mass of the observable universe is 3x10^{54} kg. For the total matter of entire universe, we have to multiply by a factor of $(150)^3$. The simple calculation shows that the total mass of the entire universe is 1.01 x 10^{61} kg. The value obtained in this paper for the total mass of the universe in (48) is in good agreement with the assumptions of modern cosmologists about the entire universe [17]. In FLRW (Friedman-Lemaître-Robertson-Walker) model of cosmology, the ultimate fate of the expansion of the universe depends on the value of the critical density determined by the expansion parameter Hubble's constant H_0. According to the inflationary paradigm, the universe becomes extremely flat at the end of the inflation and the ratio of the total density of matter and energy of the universe to the critical density Ω becomes very close to 1. Additionally, this ratio remains very close to 1 during subsequent evolution. Using this fact, we can calculate the critical density and then the Hubble's constant.

The critical density using the total mass (48), total size (51), and the flat euclidean geometry is:

$$\rho_{cr} = \frac{6\ M_{tot}}{\pi\ L_{tot}^3} = 9.7884 \times 10^{-27} kg/m^3 \tag{52}$$

The value of Hubble's constant is:

$$H_0 = \sqrt{\frac{8\ \pi\ G\ \rho_{cr}}{3}} = 2.3395 \times 10^{-18} s^{-1} = 72.2061\ km/s/Mpc \tag{53}$$

The value of H_0 obtained in this paper is in good agreement with the measured value for Hubble's constant. Astronomers measured two different values for Hubble's constant using two different experimental methods [18,19]. One group of astronomers measured fluctuations in the cosmic microwave background radiation and obtained a value of 67.4 km/s/MPc. The other group of astronomers use the type Ia supernovae explosion to determine the distance and the redshift of the standard candles. The value of H_0 obtained using standard candles is 74 km/s/Mpc. The value of the H_0 obtained in this paper is well within the range of values. The latest value of H_0 obtained from the gravitational lensing by dark matter is 71.6 km/s/Mpc. It is noteworthy that the value of H_0 obtained in this paper is determined by the information carried by fundamental particles and fundamental physical constants. In other words, the noticeable agreement of the value of the H_0 with the the value of astrophysical measurements shows the consistency of all calculations presented in this paper.

The present day accelerated expansion is well known observable fact about the universe. In Lambda CDM model of the universe, this expansion is caused by the energy of the empty space. This contribution of empty space is accounted by the addition of a constant term to the Einstein's field equations of general relativity. The constant known as cosmological constant was introduced by Einstein himself, though he regretted later for introduction of this constant. For long time, astrophysicists neglected the contribution of the cosmological constant in the model of the universe, but the discovery of the accelerated expansion at the end of the previous century evoked the interest of astrophysicists to this constant.

In Friedman model of cosmology, the ratio of the vacuum energy and the critical density is denoted by Ω_{vac}. The observed value of Ω_{vac} is 0.68 since the fraction of the dark energy in the universe is 68%.(ESA/Planck)[20]. The value of the cosmological constant is given by the following formulas:

The vacuum energy density parameter is defined as:

$$\Omega_{\text{vac}} = \frac{\rho_{\text{vac}}}{\rho_{\text{cr}}} \tag{54}$$

The cosmological constant in terms of vacuum energy density is given by:

$$\Lambda = \frac{8\pi G\rho_{\text{vac}}}{c^2} \tag{55}$$

Substituting the vacuum energy density parameter into the expression for the cosmological constant:

$$\Lambda = \frac{8\pi G\Omega_{\text{vac}}\rho_{\text{cr}}}{c^2} = 1.2423 \times 10^{-52}\ \text{m}^{-2} = 1.1165 \times 10^{-35}\ \text{s}^{-2} \tag{56}$$

The radius of the universe at time t after the onset of the accelerated expansion is given by

$$R = R_0\ exp(\ \sqrt{\Lambda/3}\ t) \tag{57}$$

where R_0 is the radius of the universe at the beginning moment of expansion. The critical time for expansion is

$$T_{cr} = \ \sqrt{\frac{3}{\Lambda}} = 5.1836 \times 10^{17} s = 1.6426 \times 10^{10} years \tag{58}$$

The critical time of accelerated expansion (16.426 billion years) denotes the time required for the universe to increase its size by a factor of e (2.71). It means if the accelerated phase of expansion of the universe began about 5 billion years ago, the universe expanded by a factor of 1.36 in 5 billion years.

