Article

From Drake's Equation to Cosmobiology in the Timeless Quantum Vacuum

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Abstract

A model of the frequency of planetary "origin of life"-type events in terms of the fundamental intrinsic properties of a three-dimensional timeless non-local dynamic quantum vacuum is proposed, which provides a new key of reading of the Drake equation. The perspectives of this model towards a view of life as a non-local global property of the entire universe, that abiogenesis indeed refers to a nonlocalized series of assembly steps or processes that lead directly and irreversibly to an evolvable living universe as a consequence of the non-local action of a fundamental quantum potential of the vacuum, are analysed.

Keywords: Origins of life, Drake equation, timeless, non-local, quantum vacuum, quantum potential, cosmobiology.

1. Introduction

In 1600 Giordano Bruno was condemned to the stake and burned alive in Rome for heresy for having claimed that the universe has no centre, that the stars like our Sun are infinite, around which a multitude of planets orbit, some of which could to be inhabited by other living beings. Today, more than 400 years later, not a day passes that Giordano Bruno does not have his revenge, in light of the fact that almost every day extrasolar planets are discovered, to the point that about four thousand extrasolar planets have been discovered in the Milky Way.

In the second half of the 20th century, the debate on the search for extraterrestrial forms of life and, in particular, of intelligent civilizations was largely shaped by the Drake equation, originally proposed in 1961 by American astronomer Frank Drake [1]. This equation, on the basis of some factors, allows an estimation of the potential number of communicative civilizations in the Milky Way galaxy, serving as a useful tool for focusing discussion on the problem of finding life in the universe over a given period [2].

Soon after, von Hoerner [3], Shklovskii and Sagan [4] concluded that Drake equation's precision depended principally on a parameter, indicating the mean lifetime of a communicating civilization, which – despite subsequent advances in astrophysics have improved the precision of several parameters in the Drake equation [5-7] – remains highly uncertain [8-16]. The apparent

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absence of communicating civilizations [17] in our planet-rich galaxy [18] underscores the possibility that such civilizations have short values of this peculiar parameter [17, 19], potentially owed to factors exogenous to the civilization (e.g., nearby supernovae) and/or endogenous to the civilization (e.g., self-destruction).

On the other hand, if when the Drake equation was introduced, it was of little help because of the presence in it of many unknown terms, now thanks to the large amount of exoplanets that have been discovered, the uncertainty associated with its various factors can be greatly reduced and we have much more realistic ideas. Various authors (such as Claudio Maccone and Stanley Jaki) have recently made many significant corrections to the Drake equation which take into account the fact that, in order to give rise to life forms, the planets of terrestrial type must be accompanied by both planets of a Jupiter in circular orbits, which serve to clean up space from asteroids and debris that otherwise would annihilate the life, both from large moons that stabilize the rotation, otherwise they would put to swing and even overturn over a few million years [20, 21].

In this way, thanks to modern science, today we have acquired an extraordinary amount of data that allows us, through the modified versions of Drake's equation, to estimate how many planets are capable of sustaining life and at the same time understanding many more ways in which life can be extinguished, following natural disasters or accidents. In light of the disasters occurring on Earth, it is in fact of fundamental importance to know what percentage of the planets that meet the criteria for the existence of life guests it actually and, among the planets that host life, what percentage escaped disaster on a planetary scale and gave rise to an intelligent civilization [22].

In this paper, our purpose is to provide new keys of reading of the Drake equation which are based on the cosmological consequences of a recent model proposed by the authors, according to which universe is a non-created timeless phenomenon in a permanent dynamic equilibrium whose fundamental arena is a three-dimensional timeless non-local dynamic quantum vacuum (DQV) characterized by elementary reduction-state (RS) processes of creation/annihilation of quanta corresponding to elementary fluctuations of the quantum vacuum energy density. In this picture, time is merely a mathematical parameter measuring numerical order of change, i.e. motion, universe exists in what Albert Einstein used to call NOW, namely past, present and future are not physical realities which can be associated to a 4th dimension of space, they are only emergent realities which have a mathematical existence [23-26]. And here consciousness is the frequency of n-dimensional Hilbert space which is the fundamental space in which universe exists: matter exists in consciousness and thus has the intrinsic property to develop into systems which are tending to have frequency similar to the frequency of consciousness [27].

