Self-division of the Primal Cosmic Substance[1].
Paradigm Shift for Cosmology. Critical Step Forward for Humanity.

– The energies that drive the Universe are the same as those driving the Mind

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Abstract: The emergence of the observable universe from the self-division of a preexisting Substance at high entropy is further developed [1]. Using a four-parameter Weibull growth model without inflation, the emanant 5-component vacuum comprising (+) and (–) energy densities is further described in connection with: the origin and anisotropy of the Thermal IR radiation (CMB observed today); the expansion of a fluid within another fluid; the Hubble parameter associated with a drag coefficient; Bekenstein entropy linked to entanglement information and driving the arrow of time; the decoupling of ρ_+/ρ_- leading to the twin universes; and the golden ratio embedded in the multiple and successive divisions of the Substance. Finally, the nature of the preexisting Substance will be discussed in the context of the Wheeler-DeWitt equation, and the 3rd law of thermodynamics.

1- Introduction

The pre-Planck occurrence that triggered the so-called Big Bang is one of the unsolved mysteries in physics [2]. It more or less corresponds to the point zero of the unidirectional arrow of time as manifested in our dimension. Although widely accepted, the development of the standard hot Big Bang cosmological model has left unresolved a number of outstanding problems and mysteries [3]. The inflationary model designed to resolve the horizon, the magnetic monopole, and the flatness problems have created other issues, such as the homogeneity problem for inflation. Further, the Inflaton, responsible for the scalar field driving the cosmic inflation, has not yet been discovered, and many physicists including some founders of the inflationary theory are no longer advocating the model [4]. The 2019 Nobel Prize in Physics, Jim Peebles, stated in his award presentation about the Big Bang theory: *" It's very unfortunate that one thinks of the beginning whereas in fact, we have no good theory of such a thing as the beginning"* [5].

On the other hand, the self-division of a preexisting cosmic Substance at maximum entropy resolves the issues listed above, in particular:

- *The singularity:* the mathematical singularity associated with the origin of the universe still violates the first law of thermodynamics, despite numerous attempts to circumvent the subject such as the classical bounce [6]. In this model, the singularity vanishes due to the existence of an initial Substance pervading the whole "space", precursor of our observable universe. This Substance provides, via asymmetric self-division, the potential energy required to satisfy the first law of thermodynamics.

- *The expansion of space:* the universe expansion naturally finds a "medium" to expand into. The expansion of space, usually described by the metrics scale factor a(t), intuitively implies the existence of an euclidian "space" that can potentially be "filled". Further, attributing a low entropy to the early universe, tacitly infers the existence of an observer located "outside".

- *The high initial entropy:* The second law and the past hypothesis predict that the early universe was at low entropy. However, the photons from the cosmic microwave background (CMB) have temperature deviations of $\Delta T/T \sim 10^{-5}$ [7]. The entropy for the co-moving volume of photons in the expanding universe must remain constant [8] and correspond to maximal entropy for the photons. Therefore the CMB radiation is very close to an equilibrium blackbody spectrum, thus revealing an apparent early universe close to thermal and chemical equilibrium [9]. As a matter of fact, the preexisting Substance appears at maximum entropy at the time of the initial self-division, from which the CMB is concurrently released. This CMB will therefore carry this quasi-perfect isotropy throughout the expansion.

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1 For lack of appropriate terminology, Substance will be spelled with a capital S throughout the text to express its unknown fundamental nature. This spelling will also make the link with all the great philosophers and/or scientists including Aristotle, Descartes, Leibniz, Locke, Russel, Hume, Kant, and especially Spinoza who used this terminology. Spinoza had much influence on Einstein.

- *Horizon and homogeneity:* the inflationary theory relies on an homogeneous and isotropic scalar energy field dominating the universe at early period. How homogeneous must have been the initial conditions to trigger such an inflation? This question has been tackled by many authors for more than 20 years [10]. One of the simplest model of inflation is based on the Higgs field when the Higgs is non-minimally coupled to gravity. Arising from the standard model of particle physics, this scalar field potential is in the form (in the Einstein frame) [11]:

$$V(\varphi)=\Lambda^4\left(1-e^{-\left(\sqrt{2/3}\,\varphi M_{pl}\right)}\right)^2 \qquad (1)$$

In this formula, the only free parameter Λ can be fixed by normalizing the scalar power spectrum amplitude to Planck measurement. But it has been shown, for the simplest scalar field potential, that the universe must have been initially homogeneous on scales *larger than the Hubble radius* [12-17]. Therefore, the inflation merely transforms one problem of homogeneity into another one. This problem vanishes when we consider the existence of a homogeneous and isotropic initial cosmic Substance at high entropy.

Coincidentally, this proposed model somewhat relates to George Lemaître intuition quoted in his 1931 Nature paper, where he writes about the division of the original quantum: "*If the world has begun with a single quantum, the notions of space and time would altogether fail to have any meaning at the beginning; they would only begin to have a sensible meaning when the original quantum had been divided into a sufficient number of quanta*" [20]…

And "*The world has proceeded from the condensed to the diffuse. The increase of entropy which characterizes the direction of evolution is the progressive fragmentation of the energy which existed at the origin in a single unit*" [21].

2- Initial split of the primal cosmic Substance. Synchronous release of the thermal IR radiation (CMB observed today)

The initial asymmetric cleavage of the preexisting Substance give rise to two new vacuum constituents, creating the potential energy required to trigger down a chain of events and further subdivisions [1]. This initial division is thought to be exothermic and generate a Near-IR radiation, which is the source of the CMB observed today.

Given the redshift of the CMB observed today estimated at z~1100 [18], the original frequency ν and temperature T are given by:

$$\begin{cases} \nu=\nu_o(1+z) & \Rightarrow \text{knowing } \nu_{o,peak} \sim 160 \text{ GHz} \Rightarrow \nu_{peak} \sim 176 \text{ THz} \\ T=T_o(1+z) & \Rightarrow \text{knowing } T_o \sim 2.73\text{K} \Rightarrow T \sim 3000^o \text{ K} \end{cases}$$

with $\nu_{t,peak}$ being the peak frequency of the black body radiation spectrum @ time t.

Suspecting that the temperature of the preexisting Substance is ≳ 0° K (cf. paragraphs 9 & 10), it becomes somewhat astonishing and intriguing to realize that the radiation released at the source is in the Near-IR domain, therefore qualified as Thermal IR. This frequency is also very close to visible light.

Further, the ratio: $$\frac{\nu_{peak}}{T} = 5.9\times10^{10}\ s^{-1}K^{-1} \qquad (2)$$

This ratio is very close to the ratio ν_{th}/T predicted by the Thermal de Broglie wavelength equation for massless particles [19]:

$$\lambda_{th} = \frac{\pi^{2/3}\hbar c}{k_B T} \quad\Rightarrow\quad \frac{\nu_{th}}{T} = \frac{k_B}{\pi^{2/3}\hbar} = 6.1\times10^{10}\ s^{-1}K^{-1} \qquad (3)$$

Further subdivisions of the two initial components will generate three other vacuum constituents. Those three components appear close or equivalent to the dark energy (DE), cold dark matter (CDM) and baryonic matter (B) found in the ΛCDM framework.

3- CMB anisotropy and temperature fluctuations at the initial self-division propagation wavefront

In the standard cosmological model, anisotropies in the CMB are attributed to matter density fluctuations in the "baryon-photon fluid" prior to the creation of the CMB. The distribution of those temperature anisotropies are described by a damped oscillator equation that includes the effects of gravitating matter, photon pressure and the expansion of the universe [22].