5.2.4 The Planck's Universe and the Black Hole

There are two types of singularities in the general theory of relativity. The first kind of singularity is a solution of Einstein's field equation with spherically symmetric metric in a vacuum. The behavior of the metric becomes singular at a particular value of the radius vector. This radius is known as the Schwarzchild's radius in cosmology. The singular behavior of the metric destroys the deterministic nature of Einstein's theory of gravity. To avoid this problem, Roger Penrose formulated a cosmic censor conjecture that states: every black hole created from the collapse of a star must be hidden behind an event horizon - a boundary limiting the black hole. No events inside the events horizon can influence any process outside it [21]. The other singularity is associated with the solution of the Friedman equation of general relativity applied for the expanding universe. In the Friedman solution, the density of the universe varies as t^{-2} with time t. Consequently, the density of the universe becomes infinitely large at t = 0. This means the universe begins at a singular state where the equations of general relativity can not be applied. There is no event horizon blocking this singularity from the observer. These two kinds of singularities translate into two kinds of evolutionary stuff: the primordial matter before the Big Bang and the matter produced from the gravitational collapse of ordinary matter after the Big Bang. In ANEP, the goal of the natural evolution is to produce an information processing center like human civilization. So the evolutionary laws must ensure that human civilization must not end by the gravitational collapse of ordinary matter. Consequently, ordinary matter must not return to Planckian universe, and there must be an upper limit of mass that can collapse under gravitational forces. In other words, there must be a lower and upper limit to the mass of a black hole formed from the gravitational collapse of the ordinary matter of the Einsteinian stage.

Stellar mass black holes are the product of the ultimate gravitational collapse of an object made of ordinary matter. Supermassive black holes, such as the galactic core, are the product of the gravitational collapse of primordial matter, including dark matter. In framework of UMNE, the stuff in black holes has undergone a transition to the Planckian stage from a higher stage of evolution. According to the UMNE, there are two kinds of simplest existence in space and time. The matter in Planck's universe exists in the randomized space and the randomized time; no processes except entanglements exist there. On the contrary, the matter of gravitational collapse has the gravitational interaction with the outside universe because it exists in the space-time continuum defined by the Planck's unit of space and time. From evolutionary point of view, these two states of the matter are different. The matter before the Big Bang are made of PlanckITs representing only existence in the randomized space and the randomized time, and the matter of the black hole is made of PlanckYTEs: a basic constituent of space-time continuum and primordial matter. As a result, the stuff in the Planckian universe and that of the black hole must have different evolutionary properties. Additionally, the matter of the black hole is an evolutionary product of collapsed ordinary matter with higher forms of symmetry than that of the stuff of the Planckian universe. In other words, these two types of matter must have some distinct properties due to their difference in evolutionary origin. To find this distinction, we can use the fact that the transition from the Planckian stage of evolution to the Einsteinian stage of evolution was associated with many fold increase of the entanglement entropy associated with the creation of de Sitter space-time with maximal Poincaré symmetry and primordial matter with additional internal symmetries. We can assume that the ordinary matter retains some of these internal symmetries at the end of gravitational collapse. In the light of this phenomenon, we can assume that a certain amount of stuff in black holes always possesses more entropy than the same amount of stuff of the Planckian universe does. Using this fact, we can deduce some basic features of the black hole, for instance, the minimum mass of a black hole.