This means that development of these systems is happening in the entire universe, in other words cosmology and biology can be incorporated in a single view that can be named as "cosmobiology in a timeless three-dimensional dynamic quantum vacuum" [28]. This new model allows us to unify the thermodynamic evolution concerning matter, on the one hand, and the evolution of life and consciousness on the other hand, which can thus be seen as two sides of the same coin, as distinct parts of a single universal process. In short, our model wants to transmit the message that, in the universe in dynamic equilibrium, matter has a continuous tendency to

develop into intelligent and conscious organisms: the evolution of the universe and the evolution of life are processes generated by the frequency of consciousness and are always directed towards the fundamental vibratory state of consciousness. In other words, the fundamental vibratory state of consciousness can be seen as a sort of physical environment in which matter has a continuous tendency to develop into conscious species.

This paper is structured in the following way. In chapter 2 we will revisit the Drake equation and its state-of-the-art also on the basis of some recent research. In chapter 3 we will review the fundamental results of our three-dimensional quantum vacuum model about matter and consciousness. In chapter 4 we will introduce a new version of the Drake equation, which provides the frequency of planetary "origin of life"-type events in terms of the fundamental intrinsic properties of the 3D timeless non-local DQV. Finally, in chapter 5 we will analyse the epistemological perspectives introduced by our approach towards a cosmobiological view of the universe, in which evolution of inert matter and evolution of life are two distinct aspects of a single universal process, namely in a picture where matter has a continuous tendency to develop into life and further on into conscious species.

2. About the Drake equation

In its original formulation, the Drake equation reads:

$$N = R f_p n_e f_l f_i f_T L \tag{1}$$

where R is the rate of star formation in the Galaxy (i.e. number of stars per unit time), f_p is the fraction of stars with planetary systems, n_e is the average number of planets around each star, f_l is the fraction of planets where life developed, f_i is the fraction of planets where intelligent life developed, f_T is the fraction of planets with technological civilizations and L is the mean lifetime of communicating civilizations. Obviously, *N* and *L* are intimately connected: if *N* is the number of radio-communicating civilizations – as in the original formulation by Drake – then *L* is the average duration of the radio-communication phase of such civilizations (and not their total lifetime, as sometimes incorrectly stated). On the other hand, if *N* is meant to be the number of technological or space-faring civilizations then *L* represents the duration of the corresponding phase.

In the recent paper "A joint analysis of the Drake equation and the Fermi paradox", Nikos Prantzos follows a different approach from most previous ones which, instead of introducing additional terms in Equation (1), condenses its seven terms to only three, by rewriting the Drake equations as follows:

$$N = R_{astro} f_{biotec} L \tag{2}$$

where $R_{astro} = R f_p n_e$ represents the production rate of habitable planets (determined through astrophysics) and $f_{biotec} = f_l f_i f_T$ represents the product of all chemical, biological and sociological factors leading to the development of a technological civilization. Obviously, f_{biotec}

≤ 1; its maximum possible value $f_{biotec} = 1$ requires $f_l = f_i = f_T$ (a rather implausibly optimistic combination) but there is no constrain on its lower value [29].