In this proposed model, baryogenesis will begin much later than CMB release (Fig.9), and therefore baryon density cannot be accounted for in a theory explaining the CMB anisotropy. However, it is believed that temperature fluctuations arise during the initial self-division of the primal cosmic Substance. During this fast process which simultaneously releases the CMB, local temperatures at the wavefront reach ± 3000° K with minute temperature variations imprinted in the CMB.

It maybe necessary at this time to differentiate between local conditions at the wavefront surface (e.g. temperature, pressure, density) where physico-chemical processes are under activation and propagation, from the average condition of the cosmic scale Substance. This active zone is the active horizon.

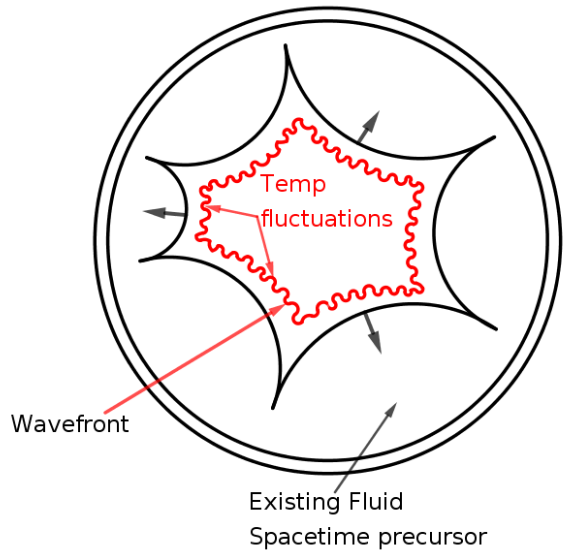


Figure 1: →
Temperature fluctuations at the wavefront during propagation of the initial self-division of the preexisting Substance.

4- Five vacuum constituents

The preexisting cosmic Substance will undertake successive self-divisions giving rise to the five basic components of the vacuum [1]. The evolution in spacetime of those five constituents will drive the expansion of the observable universe. As mentioned earlier, this expansion is considered taking place within a preexisting medium.

The initial asymmetric self-division of the primal Substance necessarily requires the creation of both positive and negative energy densities in order to satisfy overall neutrality, and to conform with the total energy of the universe which is zero. Therefore the universe requires polarization and symmetry, which seems to be an intrinsic characteristic of this cosmos. As the matter of fact, everything in the universe appears to exist along with its opposite counterpart, electrical charges, magnetic poles, numbers, categories, properties, etc., and these opposites built up the dynamic unity of the universe.

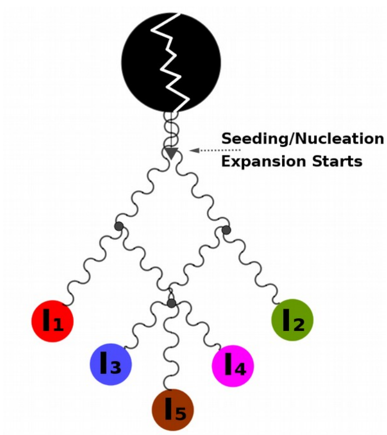
The myriad of forms, shapes and manifestations of the observable and non-observable universe, as well as the numerous intellect or mind-related phenomena and properties, all originate from the multiple divisions and subdivisions of the cosmic Substance and their unlimited combinations.

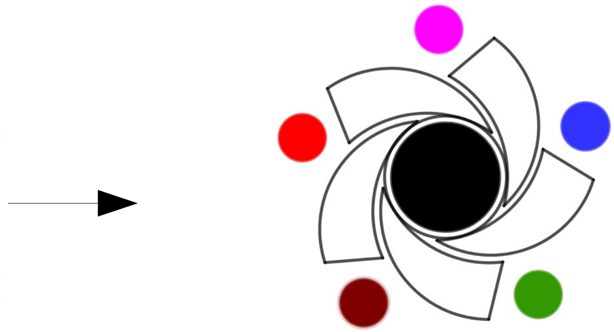
← **Figure 2:** Illustration of the initial asymmetric self-division of the primal cosmic Substance, generating the first two constituents of the vacuum.
One constituent appears more active (spiral symbol) than the other, the latter being considered more passive. Those two constituents pervade the whole vacuum.

Further evolution and subdivision of the two components will give rise to three other components as illustrated in Fig.3 and Fig.4, [1].

Figure 3: From the initial split of the primal cosmic Substance to the five basic constituents of the vacuum

Figure 4: Illustration of the dynamics of the universe driven by the five basic constituents of the vacuum





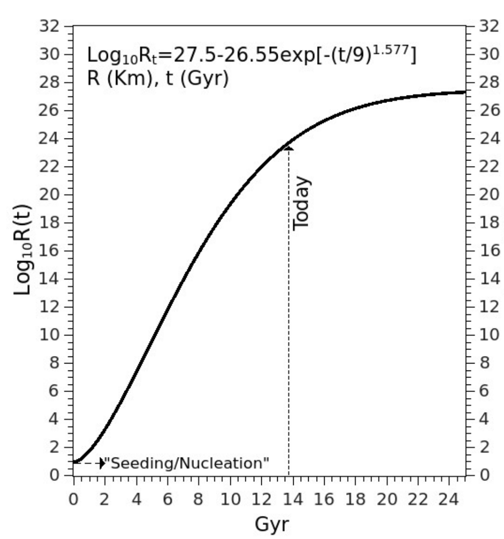
5- Evolution of R(t) without inflation

As discussed earlier, the high entropy of the preexisting Substance naturally transfers its homogeneity and isotropy to the CMB at the release point, which renders the inflationary epoch pointless. Therefore, the search for a simple function $\log_{10}(R_t)$ to model the average cosmic expansion of a spherical universe in the euclidean geometry led naturally to the four-parameter Weibull growth model. This model is widely used for simulating growth kinetics in a variety of domains including medical and biomedical studies, agriculture growth phenomena, populations variability, etc [23-26]. The four-parameter Weibull model takes the form :

$$\log_{10}(R_t) = \alpha - \beta \exp\left[-\left(\frac{t}{\gamma}\right)^{\delta}\right] \qquad (4)$$

where α is the upper size limit, β is the scale factor relative to the initial value, γ is the scale parameter, and δ is the shape parameter. By carefully choosing the shape parameter δ (i.e. $1<\delta<2$) the growth is compatible with a flat (k=0) universe, it provides an accelerated expansion after an initial period of slow expansion rate, it expands indefinitely and asymptotically, and it presents a nearly Gaussian density parameter profile Ω(t), (cf. Paragraph 9).

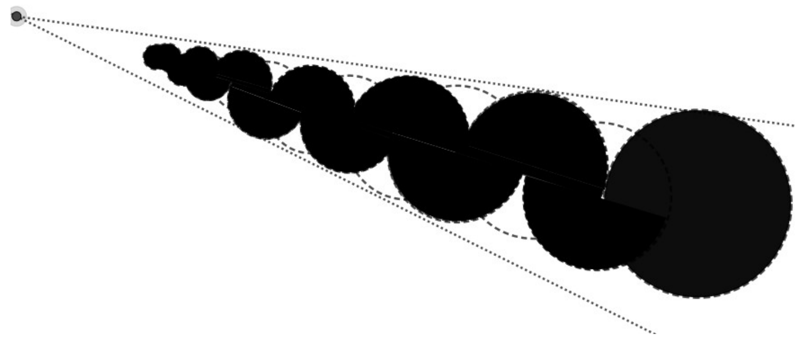
Figure 5: →
Average cosmic expansion using a four-parameter Weibull growth model. The parameters found at [1] were: α=27.5 β=26.55, γ=9, and δ=1.577



Further and insofar as dR/dt remains ≲c then causally disconnected patches are avoided and the horizon problem disappears. The model requires a seeding/nucleation to initiate the expansion process and further subdivision of the initial Substance. The Planck unit could be accomplishing the seeding requirement.