The Hawking-Bekenstein formula for the entropy of a black hole [22] is given by:

$$S_{BH} = \frac{kA_{BH}}{4L_P^2} \tag{59}$$

Using equation (21) for L_P, we obtain:

$$S_{BH} = A_{BH}\frac{kc^3}{2G\hbar} \tag{60}$$

$$A_{BH} = 4\pi r_s^2 = 4\pi\left(\frac{2GM_{BH}}{c^2}\right)^2 \tag{61}$$

$$M_{BH} = NM_P \tag{62}$$

where r_s is Schwarzschild's radius, and N is the total number of PlanckITs in the black hole.
Based on the assumption that gravitationally collapsed matter must have greater entropy than the primordial matter of Planck's universe, we obtain the inequality:

$$S_{BH} > S_{PL} \tag{63}$$

Using equations (35), (59), (60), (61), (62), and (63), the minimum mass of a black hole can be expressed as:

$$M_{BH} > \frac{\log N_0 - 1}{4\pi}M_P \tag{64}$$

The creation of the space time continuum leads to the inflationary expansion of the universe during the onset of the Einteinian stage of evolution. We can assume that the cosmological expansion of the space does not change the basic properties of the space-time continuum. Every patch of the space-time metric exponentially enlarged during the inflation by a factor Z. The value of the expansion factor is given by the ratio of the size of the universe at the end of the initial cosmological inflation to the size of the Planckian universe. In the Planckian universe, the spatial uncertainty in position is given by σ_L. Hence, the total spatial uncertainty of a PlanckYTE is $N_0\sigma_L$. At the end of initial cosmological expansion, the spatial uncertainty is also multiplied by the same expansion factor Z. In other words, spatial uncertainty at the end of cosmological expansion becomes $ZN_0\sigma_L$. On the other hand, the Schwartzchild's radius of a black hole in the Einsteinian universe represents the spatial uncertainty in position. This is because the event horizon limits the uncertainty in position of any two evolving objects in Einsteinian universe. Again, we can assume that the spatial uncertainty derived from the uncertainties of a PlanckYTE and cosmological expansion defined the maximum possible spatial uncertainty in de Sitter's vacuum. Then it follows that the maximum size of spatial uncertainty from a singularity due gravitational collapse in the Einsteinian universe is $ZN_0\sigma_L$. If we take the uncertainty σ_L is equal to the Planck's unit of length L_P, then the maximum Schwartzchild's radius of a black hole cannot exceed the value ZN_0L_P. Based on this assumption, we can deduce an expression for the maximum possible mass for a black hole.

The maximum mass of a black hole is

$$\frac{2GM}{c^2} < N_0L_PZ \tag{65}$$

$$Z = L_{tot}/S_0 \tag{66}$$

Using the expressions (21) ,(49),(50),(51),(65), and (66), we get the following:

$$M_{BH} < \frac{(m_d m_e)^{\frac{1}{3}}}{2m_p m_\nu}(N_0M_P)^{\frac{7}{3}} \tag{67}$$

Combining the expressions (64) and (67), we get the range of values for the mass of a black hole as following:

$$1.5M_P < M_{BH} < 1.5\times 10^{14}M_S \tag{68}$$

The mass of a black lies between 1.5 times the Planck's mass or 23 micro-gram and 150 trillion solar mass. The experimental and theoretical values for the mass of stellar black holes (BH), super massive black holes (SMBH), stupendously large black holes (SLBH), and primordial black holes (PBH) [23,24] lies in the range given by equation (68). It is noteworthy that the range of values for the mass of black holes obtained in this paper is determined by the fundamental properties of the space and the time only. Additionally, these properties of the space and time are derived in the UMNE. In other words, the calculated values for the range of the mass of a black hole support the unified model of natural evolution (UMNE).