The astrophysical factor R_{astro} is expected to be reasonably constrained in the foreseeable future. Indeed, its first term, R, is already constrained by observations in the Milky Way to be ~4 stars/yr but in order to reproduce well the stellar mass of $5 \cdot 10^{10} M_\odot$ (where $M_\odot$ is the mass of the Sun) or the 10^{11} stars of the Milky Way (if assumed to hold for the age of the Galaxy A~10 Gyr), the average star production rate is probably ~110 stars/yr. Only 10% of those stars are appropriate for harboring habitable planets, because their mass has to be smaller than 1,1 $M_\odot$, i.e. they have to be sufficiently long-lived (with main sequence lifetimes larger than 4,5 Gyr) and larger than 0.7 $M_\odot$, to possess circumstellar habitable zones outside the "tidally locked region" [30]. On the other hand, according to Mayor *et al.* [31], the statistics currently available on extra-solar planets suggest that about 13% of the surveyed stars possess super-Earths, i.e. planets in the 3-30 $M_\oplus$ range (where $M_\oplus$ is the mass of the Earth). This fraction can be associated to the product $f_p n_e$ in the Drake equation, corresponding to stars with continuously habitable planets (i.e. Earth-like planets orbiting continuously their star within the circumstellar habitable zone). On the basis of these considerations, one obtains $R_{astro} = 0,1$ habitable planet per year. We shall adopt this value here and we shall investigate the space of the remaining parameters f_{biotec} and *L,* which are totally unknown at present.

Moreover, in Prantzos' approach, at first approximation, the Galactic disk is assumed to be described by a cylinder of radius $R_G = 12 kpc$ and height h=1 kpc, where the *N* civilizations of the Drake equation are distributed uniformly. By equating the volume of the Galactic cylinder $V = \pi R_G^2 h$ with the sum of *N* volumes of spheres of average radius r occupied by each civilization, the average distance between two civilizations turn out to be $D = 2r = 2 \left(\frac{3V}{4\pi N} \right)^{1/3}$ for the case where D<h. In the case of a small number of civilizations (say *N*<1000) it turns out that D>h and a more appropriate expression is then $D = 2r = 2 R_G / \sqrt{N}$.

For each number *N* of civilizations co-existing in the Galaxy during *L* (and by assuming that all civilizations have similar values of *L*, namely that dispersion ΔL in *L* is much smaller than *L* itself) there is a minimum value L_{MIN}, corresponding to $f_{biotec} = 1$ in equation (2) for the adopted value of R_{astro}=0.1 per yr. Obviously, communication between neighbouring civilizations requires their duration *L* to be larger than twice the travel-time *D/c* (where *c* is the light speed) of radio-waves. As a consequence, if there are less than a few hundred co-existing civilizations in the Galaxy, their radio-emission phase has to last longer than 10^4 years to allow them to establish radio-communication.

Other fascinating results regarding the Drake equation have been obtained by Caleb Scharf and Leroy Cronin in the recent paper "Quantifying the origins of life on a planetary scale" [32]. These two authors suggest an equation to estimate the frequency of planetary "origin of life"-type events that is similar in intent to the Drake Equation but with some key advantages, specifically by making an explicit connection between "global" rates for life arising and granular information about a planet. Scharf's and Cronin's approach suggests that the probability of life

beginning on a given planet is very likely connected to whether there are building blocks available on a given planet, and how much of them there might be.

More specifically, Scharf's and Cronin's equation states that the odds of life emerging on a planet are driven by the number of building blocks that could possibly exist, the number of building blocks available, the probability that these building blocks will actually go on to create life (i.e. assembly), and the number of building blocks needed to produce a given life form. So, in addition to identifying the chemical prerequisites for life, this equation seeks to determine the frequency at which reproductive molecules emerge.

In Scharf's and Cronin's model the abiogenesis probability P_a at time t in a planet – intended as a probability per unit time per set of chemical building blocks – has a mean number given by the following frequency equation:

$$\langle N_{abiogenesis}(t) \rangle = N_b \cdot \frac{1}{\langle n_o \rangle} \cdot f_c \cdot P_a \cdot t \tag{3}$$