If the average expansion of the observable universe can mathematically be simulated by an appropriate growing function such as exponential or power, some evidence suggest that this function could be non-strictly monotonic, at least at specific time intervals. For example, the scale factor might, at times, remain stationary for specific periods. Further, the scale factor could very likely be driven by a wave function following a conical helix pattern, as sketched in Fig.6

Figure 6: →
Sketch of the scale factor R(t) describing a conical helix



6- The Hubble parameter H(t). Expansion of a fluid within another fluid. Laminar flow and drag force.

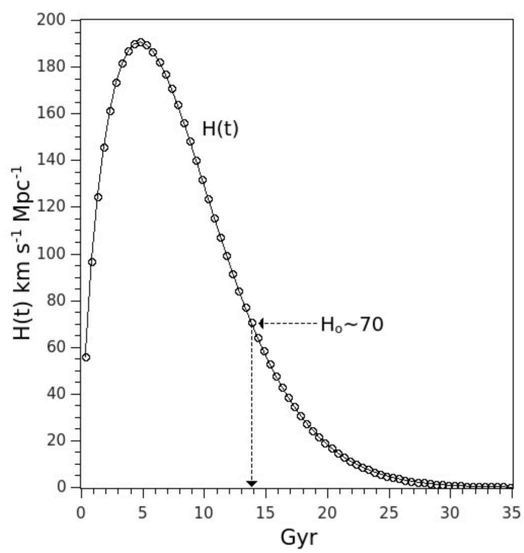
It was a strange coincidence to realize that the Hubble parameter dR(t)/Rdt derived from the scale factor in Eq.(4) required an extra factor to produce the Hubble value H_o observed today (~70 Km s^{-1} Mpc^{-1}) [1]. As a matter of fact, the Hubble parameter was found to fit the formula (5), with the extra term attributed to a velocity-dependent “friction” coefficient :

$$H(t)=\frac{dR_t}{Rdt}(1-\tilde{k}) \text{ with } \tilde{k} \simeq 0.96 \simeq n_s \ (\text{scalar spectral index}) \qquad (5)$$

In reality, it should not be surprising to find H(t) related to the scalar spectral index since the latter describes how density fluctuations vary with scale [27], and H(t) expresses both scale and density (via H_t^2 in Friedman equations). Further, and if we consider the creation and expansion of our transparent spacetime within an existing fluid, then the factor ($1-n_s$) may be considered as a friction coefficient, or more precisely a drag force coefficient. In fluid dynamics, drag forces can exist between two fluid layers. Unlike other resistive forces, such as dry friction which is nearly independent of velocity, drag forces depend on velocity [28]. For laminar flow, drag force is proportional to the velocity and this is what is observed. In the case of a turbulent flow, the drag force would be proportional to the squared velocity.

And friction implies heat, therefore adiabatic expansion cannot be considered in this model. Non-adiabatic expansions have been examined by a few authors [29-31].

Figure 7: →
Profile of the Hubble parameter derived from the four-parameter Weibull growth model in Eq.(4)



The expansion velocity dR(t)/dt seems to peak around 22-23 Gyr [1]. However, H(t) already had peaked at t~5 Gyr as depicted in Fig.6, and despite the accelerated expansion, H(t) continuously decreased ever since. This is due to R(t) increasing faster than dR/dt.

Eventually, H(t) will asymptotically slow down toward zero, contrary to the ΛCDM model which predicts a lower bound for H(t) around 57 Km/s/Mpc [32]. This difference may reasonably be attributed to the absence of negative energy density in the ΛCDM model.

Taking into consideration the friction coefficient, the scale factor R(t) in Eq.(4) could be derived back from H(t) if a simple function reproducing H(t) could be found. As the matter of fact, the following function in Eq.(6) was found to adequately describe the Hubble parameter H(t) depicted in Fig.7. The corresponding coefficients found in Eq.(6) were the following:

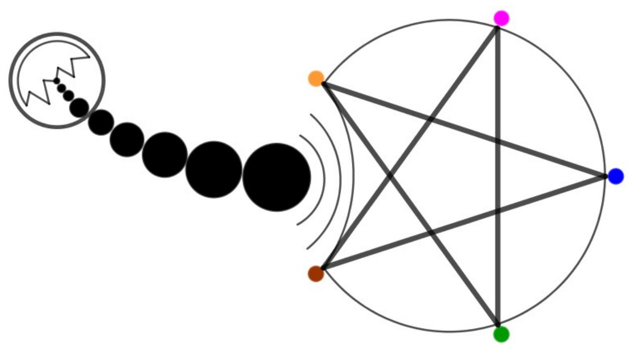
$$\begin{cases} \alpha = 35.8 \\ \beta = 1.8 \\ \gamma = 0.295 \end{cases}$$

$$H(t) = \frac{\alpha t^{\beta}}{e^{\gamma t} - 1} \quad (6) \qquad \text{therefore} \quad \frac{dR}{Rdt} = \frac{\alpha t^{\beta}}{e^{\gamma t} - 1} \quad \text{and} \quad \frac{dR}{R} = \frac{\alpha t^{\beta}}{e^{\gamma t} - 1} dt$$

Integrating both sides we obtain the non-trivial integral $\ln(R_t) = \int \frac{\alpha t^{\beta}}{e^{\gamma t} - 1} dt$ (7)

7- Natural emergence of positive and negative energy densities

Figure 8: →
From the initial self-division to the 5-component vacuum



The illustration in Fig.8 depicts the evolution of our observable universe from the initial split of the primal cosmic Substance into two constituents called I_1 and I_2, seeding and nucleation, opening and expansion within an existing fluid. The expansion is concurrent to the subdivision of the two initial constituents I_1 and I_2 giving rise to three additional ingredients called I_3, I_4, and I_5. The pentagram thus symbolizing the five-component vacuum.

If we neglect the radiation contribution to the total density over the entire timescale, including in the early universe where the two initial components are by far the two dominant species, we can write the total density of the universe:

$$\left(\frac{H(t)}{H_o}\right)^2 = \sum_1^5 \Omega_i(t) \qquad (8)$$

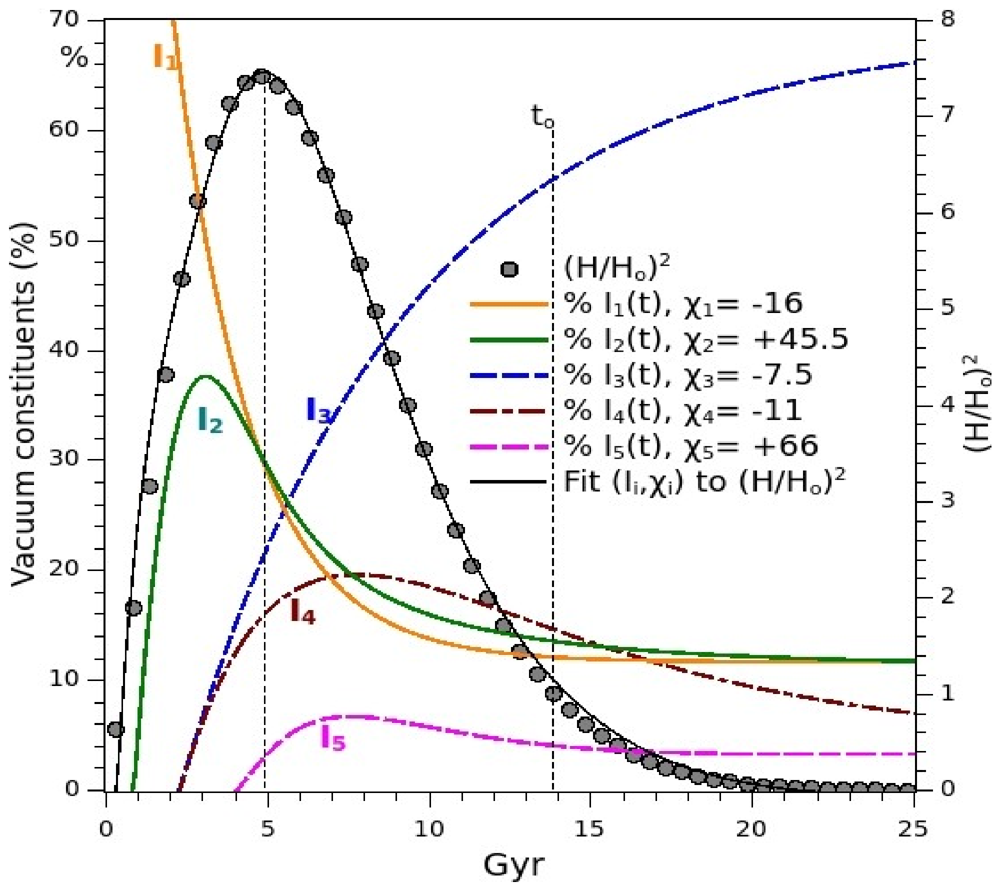
And if we posit $\Omega_i(t) = \frac{\rho_i(t)}{\rho_c} = \chi_i I_i(t)$ then the equation becomes $\left(\frac{H(t)}{H_o}\right)^2 = \sum_{i=1}^{5} \chi_i I_i(t)$ (9)

In these equations, Ω_i is the density parameter, ρ_i the density, I_i the fraction (or percent), and χ_i the density contribution factor of component {i}. Attempts to correlate the fractions $I_i(t)$ of the five vacuum components {i} and corresponding density contribution factors χ_i to the total energy density curve Ω(t) were carried out at [1]. Computerized fitting scenarios led to the optimum correlations reproduced graphically in Fig.9, where both positive and negative contributions χ_i to the total energy density naturally appear. The resulting fit of $\{I_i(t),\chi_i\}$ pairs to Ω(t) is represented by the black line in Fig.9. Taking into account both (+) and (–) contributions to the total density parameter we can then write:

$$\Omega(t) = \Omega_+(t) + \Omega_-(t) \qquad (10)$$

The total energy density appears to reach a maximum $\Omega(t)_{max} \simeq 7.5$ at time ~5 Gyrs, and has been decreasing ever since. When positive and negative energies balance out, the total density will be zero. This does not translate into a universe depleted from energy, but rather a fine-tuned equilibrium between (+) and (-) energy densities. A number of articles postulating the existence of negative mass-energy have been published in recent years [33-39].

Figure 9: Computerized correlation of $\{I_i(t), \chi_i\}$ pairs to $\Omega(t)$ (dots) and resulting fit (black line)



In addition, Fig.9 reveals a number of critical points which, at times, oppose the ΛCDM model:

- The fraction of component I_1 is 100% when I_2 emerges on the timescale at t~0.8 Gyr. This might be the result of a scenario where I_2 emerges slightly after I_1 and possibly from I_1 itself. Therefore, it is speculated that the initial self-division of the primal cosmic Substance leading to the two components I_1 and I_2 occurs in two distinct phases. The first phase (fast process) produces I_1 with simultaneous release of the Thermal IR radiation (CMB today). And the second phase leads to the emergence of I_2 from I_1. This scenario would be consistent with the Fibonacci sequence 0,1,1,2,3,5 with 0 assigned to the void.
- I_3 and I_4 emerge synchronously around 2.3 Gyrs. Curiously at that moment, the fraction of I_1 and I_2 are nearly and respectively Φ^{-1} and Φ^{-2}, knowing that $\Phi^{-1}+\Phi^{-2}=1$ (cf. paragraph 11). A small incertitude on the timescale could be the source of the slight shift observed in Fig.9. Here Φ is the ubiquitous golden ratio, omnipresent at large cosmic scale, but also at quantum scale.
- Most surprising is the emergence of baryonic matter I_5 "very late" on the timescale ~4 Gyrs. This observation might disrupt the standard Big Bang nucleosynthesis (BBN) framework.
- A variable and negative contributing energy density was found for the cosmological constant Λ(t) at [1], which is represented on the graph by the component I_3 and expressed by the following equation:

$$\Lambda(t) = \frac{8\pi G \rho_\Lambda(t)}{c^2} \qquad (11)$$

The domination of the exponential component $I_3(t)$ is explicit, and seems to level off around 69%. It appears to be the natural candidate for the cosmological constant Λ(t). This constituent $I_3(t)$ has a relatively small negative contribution to ρ(t). Negative values for Λ have been proposed in other studies [40-41], in particular in the Anti-de Sitter space where the inherent negative spacetime curvature (k= –1) corresponds to a negative cosmological constant.

At the present-time, the fraction $I_3(t_o)$ is ~56%. Determination of the current value $\Lambda(t_o)$ can then be estimated via the classic formula (12):

$$\Lambda(t_o) = \frac{8\pi G \rho_\Lambda(t_o)}{c^2} = -6.7\times10^{-52}\ \mathrm{m}^{-2} \qquad (12)$$

with $\rho_\Lambda(t_o)=\Omega_3(t_o)\rho_c=\chi_3 I_3(t_o)\rho_c$ obtained from Fig.9 at t_o=13.8. And $\rho_c=+8.6\times10^{-27}$ kgm^{-3}, $G=6.674\times10^{-11}$ m^{3}kg^{-1}s^{-2}, $c=2.998\times10^8$ ms^{-1}, $I_3(t_o)=0.555$, and $\chi_3=-7.5$.

8- Positive mass equivalence

In general relativity, the universe is considered a manifold equipped with a metric $g_{\mu\nu}$ satisfying the Einstein field equation:

$$R_{\mu\nu}-\frac{1}{2}R\ g_{\mu\nu} = +\chi T_{\mu\nu} \quad \text{(using a zero cosmological constant)} \qquad (13)$$

In this equation, the Stress-Energy-Momentum tensor $T_{\mu\nu}$ is the source of the gravitational field, where it is considered that (+) and (-) particles wafting in the gravitational field behave in the same manner and follow the same world lines derived from $g_{\mu\nu}$. In the same order of ideas, the solutions to Einstein field equations for the FLRW metrics and the associated perfect fluid equation of state (EOS) are the source of Friedman equations. In these equations, only positive energy density is acknowledged, or tacitly implied.

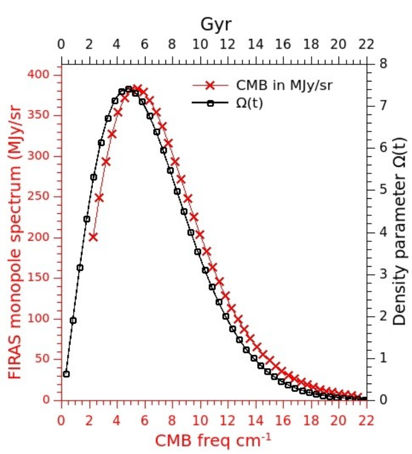
However, when examining a mixture of (+) and (-) energy densities, Friedman equations may still hold, insofar as the resulting positive-like action of (-) energy is solely considered, regardless of whether this action is opposite or in the direction of positive mass-energy. For example, the rotation velocities of galaxies and other celestial bodies are observables resulting from the influence of different forms of mass-energy, such as matter or dark matter, but only their resulting positive action on the gravitational field is observed.