6 A Brief Discussion

This work represents a new approach to the understanding of the fundamental properties of the fabric of the space and the time. Two completely new concepts are introduced in this research paper: PlanckIT and PlanckYTE. They represent the fundamental entities that constitute the physical universe. The main approach in the understanding of the fabric of the space and the time is characterized by the comparison of the space-time continuum with computer memory. This means that we have to understand the concepts of PlanckIT and PlanckYTE in accordance with terminology used in modern information processing. PlanckITs and PlanckYTEs are not particles. PlanckITs code the events of existence in the randomized space and the randomized time, and PlanckYTEs do the same in space-time continuum known as de Sitter vacuum. We know that the special and the general relativity describe the relation between events in the space-time continuum. The Planckian universe is a collection of events representing existence. A PlanckIT is a code for existence of an event in our universe as a bit is a code for existence of information in computer memory. The nature of the bit does not depend on the mode of its physical realization. For example, a bit can be realized by a magnetic bubble, a CCD or simple a hole in a paper strip. But the physical properties of representation don't reflect into the nature of information content of the bit. A collection of 8 bits is called a byte. The physical or spatial organization of bits in a byte does not affect the nature of the byte. A byte is simply an addressable collection of 8 bits. The bit and byte are concepts related to information processing. Similarly, the PlanckIT and PlanckYTEs are concepts related to the memory space represented by the fabric of space and time. We can't give them any particular physical meaning in the way as we can do in the case of ordinary matter particles.

In this paper, a new fundamental constant was introduced: Planck's number N_0. The Planck's number plays an important role in defining the limit of application of the classical theory of gravity in describing the nature of space-time continuum. According to this paper, the largest distance where the quantum effects of gravity cannot be ignored is $N_0\, L_P = 4.69 \times 10^{-27}$ m. Now it is clear that theories of quantum gravity must play role in the interval of length from 1.14×10^{-35} m to 4.69×10^{-27} m. It is probable that the nature of the dark matter and the dark energy is determined by the processes in this region of space.

This model of the space and the time is background independent in the sense that PlanckITs and PlanckYTEs describe the phenomenon of the existence of the space and the time themselves. The space and the time are generated through random events. These events are described by their probability distributions. PlanckITs do not live in space and time; they are the space and time themselves. According to this hypothesis, the space-time continuum (dark energy), the matter, and the radiation represent some form of existence emanating from these objects representing the basic form of existence. This is the main theme of the unified model of natural evolution (UMNE).

7 Conclusion

The purpose of this paper is to provide information in support of the unified model of natural evolution (UMNE). The derivations of the formulas presented in this paper are not random. All these formulas can be derived systematically by using the information carried by the individuals fundamental particles. The most important feature of the process of derivation is that only 10 physical quantities listed in section 5.1 are used. There are no extra factors or free parameters used to calibrate the values to the accepted values in cosmology. If we consider the agreement of these values with the currently acceptable values from other sources, for example, direct observation or model based calculations, then we can say with some certainty that the hypothesis that the elementary particles carrying evolutionary information may be correct. The results obtained in this paper and another paper ”Evolutionary Anthropodynamics: The Evolution of Intellectual Systems”[2] support the UMNE presented in the paper ”A Unified Model of Natural Evolution and the Crises in Particle Physics and Cosmology” [1]. This is a very preliminary work on a vast topic of natural evolution. But I hope that the results obtained in these three research papers will inspire more researches to explore the unity of physical, biological, and social evolution in future.

Acknowledgements

This work is not supported by any government or institutional funds. The author wants to express his infinite gratitude to Prof. M. M. Musakhanov, National University of Uzbekistan. He is also indebted to his wife and other family members for allowing him to dedicate ample time for this research. He is also thankful to the friends who always encouraged him to continue the research.