Here, N_b is the number of Potential Building Blocks, namely the set of functional chemical components (for example, carbohydrates, lipids, proteins, and nucleic acids, metal ions, silicon) which are necessary for the development of terrestrial-type life. The term N_b can be connected to bulk planetary properties, namely expressing a maximal set of building blocks for life that can be estimated from the total mass and composition of the outer planetary layers. $\langle n_o \rangle$ is the Mean Number of Building Blocks per "Organism," or Biochemically Significant System, which could be at least a minimal lifeform, one that is capable of homeostasis, reproduction, and open-ended evolution. f_c is the Fractional Availability of Building Blocks necessary for the development of life During Time t: in fact, within any given timespan, t, only a certain fraction of the total number of potential building blocks in a planetary environment will actually be available for life. This factor can be strongly dependent on planetary details, such as environmental temperature and can be significantly expanded to include explicit treatments of these details of planetary habitability and the interplay between living systems and environment (e.g., the sequestration of building blocks by prior life). P_a is the Probability of Assembly per Unit Time, namely represents the probability of an abiogenesis "event" per unit time, per set of suitable building blocks, through the assembly of those building blocks.

The importance of the formula (3) lies in the fact that, according to results of space researchers, the building blocks available do not necessarily have to be of the type that led to life beginning on our planet. Moreover, this equation seems to imply the likelihood that life beginning events are more likely to occur in solar systems where there are multiple planets, which allow for an opportunity to share materials that could lead to building blocks. The equation is basically saying that the probability of life arising on a planet is closely tied to the amount of life-sustaining chemical "building blocks" available on the planet. By building blocks, the researchers are referring to the minimum chemicals required to start the processing of making a simple life form. This could be DNA/RNA base pairs or amino acids, but it could also mean any available molecules or materials on the planet that can get involved with the chemical reactions that could lead to life. Chemistry is still chemistry across the universe, but other planets may have stumbled upon different approaches for spawning life.

Finally, other important recent results regarding the Drake equation have been obtained, by Claudio Maccone in the paper "Statistical Drake-Seaver equation for exoplanets and SETI searches" [20]. Maccone considers a statistical version of the Drake equation where each input is replaced by a positive random variable D_i and then takes the natural logs of both sides of this equation to convert it into a sum:

$$ln(N) = \sum_{i=1}^{7} ln(D_i) \tag{4}$$

and, by assuming that the number of independent random variables will increase with a better and better knowledge of the astrophysics of exoplanets, he finds that the probability density function of the output random variable $ln(N)$ will approach a Gaussian (normal) distribution and thus N will approach the lognormal distribution:

$$N = \frac{1}{n}\frac{1}{\sqrt{2\pi}}e^{-\frac{(ln(n)-\mu)^2}{2\sigma^2}} \quad (n \geq 0, \sigma \geq 0) \tag{5}$$

whose mean value μ is the sum of the input mean values, each being of the type:

$$\langle ln(D_i)\rangle = \frac{b_i[ln(b_i)-1]-a_i[ln(a_i)-1]}{b_i-a_i} \tag{6}$$

and whose variance σ is the sum of the input variances, each being of the type:

$$\sigma_{ln(D_i)} = \sqrt{1 - \frac{a_i b_i[ln(b_i)-ln(a_i)]^2}{(b_i-a_i)^2}} \tag{7}$$

where a_i is the real and positive number representing the lower limit of the range of the ith uniform input random variable, b_i is the real and positive number representing the upper limit of the range of the ith uniform input random variable.

3. Matter and consciousness in the three-dimensional timeless quantum vacuum model

According to Big-Bang cosmology, universe was born in a singularity in some remote physical past and its evolution occurs in space-time intended as a fundamental arena. The authors of this paper have recently proposed a model in which all the physical events of our everyday life derive from elementary processes of a fundamental, deep arena, a three-dimensional (3D) timeless non-local dynamic quantum vacuum (DQV) characterized by RS processes of creation/annihilation of quanta corresponding to opportune fluctuations of the quantum vacuum energy density. According to this model, universe is a timeless phenomenon in dynamic equilibrium which has no beginning and no end, where energy flows in cycles: it is characterized by cyclic Big-Bangs, it is infinite and the cosmic microwave background radiation has its origin in the 3D timeless non-local DQV.