As a consequence, we may identify the total density $\rho(t)$ in Friedman equations as positive mass equivalence, and consider $\rho(t)$ as an apparent positive energy density resulting from the various (possibly conflicting) contributions of all different forms of energy densities present in the vacuum. Therefore Friedman equations hold and we can write Eq.(14), legitimately assuming the density contribution factor χ_i of component {i} as time-independent.

$$\Omega_i(t) = \frac{\rho_i(t)}{\rho_c} = \chi_i I_i(t) \quad \text{with } i=1-5 \qquad (14)$$

9- Energy density profile $(H_t/H_o)^2$ and low temperature of the universe

It was found in [1] that the shape of the energy density parameter $\Omega(t)$ derived from the four-parameter Weibull growth model in Eq.(4) was almost perfectly symmetrical to the CMB spectral radiance spectrum. As seen in Fig.10, a small shift of ~0.7 Gyr on the time scale would perfectly overlay the two graphs. And this coincidence goes down to the X-scales numerical values regardless of the two different scale units.



← **Figure 10:** Striking profile similarity between CMB and $\Omega(t)$

Above and beyond this coincidence, $\Omega(t)$ profile is remarkably similar to the spectral energy density of a black body, which follows Planck's law. It is as if each value on the timescale (Gyr) corresponded to a frequency, and as time evolves so does the corresponding frequency within the whole gamut. Is the universe ultimately vibrational in nature? That sounds familiar and already heard. Hence, what would be the corresponding frequencies and temperatures?

Our observable universe is obviously not a perfect black body filled with electromagnetic radiation. If that were indeed the case, the temperature T_o of a universe with a total energy density $\rho_o \approx \rho_c \approx 9 \times 10^{-27}$ Kg/m^3 would be given by the formula:

$$T_o = \left(\frac{\rho c^2}{\sigma^*}\right)^{1/4} \approx 32^o K \quad \text{(with } \sigma^* = 4\sigma/c \text{ and } \sigma \text{ being the Stefan-Boltzmann constant)} \qquad (15)$$

Today the CMB suggests an average temperature of the universe ≈2.73° K, (factor of ~11.7)[2]. In the same order of ideas, the average temperature at maximum energy density (Fig.9 $\rho_{max} \approx 7.5\rho_c$) would have been $T_{max} \approx 53°$ K. And if the corrective factor 11.7 may be extrapolated ~9 Gyrs back in time, then the actual temperature would be only ~4.5° K. As a consequence, the average temperature of our universe appears to remain steadily close to or slightly above 0° K. It is concluded that, looking at Fig.9, the temperature of the preexisting Substance ought to be nearly zero at the time of the initial split. How close was it from zero is a great mystery.

Paradoxically, when we estimate the Hawking Temperature of black hole horizons in Eq.(16), we find a temperature infinitely close to 0° K, but not exactly 0. Such temperature is closely related to the de Sitter temperature. Does this temperature make any sense at all? And could it reveal the true temperature of the preexisting substance? Then this temperature should reflect the lower bound for the third law of thermodynamics, in which case T=0 should be substituted with $T \gtrsim T_\beta$

$$T_\beta = \frac{\hbar \; H}{2\pi k_B} \simeq 3 \times 10^{-30} \; K \qquad (16)$$

The fact that the preexisting Substance exhibits a high entropy, in spite of a temp ~0° K, is indicative of a large number of inherent microstates, in accordance with Boltzmann famous entropy formula:

$$S = k_B \, Log(\Omega) \qquad (17)$$

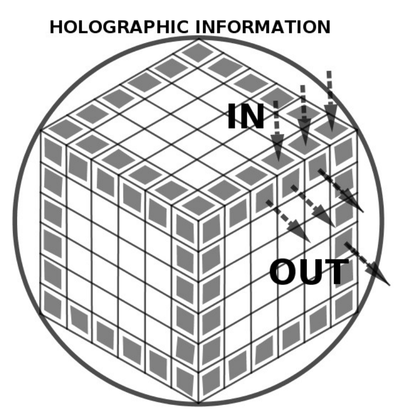
with Ω being the number of microstates consistent with the macroscopic configuration.

10- Bekenstein entropy profile

Despite the connection between gravity and thermodynamics [42], the universe cannot be expected to respond exclusively like a thermodynamic system. This is likely due to the existence of a number of “hidden variables” [43]. As W. Heisenberg stated : *“Not only is the Universe stranger than we think, it is stranger than we can think”.*

However it seems a reasonable assumption that the entropy of the observable universe may be dominated by the entropy of the cosmic horizon. For example, in the current universe, the entropy of the horizon has been estimated to exceed that of supermassive black holes and stellar black holes by respectively 18 and 25 orders of magnitude [44]. Further, the holographic principle states that the entropy of ordinary mass is proportional to surface area, and the hologram is isomorphic to the information encoded on the surface of its boundary [45].

Figure 11: →
Illustration of the unique holographic properties of the 6 cube



The holographic principle is illustrated by the 6-cube in Fig.11 where the number of interior 1x1x1 cubic volumes equals the number of 1x1 surface units at the cube boundary, which are both equal to 6^3. Therefore every bit of information within a small cubic volume can be encrypted on a small square, provided that an appropriate algorithm exists and allows such a transformative encoding. The 6-cube is the only cube bearing this property. We may also imagine bits of information transferred in and out through the 60 surface units located at the edges.

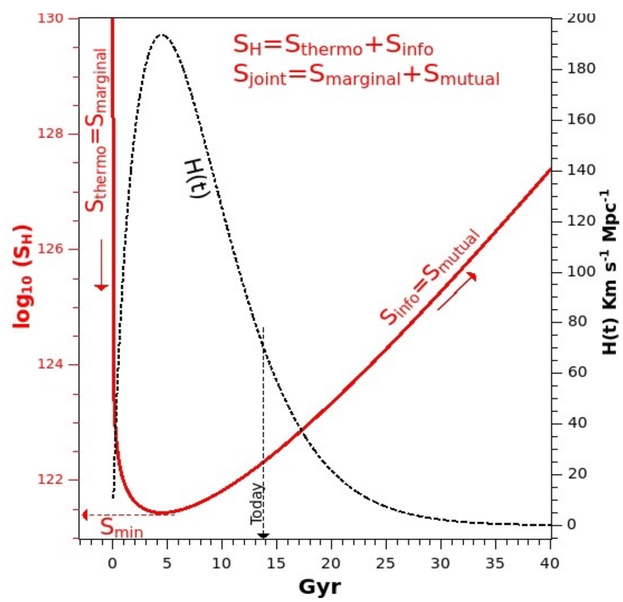
2 Strikingly $\alpha^{-1/2}$ =11.706 with α being the fine structure constant

Considering a spherical observable universe with a Hubble horizon and radius $R_H = c/H(t)$, we can estimate its Bekenstein entropy S_H. This entropy is defined by the well-known formula

$$S_H = \frac{k_B c^3}{G\hbar}\frac{A}{4} = \frac{k_B c^3}{G\hbar}\frac{4\pi R_H^2}{4} = \frac{k_B c^3 \pi}{G\hbar}\frac{c^2}{H_t^2} = \frac{k_B c^5 \pi}{G\hbar}\frac{1}{H_t^2} \qquad (18)$$

Therefore S_H varies with $1/H^2$, and having defined H(t) in paragraph 6, we can estimate the profile of the entropy $S_H(t)$, as depicted in Fig.12

Figure 12: →
Profile of the Bekenstein entropy $S_H(t)$ which is proportional to $1/H_t^2$



The $\log_{10}(S_H)$ was graphed to clearly show that the entropy decreases right after the initial split of the primal Substance. The entropy keeps going down to a minimum of $[10^{121}–10^{122}]$ k_B and then rises again in accordance with the second principle of thermodynamics: $\Delta S \geq 0$.