References

[1] Chowdhury, P. (2025). A Unified Model of Natural Evolution and the Crises in Particle Physics and Cosmology: Unified Model of Natural Evolution-01. IPI Letters, 3(1), O1-O28. https://doi.org/10.59973/ipil.156

[2] Chowdhury, P.K. ”Evolutionary Anthropodynamics : The Evolution of Intellectual Systems” , 2021 (soon to be published)

[3] Stanford Encyclopedia of Philosophy. https://plato.stanford.edu/entries/reduction-biology/

[4] Stanford Encyclopedia of Philosophy. https://plato.stanford.edu/entries/scientific-reduction/

[5] Uzan, Juan-Philippe(2011). ”Varying Constants, Gravitation, and Cosmology”, Pub-Med Central, Mar 29, 2011 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5256069/

[6] Stephan, Jean-Marie;et al.(2009).”Shanon and entanglement entropies of one- and two- dimensional critical wave functions” arXiv, Oct 22, 2009 https://arxiv.org/pdf/0906.1153

[7] Principle of Maximum Entropy https://en.wikipedia.org/wiki/Principle_of_maximum_entropy

[8] Nambu, Yochiro (1976). ”The Confinements of Quarks.” 12020976, Scientific American Inc. http://physics.gmu.edu/~rubinp/courses/440-540/undergrad/QuarkConfinement.pdf

[9] Chowdhury ,Pronab Kenti(1989). ”The Evolution of the Universe and Fundamental Constants ” Mar 1989 ,Report Number:Print:89-0327 https://inspirehep.net

[10] Romeo Jessico (2020),”How Do Neutrinos Get Their Mass?, Symmetry, June 09, 2020,https://www.symmetrymagazine.org/article/how-do-neutrinos-get-their-mass

[11] Physical Constants, https://physics.nist.gov/constants

[12] Monohar, A.V.;et. al.(2016). ”Quark Masses”,https://pdg.lbl.gov/2017/reviews/rpp2017-rev-quark-masses.pdf

[13] Woo, Marcus (2019). ”How the Neutrino’s Tiny Mass Could Solve Big Mysteries.” Quantamagazine, October 15, 2019 https://www.quantamagazine.org/how-the-neutrinos-tiny-mass-could-help-solve-1015big-mysteries-2019/

[14] Ali, Ahmed (1998) ”Quark Mixing and CP violation” ,arXiv,June2,1998 https://arxiv.org/pdf/hep-ph/9806230

[15] Kajita, Takaaki(2010).” Atmospheric Neutrino and Neutrino Oscillation. PubMed Central,April,2010, https://pmc.ncbi.nlm.nih.gov/articles/PMC3417797/

[16] Whitwam, Ryan (2021) ,”The First Star Formed 200 to 300 Million Years After the Big Bang”, ExtremeTech, June26,2021 https://www.extremetech.com/extreme/324153-the-first-stars-formed-200-to-300-million-years-after-the-big-bang

[17] Observable Universe, https://en.wikipedia.org/wiki/Observable_universe

[18] Sloman, Leila(2019) , ”Hubble Tension Headache :Clashing Measurements Make the Universe Expansion a Lingering Mystery.” Scientific American July 29 ,2019 https://www.scientificamerican.com/article/hubble-tension-headache-clashing-measurements-make-the-universes-expansion-a-lingering-mystery/

[19] Freedman, Wendy L (2017).”Cosmology at a Crossroad: Tension with Hubble Constant.” arXiv, June 08, 2017 https://arxiv.org/abs/1706.02739

[20] ESA and Planck, https://sci.esa.int/web/planck/-/51557-planck-new-cosmic-recipe

[21] Ong, Yen Ching(2020).”Spacetime Singularities and Cosmic Censorship Conjecture: A Review With Some Thougths”, arXiv, May 26, 2020 https://arxiv.org/pdf/2005.07032

[22] Damour,Thibault (2004),” The Entropy of Black Holes: A Primer”, Jan 22, 2004, pp.12-13 https://arxiv.org/pdf/hep-th/0401160

[23] Wall, Mike (2021). ”A giant black hole keeps evading detection and scientists can't explain it.” Space, January 01, 2021, https://www.space.com/abell-2261-supermassive-black-hole-missing

[24] Carr, Bernard ; et al.(2020). ”Constraints on Stupendously large Black Holes”, arXiv, Sep 09,2020,https://arxiv.org/abs/2008.08077