In this model, the ground state of the universe is defined by the Planck energy density of the 3D DQV given by equation:

$$\rho_{PE} = \frac{m_p \cdot c^2}{l_p^3} \tag{8}$$

where m_P is Planck's mass, c is the light speed and l_p is Planck's length. The Planck energy density (8) physically corresponds to the total average volumetric energy density, owed to all the frequency modes possible within the visible size of the universe, expressed by:

$$\rho_{PE} = \frac{c^7}{\hbar G^2} \approx 4{,}641266 \cdot 10^{113} \, J/m^3 \tag{9}$$

$\hbar$ being Planck's reduced constant, G the universal gravitation constant. In the outer intergalactic space curvature of space is zero and its energy density corresponds to the value (9). The Planck energy density is the average energy density of *empty* universal space in which there are no material objects. Out of this fundamental energy pool of the universe particles and antiparticles continuously appear and disappear [23-26].

Each material particle is associated with fluctuations of the quantum vacuum which determine a diminishing of the energy density of space and occur in correspondence to opportune elementary RS processes of creation/annihilation of quanta. Each material object is a structured energy of DQV which is associated to a specific excited state of the DQV defined by a quantum vacuum energy density given by relation

$$\rho_{qvE} = \rho_{PE} - \frac{m \cdot c^2}{V} \tag{10}$$

where ρ_{qvE} is the energy density of quantum vacuum inside the physical object, ρ_{PE} is the Planck energy density (given by (9)) and V is the volume of the physical object. This means that the mass of the physical object corresponding to the excited state of DQV having energy density (10) is

$$m = \frac{(\rho_{PE} - \rho_{qvE}) \cdot V}{c^2} \tag{11}$$

According to equation (11) there is a fundamental physical symmetry between the property of mass and the changes of the DQV energy density. Moreover, the evolution of the excited state of DQV which corresponds to the appearance of a material particle of mass (11) is determined by opportune RS processes of creation/annihilation of quanta described by a wave function $C = \begin{pmatrix} \psi \\ \phi \end{pmatrix}$ at two components satisfying a time-symmetric extension of the Klein-Gordon quantum relativistic equation

$$\begin{pmatrix} H & 0 \\ 0 & -H \end{pmatrix} C = 0 \tag{12}$$

where $H = \left(-\hbar^2 \partial^\mu \partial_\mu + \dfrac{V^2}{c^2} (\Delta\rho_{qvE})^2 \right)$ and $\Delta\rho_{qvE} = (\rho_{PE} - \rho_{qvE})$ is the change of the quantum vacuum energy density. Equation (12) corresponds to the following two equations:

$$\left(-\hbar^2 \partial^\mu \partial_\mu + \frac{V^2}{c^2} (\Delta\rho_{qvE})^2 \right) \psi_{Q,i}(x) = 0 \tag{13}$$

for creation events and

$$\left(\hbar^2 \partial^\mu \partial_\mu - \frac{V^2}{c^2} (\Delta\rho_{qvE})^2 \right) \phi_{Q,i}(x) = 0 \tag{14}$$

for destruction events.

The virtual particles-antiparticles corresponding to the RS processes of creation/annihilation of the 3D quantum vacuum give rise to a total zero spin, thus constituting an organized Bose ensemble, analogous to the superfluid helium [33]. As a consequence, if in a recent model proposed by Sbitnev in a series of recent papers [34-37] the physical vacuum is a super-fluid medium and contains pairs of particles-antiparticles which make up a Bose-Einstein condensate, in a similar way our model of DQV implies that, in presence of ordinary baryonic matter, the 3D DQV physically acts as a superfluid medium.

The crucial element which derives from the superfluid nature of the DQV lies in the fact that it can provide a unifying view of gravity, electromagnetic fields and quantum behaviour of matter as different aspects of the same fluctuations of the quantum vacuum energy density and, in this picture, the non-local, timeless character of the 3D DQV is determined by the quantum potential of the vacuum of the form

$$Q_{Q,i} = \frac{\hbar^2 c^2}{V^2 (\Delta\rho_{qvE})^2} \left(\frac{\left(\nabla^2 - \dfrac{1}{c^2} \dfrac{\partial^2}{\partial t^2} \right) \left| \psi_{Q,i} \right|}{\left| \psi_{Q,i} \right|} - \frac{\left(\nabla^2 - \dfrac{1}{c^2} \dfrac{\partial^2}{\partial t^2} \right) \left| \phi_{Q,i} \right|}{\left| \phi_{Q,i} \right|} \right) \tag{15}$$