It is conjectured that in the early universe, the thermodynamic entropy (S_{thermo}) dominates and causes the sharp decrease of S_H. However, around t~4 Gyrs, the information entropy (S_{info}) arises and quickly becomes the dominant force, driving S_H to $\Delta S \geq 0$, the second law of thermodynamics.

This entropy profile accounts perfectly for the isotropic and homogeneous CMB, considering that the entropy of the early universe is high at the time the CMB is released. This entropy, as well as a thermodynamic and chemical equilibrium, are intrinsic characteristics of the preexisting Substance before its initial self-division.

In information theory, S_{thermo} is sometimes called marginal entropy, while S_{info} is called mutual entropy. The sum of the two forms the joint entropy. By analogy to Shannon entropy, the differential entropy for continuous random variable with probability density f(x) is usually expressed by [46]:

$$h[f] = -\int f(x)\log(f(x))dx \approx S_H \approx \frac{K'}{H_t^2} \qquad (19)$$

With $K' = \frac{k_B c^5 \pi}{G\hbar}(3.086e^{19})^2$ and $H_t \simeq \frac{35.8t^{1.8}}{e^{0.295t}-1}$ as defined in para. 6, with t in Gyr

In Fig.12 the minimum entropy S_{min} appears at 4–5 Gyrs, which seems to coincide in Fig.9 with the beginning of baryogenesis. Therefore the information entropy S_{info} appears linked to baryons, an important building block of ordinary matter and living beings, should we say sentient beings. In Fig.12 the slope of the rising information entropy depends on the information content, more specifically entanglement information. Entanglement is suspected to drive the arrow of time [47], which in turns appears linked to entropy [48], so the three appear closely connected.

Particle entanglement infers correlation, and a crucial difference between past and future is linked to correlation. For example, if we consider the initial conditions of a system of particles initially uncorrelated, as the system evolves with time, particles within that system interact with each other and therefore become more and more correlated, so less independent.

"*It is as if particles gradually loose their individuality and become parts of a collective state... Eventually, the correlations contains all the information, and the individual particles contain none. The arrow of time is an arrow of increasing correlations."* This idea was presented by Seth Lloyd in his 1988 doctoral thesis [47], but was totally ignored at the time.

Figure 13: →
Entanglement creating mutual entropy and driving the arrow of time

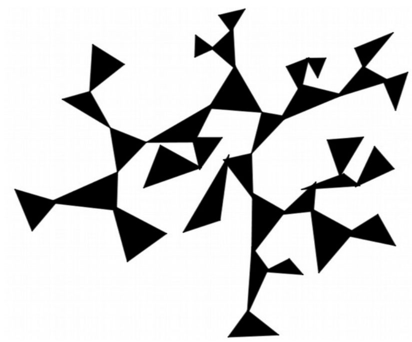


Fig.13 illustrates a multiple correlation pattern between triangles of various dimensions, thus creating high mutual entropy. Each living being in the universe is essentially shaped from the three basic ingredients represented in Fig.9 by I_3, I_4, I_5 in countless proportions and combinations. And the length of each side of a triangle unit symbolizing one of these ingredient at a given ratio, the 3 ratios being specific to a particular species.

This entanglement is somehow the essence of quantum mechanics. The growing number of correlations between all particles in the universe seems to drive the arrow of time, and therefore the existence of the physical universe. It seems that when the maximum correlation state is achieved, the physical universe will have reached the objective of it's very existence.

When maximum entropy is accomplished through "total" entanglement of all those "sentient triangles", will the physical universe eventually reach its goal and somewhat loose any further reason for it's own existence? In the astonishing words of the great 14th century mystic and philosopher Hafiz: *"The aim of the inner working of the universe is to nullify itself"* [49].

11- The golden ratio embedded in the Self-division of the Substance

In Nature, when it comes to division, the ubiquitous golden ratio is never too far. The self-division of the primal cosmic Substance seems to be no exception. In fact, the golden ratio primordial pertinence may have been precisely the initial self-division of the primal Substance.

This primal cosmic Substance is characterized by this particular oneness which defines an all-pervading fluid. Consequently, the fractions of all vacuum constituents arising from the initial division and successive subdivisions of the preexisting Substance should always sum up to 1 (or 100%). And the golden ratio entertains an array of successive partitions producing one as a sum, and from where self-similarity naturally emerges. For example, the following recursive formula is specific to Phi (Φ) :

$$\Phi^n = \Phi^{n-1} + \Phi^{n-2} \qquad (20)$$

With n=0, the formula becomes $\{1 = \Phi^{-1}+\Phi^{-2} \approx 0.618+0.382\}$ and appears to be the distribution, at t~2.3 Gyrs, of the two constituents arising from the initial self-division. When we look at Fig.9 @ t~2.3 Gyrs corresponding to the synchronous emergence of constituents I_3 and I_4 from the two precursors I_1 and I_2, the last-mentioned have fractions close to 61.8% and 38.2% respectively. Little differences might be the result of an inaccuracy in the universal timescale causing a small shift.

Fig.14 is a spanning tree driven by the golden ratio in Eq.(20). Considering that the initial self-division and further subdivisions of the primal cosmic Substance adhere to the recursive formula (20), the fractions of the five vacuum basic constituents can therefore be predicted. This exercise in Fig.14 was carried out all the way to $t\to\infty$. Some constituents are seemingly arising from the combination of multiple sub-fractions.

In particular, when $t\to\infty$ the fractions $I_{i,\infty}$ of the five basic constituents of the vacuum can be predicted from Fig.9 by extrapolating the individual functions $I_i(t)$. On the other hand, these values can be confirmed and substantiated via the spanning tree in Fig.14. The results are conveniently summarized in Table 1 for comparison.

Figure 14: →
Spanning tree constructed from Eq.(20) and leading to the estimated fractions of the 5 vacuum constituents @ t→∞

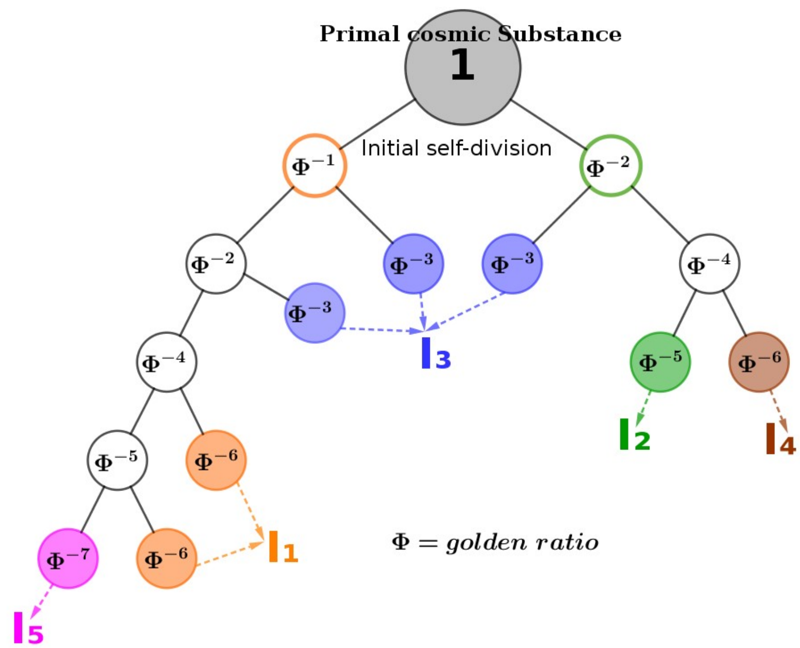


Table 1: Comparison of the fractions at t→∞ of the five constituents predicted from Fig.9 and those anticipated from the spanning tree constructed in Fig.14 (radiation is negligible and not included)