which is the fundamental entity which the guides the occurring of the processes of creation or annihilation in space. In particular, in the non-relativistic domain, the quantum potential of the vacuum (15) becomes:

$$Q_{Q,i} = -\frac{\hbar^2 c}{2V\Delta\rho_{qvE}}\left(\frac{\frac{\nabla^2|\psi_{Q,i}|}{|\psi_{Q,i}|}}{-\frac{\nabla^2|\phi_{Q,i}|}{|\phi_{Q,i}|}}\right) \tag{16}$$

The primary physical reality of the processes of creation and annihilation as well as the non-local action of the quantum potential associated with the amplitudes of them (as well as the opposed sign of its second component with respect to the first component), imply that in the 3D quantum vacuum the duration of the processes exists only in the sense of numerical order, namely that the 3D quantum vacuum, as a fundamental medium subtending the observable forms of matter, energy and space-time, is a timeless background.

Moreover, as a consequence of the motion of the virtual particles corresponding to the elementary fluctuations of the quantum vacuum energy density, space-time is filled with virtual radiation with frequency

$$\omega = \frac{2\Delta\rho_{qvE}V}{\hbar n} \tag{17}$$

where n is the number of the RS processes of virtual sub-particles characterizing the vacuum medium. In the light of equation (17), we can say that each elementary fluctuation of the quantum vacuum energy density in a given volume produces an oscillation of the vacuum at a peculiar frequency. In other words, the 3D DQV model predicts that each material object of our physical world corresponds to a specific vibratory state of the fundamental vacuum defined by the frequency (17) [24, 25].

Now, an important aspect of our model lies in the fact that it throws new light into the interpretation of consciousness, leading to a suggestive unification between mind and matter. All the evidence indicate that organism and environment are intimately interconnected, engaging in ceaseless rounds of mutual definition and transformation, which is the essence of evolution. Living systems may be interconnected with one another and with their physicochemical environment by information flow, as well as by material and energy flow. In this regard, in particular, since 1988 Fritz Albert Popp found that practically all living organisms emit light (biophotons) and thus became convinced that biological organization of living systems is associated to bio-photons emitted and received by the living system [38]. On the other hand, in the recent paper "Origin of life: a consequence of cosmic energy, redox homeostasis and quantum phenomenon", Reddy and Pereira suggest that origin of life emerges as an eternal process associated with the interaction between energy from the cosmos and inorganic matter, that origin of life is therefore a result of the organization and reorganization of matter to support constants such as the cosmic energy, matter and quantum processes that prevailed in the cosmos and mellowed with evolution [39].

Trying inspiration from these and other research, our model states that microtubules of the brain are getting information via bio-photons from 3D quantum vacuum defined by an electric field and a magnetic field expressed by relations

$$\vec{E}_{\tau}^{zp}(\vec{r},t) = \sum_{\lambda=1}^{2} \int d^3k \left(\Delta\rho_{qvE}V/n\pi^2\right)^{1/2} \hat{\varepsilon}(\vec{k},\lambda)\cos\left[\vec{k}\cdot\vec{r} - \frac{2\Delta\rho_{qvE}V}{\hbar n}t - \theta(\vec{k},\lambda)\right] \tag{18}$$

$$\vec{B}^{zp}(\vec{r},t) = \sum_{\lambda=1}^{2} \int d^3k \left(\Delta\rho_{qvE}V/n\pi^2\right)^{1/2} \left[\hat{k}\times\hat{\varepsilon}(\vec{k},\lambda)\right]\cos\left[\vec{k}\cdot\vec{r} - \frac{2\Delta\rho_{qvE}V}{\hbar n}t - \theta(\vec{k},\lambda)\right] \tag{19}$$

where $\hat{\varepsilon}$ is a unit vector, $\vec{k}$ is the polarization vector such that $|\vec{k}| = \omega/c$ and $\theta(\vec{k},\lambda)$ is a random variable uniformly distributed in the interval $(0,2\pi)$ and independently for each wave vector $\vec{k}$ and polarization index λ. According to equations (18) and (19) respectively, the magnetic field can be seen as the polarization of space in $\hat{k}\times\hat{\varepsilon}(\vec{k},\lambda)$; the electric field is the polarization of space in $\hat{\varepsilon}(\vec{k},\lambda)$.

In this approach, consciousness emerges as the frequency of n-dimensional Hilbert space which is the fundamental space in which universe exists. By applying the Fourier Transform, the amplitude of creation events and destruction events may be written as expansions of infinite frequency modes living in higher Hilbert spaces:

$$\psi_{Q,i}(t) = \int_{-\infty}^{+\infty} g_{Q,i}(v)e^{2\pi i vt}dv \tag{20}$$

and

$$\phi_{Q,i}(t) = \int_{-\infty}^{+\infty} h_{Q,i}(v)e^{2\pi i vt}dv \tag{21}$$

$g_{Q,i}(v)$ and $h_{Q,i}(v)$ being the frequency modes characterizing the creation and destruction processes respectively, $v = \frac{\omega}{2\pi}$. Therefore, the quantum potential of the vacuum (15) which the guides the occurring of the processes of creation or annihilation in space and makes the 3D quantum vacuum a fundamentally non-local manifold, assumes the following form

$$Q_{Q,i} = \frac{\hbar^2 c^2}{V^2\left(\Delta\rho_{qvE}\right)^2}\left(\frac{\left(\nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right)\left|\int_{-\infty}^{+\infty} g_{Q,i}(v)e^{2\pi i vt}\right|}{\left|\int_{-\infty}^{+\infty} g_{Q,i}(v)e^{2\pi i vt}\right|} - \frac{\left(\nabla^2 - \frac{1}{c^2}\frac{\partial^2}{\partial t^2}\right)\left|\int_{-\infty}^{+\infty} h_{Q,i}(v)e^{2\pi i vt}\right|}{\left|\int_{-\infty}^{+\infty} h_{Q,i}(v)e^{2\pi i vt}\right|}\right) \tag{22}$$

and, in analogous way, the non-relativistic quantum potential of the vacuum (16) becomes

$$Q_{Q,i} = -\frac{\hbar^2 c}{2V\Delta\rho_{qvE}}\left(\begin{array}{c} \frac{\nabla^2\left|\int_{-\infty}^{+\infty} g_{Q,i}(v)e^{2\pi ivt}\right|}{\left|\int_{-\infty}^{+\infty} g_{Q,i}(v)e^{2\pi ivt}\right|} \\ -\frac{\nabla^2\left|\int_{-\infty}^{+\infty} h_{Q,i}(v)e^{2\pi ivt}\right|}{\left|\int_{-\infty}^{+\infty} h_{Q,i}(v)e^{2\pi ivt}\right|} \end{array}\right) \quad (23)$$

The quantum potentials (22) and (23) of the 3D DQV imply that the evolution of the occurring of the processes of creation or annihilation in space is determined by the infinite frequency modes which appear in the wave of the quantum vacuum. Consciousness is linked with the infinite frequency modes $g_{Q,i}(v)$ and $h_{Q,i}(v)$ characterizing the creation and destruction events of quanta in the 3D quantum vacuum. In other words, consciousness can be defined as the higher Hilbert space which is "guiding", via lower dimensional spaces, 3D elementary particles in the sense that it can be associated with waves which ultimately originate from higher dimensional spaces, just corresponding to the infinite frequency modes appearing in their Fourier decompositions [27, 40].