Vacuum constituent	**Fraction at t→∞ From extrapolation in Fig. 9**	**Fraction at t→∞ Predicted from tree in Fig. 14**
I_1	0.117	0.112
I_2	0.10	0.09
I_3	0.69	0.708
I_4	0.053	0.056
I_4	0.04	0.034
Total	1.00	1.00

Another remarkable characteristic of the golden ratio is found in formula (21), where the sum of all fractions equals 1. In my opinion, this is where the power of the golden ratio lies. This power is also expressed in the continued fraction or the continued square root [50].

$$\sum_{1}^{\infty} \phi^{-(n+1)} = 1 \qquad (21)$$

Likewise, the emergence of the golden ratio was also noticed in some of the correlations found in Fig.9, in particular the scaling factor $\exp(\Phi^{-2}) \sim e^{0.382} \sim 1.47$ appearing twice. Of interest, Φ^2 and Φ^{-2} are solutions of the equation (22):

$$\sqrt{x} = x - 1 \qquad (22)$$

Another striking example where the golden ratio seemed to naturally materialize is the non-linear correlation fitting of the density parameter $\Omega_t=(H_t/H_o)^2$. As may be seen in this figure, the approximation is nearly perfect. Also of interest is the value $e^{0.507} \approx 1.66$

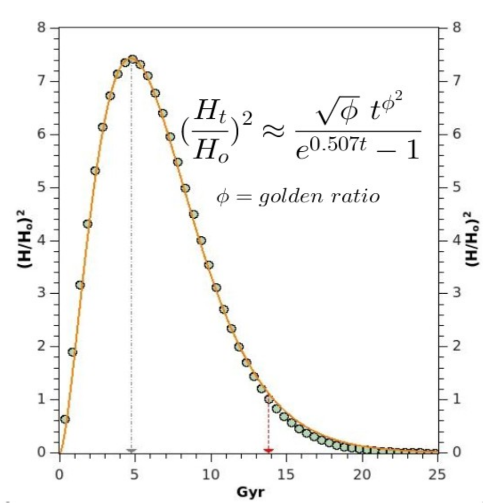


Figure 15: →
Quasi perfect replication of the density parameter Ω(t) using a suitable function containing the golden ratio

12- Decoupling of ρ+ and ρ– . The twin universes

The existence of two universes each carrying "dissociated" positive or negative mass-energy has been investigated by a number of physicists [41]. Since the early work of H. Bondi in the 1940's and 1950's [51], negative mass, although not (yet) experimentally confirmed, went from a mathematical curiosity to more adepts .

Of particular interest is the bimetric model developed over several years by the astrophysicist Jean-Pierre Petit [52] and inspired by the twin universes theory with opposite arrows of time proposed by A. Sakharov in the 1960's [53]. In the model developed by JP Petit, a system of two coupled field equations is proposed [45], and is expressed is the following forms:

$$\left.\begin{aligned} R^{(+)}_{\mu\nu} - \frac{1}{2} R^{(+)} g^{(+)}_{\mu\nu} &= +\chi [T^{(+)}_{\mu\nu} + T^{(-)}_{\mu\nu}] \\ R^{(-)}_{\mu\nu} - \frac{1}{2} R^{(-)} g^{(-)}_{\mu\nu} &= -\chi [T^{(+)}_{\mu\nu} + T^{(-)}_{\mu\nu}] \end{aligned}\right\} \qquad (23)$$

In this bimetric model, the twin universes are not physically separated, however (+) and (–) particles follow distinct worldlines. Using Cartan's free coordinates calculus, a similar bimetric model with two field equations was recently derived by P Marquet [54], leading to two FLRW-like metrics.

It is conjectured without rigorous proof that those two field equations cannot coexist until an optimum ratio of (+) and (–) energy densities is achieved. In other words, the ratio of the two stress-energy-momentum tensors $T^{(+)}$ and $T^{(-)}$ must reach a specific value. As a consequence, the twin universes may not reasonably appear in the early universe, but much later on the universal time scale, as illustrated in Fig.16. It is conjectured that this separation occurs between [9–9.5] Gyrs, when the Hubble time coincide with the universal time, as shown in Fig.17. At that specific moment and in the present model, the ratio of energy densities |ρ+/ρ–| is found ~1.52 as shown in Fig.18. Here again this ratio is close to Phi, which is within 7% of the value estimated above, therefore well within incertitude reach.

Figure 16: →
Decoupling of (+) and (–) energy densities on the universal timescale.

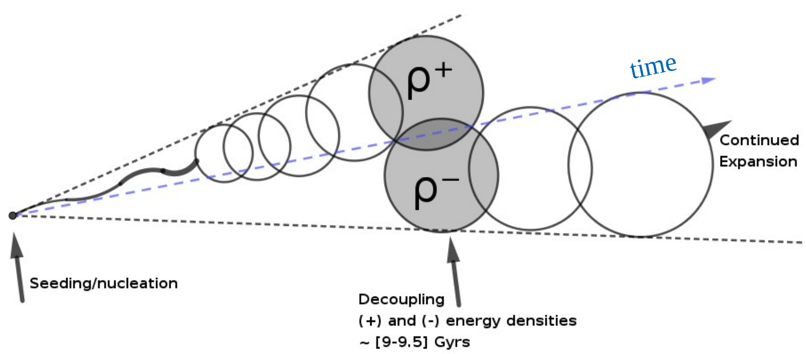
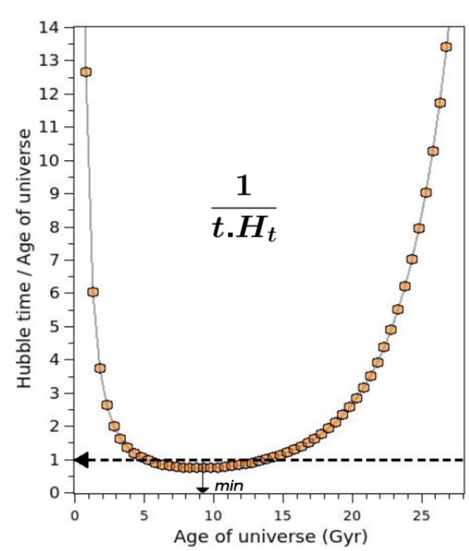
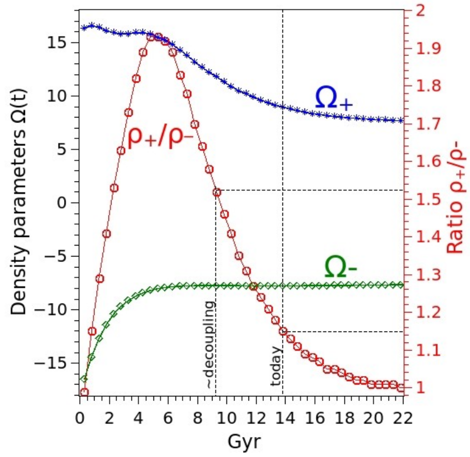


Figure 17: →
Hubble time / time



In this model of expansion without inflation, it was found that the Hubble time is remarkably close to the age of the universe for a long period of ~10 Gyrs which includes today. The ratio $(t.H_t)^{-1}$ is presented in Fig.17. It is unknown whether the bottom of the curve should actually cross the horizontal line y=1 or barely remain above. Incertitude around H_o and/or the scalar field index in the derivation of H(t) in para. 5 may have prevented the minimum of the curve from being exactly 1. It is conjectured that the decoupling in Fig.16 occurred when the bottom curve was at minimum, around 9–9.5 Gyrs.



← **Figure 18:**
Density parameter evolution for positive and negative energy densities. The ratio |ρ+/ρ–| is also presented.

Of particular interest is the ratio |ρ+/ρ–| ≈1.52 at the time of decoupling. This value is within 7% of the golden ratio, therefore well within incertitude reach.

13- On the nature of the primal cosmic Substance. The time-independent Wheeler-DeWitt equation

In 1967, Bruce Dewitt published a time-independent equation in quantum gravity theory, which later became famously known as the Wheeler-DeWitt (WdW) equation. Simply speaking, the equation can be formulated as

$$\hat{H}|\psi\rangle = 0 \qquad (24)$$

where Ĥ is the Hamiltonian constraint in quantized general relativity, and Ψ is the wave function of the universe. As Carlo Rovelli put it in 2015 [55]: *" It is a strange equation, full of nasty features... Concrete calculations, indeed, tend to give meaningless results: strictly speaking, there is no equation...".* It is probably true that instead of mathematics serving physics, the latter has progressively and insidiously become subordinate. But this equation is far from being meaningless, and the WdW equation has inspired a colossal amount of research in quantum gravity in the last decades. To a large number of physicists in such areas as black holes and cosmology, it has been a fundamental tool for thinking the quantum properties of spacetime.

Compared to the Schrödinger equation, we see that E=0 for stationary solutions to the Schrödinger equation for the physical part of the wave function, and this is equivalent to the absence of time evolution in the wave function. This absence of time variable is the immediate puzzling aspect of the WdW equation, and amid other perverse consequences and limitations of this equation, it breaks the manifest relativistic covariance between space and time dear to general relativity (GR). However, and because of the absence of time variable singled out, the WdW equation is thought to be a generalization of the Schrödinger equation.

The problem of disappearance of time has a long history in quantum gravity and cosmology [55-57]. Although this loss of the time variable in the WdW equation was already embedded in the Hamilton-Jacobi formulation of GR from which it originally derived, its true meaning is still debated. Much attention has been recently drawn into re-introducing the time variable through an effective time parameter identified as a "quantum clock" [58-59].

However the disappearance of time in the derivation of the quantum state of the universe |Ψ> must have a functional meaning. In particular it does not imply that the universe is frozen. However, when linked to the primal cosmic Substance, it seems to reveal all its significance: the visible universe has a background, and that background is independent of time. As opposed to our physical world which is ingrained in time and therefore subject to transient manifestation, life and death, this background is not subject to the arrow of time.

Then if the background of the universe is timeless, it must be at least as old as our 13.8 Gyrs old physical universe, and most likely older, probably out of time. Therefore it can be conjectured that our physical universe was derived from this time-independent background universe, which is called in this paper the primal cosmic Substance. So we seem to live in a time-driven universe, should we say a covariant world, whose background and origin are timeless.

As expressed in [60], *" In classical canonical gravity, a spacetime can be represented as a <trajectory> in configuration space - the space of all three-metrics... Since no trajectories exist anymore in quantum theory, no spacetime exists at the most fundamental, and therefore no time coordinates to parametrize any trajectory"...* And in the same vein [61]: "*in quantum gravity the notion of spacetime disappears in the same manner in which the notion of trajectory disappears in the quantum theory of a particle".*

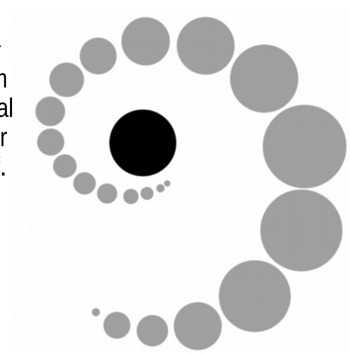
The existence of a timeless and space-less uniform background of the universe can be viewed in the words of the physicist Seth Lloyd [62]: *"The universe as a whole is in a pure state... but individual pieces of it, because they are entangled with the rest of the universe, are in mixtures."*

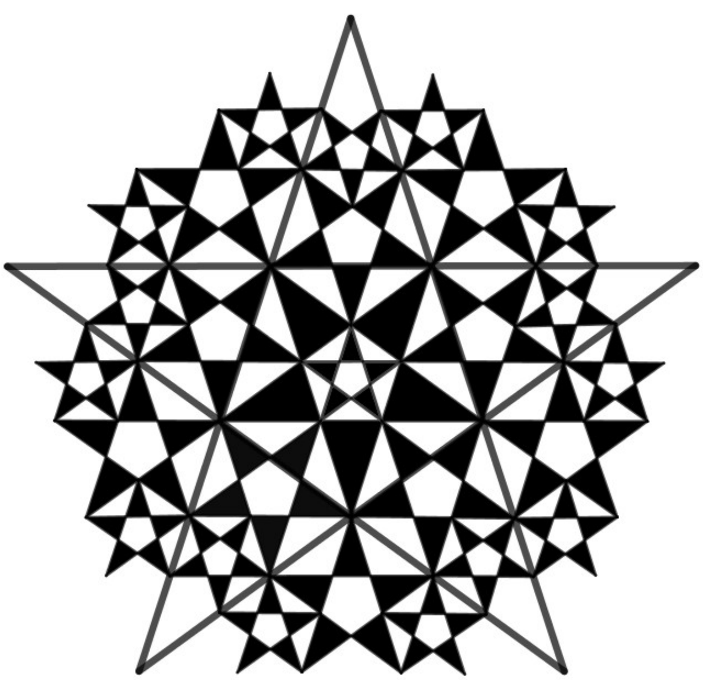
14- On the reversibility of the self-division of the primal cosmic Substance

This is a question which legitimately and naturally arises. Can a uniform, undifferentiated, homogeneous, and isotropic preexisting Substance preserve its original unity after multiple and successive divisions? That seems a priori possible if some kind of "memory" exists, with an existing "intelligence" to process the algorithm into the reverse direction. But instantaneously, the question of a preexisting consciousness sets in. Could that primal cosmic Substance be inherently self-conscious? A positive answer to such a question would explain its inherent high entropy despite its associated temperature ≈0°K. This statement obviously would violate the 3rd law of thermodynamics.

On the other hand, if the successive divisions and subdivisions are not reversible, then the entirety of the initial Substance attributes (as called by Spinoza) should have been transmitted to the parts and sub-parts, in particular its time-independent characteristic. Therefore, the five vacuum components stemmed from that Substance, including the physical universe with its observers, would not be subject to the arrow of time. Obviously, this is not the case, so the creation of the observable universe must be reversible. Q.E.D.

Figure 19: →
Illustration of the physical universe and all its observers stemming from the timeless primal Substance and subject to the arrow of time in cyclical manners. Because there is no external observer of the universe, the observer contemplating the universe is consciousness observing itself.





← **Figure 20:** Self-similarity of the five-component universe within itself. The golden ratio is fundamentally associated with the pentagram

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