4. The abiogenesis probability in the three-dimensional timeless quantum vacuum model

Our model of a 3D timeless non-local DQV characterized by elementary fluctuations of the quantum vacuum energy density occurring in correspondence to specific RS processes of creation/annihilation of quanta, Scharf's and Cronin's results about the abiogenesis probability at time t in a planet may here receive a new suggestive re-reading in which each of the term appearing in equation (3) have origin from a more fundamental corresponding term which originates from specific properties of the 3D DQV. In this regard, we propose therefore to introduce the following equation as regards the abiogenesis probability at time t in a planet, namely the frequency of planetary "origin of life"-type events:

$$\langle N_{abiogenesis}(t)\rangle = N_\omega \cdot \frac{1}{\langle n_o\rangle} \cdot f_\omega \cdot P_a \cdot t \quad (24)$$

The symbols appearing in this equation have following meaning:

N_ω= number of vibratory states associated with the fluctuations of the quantum vacuum energy density which give origin to potential Building Blocks necessary for the development of life in a planet (such as those consisting of families of carbohydrates, lipids, proteins, and nucleic acids, silicon, and many trace elements). This quantity can be easily connected to bulk planetary properties, thereby linking this expression back to the scope of the Drake Equation and our direct physical knowledge of the Earth and other planets. In this case, N_ω represents a maximal set of building blocks for life that can be estimated from the total mass and composition of the outer planetary layers.

$\langle n_o\rangle$: Mean Number of elementary vibratory states per "Organism," or Biochemically Significant System, which is capable of homeostasis, reproduction, and open-ended evolution. Such a lifeform may exist either as an encapsulated, cellular system or as a distributed (nonlocal) but interdependent and autocatalytic chemical system or as an intelligent technologically advanced

system. Properly evaluating $\langle n_o \rangle$ may therefore require the development of a coherent and quantitative definition of the "aliveness" of a set of building blocks.

f_ω: Fractional Availability of vibratory states able to give origin to potential Building Blocks necessary for the development of life, during time *t*. Within any given timespan, *t*, it can be assumed that only a certain fraction of the total number of vibratory states in a planetary environment will actually be available for life. Availability in this context may be defined through a number of factors: "free" (unbound to other molecular or atomic species), "mobile" (capable of physical transport, not restricted except in terms of necessary localization), or "energetic" (energetically favored chemical bonding and incorporation into a system). These factors can be strongly dependent on planetary details, such as environmental temperature. This factor f_ω can be significantly expanded to include explicit treatments of these details of planetary habitability and the interplay between living systems and environment (e.g., the sequestration of building blocks by prior life).

P_a: Probability of Assembly per Unit Time. This factor refers to the probability of an abiogenesis "event" per unit time, per set of suitable vibratory states, through the assembly of the building blocks associated with these vibratory states.

Equation (24) regarding the frequency of planetary "origin of life"-type events throws new light on the interpretation of the results of Drake's equation, in particular in Prantzos' approach. In fact, here one can assume that the abiogenesis probability (24) in a planet can be assimilated to the fraction f_l of planets where life developed. In this way, the Drake equation (1) reads:

$$N = R f_p n_e f_i f_T L \ N_\omega \frac{1}{\langle n_o \rangle} f_\omega P_a t \tag{25}$$

and also Maccone's statistical version of the Drake equation (4) can receive a similar re-reading.

In particular, in our approach the most important terms are the terms $\langle n_o \rangle$ and f_ω which are directly associated to the intrinsic properties of the 3D timeless non-local DQV.

Let us begin by taking into consideration the term f_ω which can be considered as the ultimate term responsible of the interconnection, mutual interaction and link between living organism and environment (namely between life and space), showing how an "additional density" of physical space is present in a living organism (living matter) with respect to inert matter, thus suggesting that physical space plays an active role into evolution of life. By following the spirit of Grossing's thermodynamic interpretation of the quantum potential provided in the papers [41, 42], in our approach we assume that the quantum interaction between a living organism with its environment is determined by a quantum potential of the vacuum which acts as a reservoir that produces an "additional density" of physical space in a living organism (living matter) with respect to inert matter. This means that fractional availability of vibratory states able to give origin to potential building blocks necessary for the development of life associated with the RS processes of the 3D DQV provided by the environment, can be expressed in the form:

$$f_\omega = \frac{\Delta\rho_{qvE}}{\rho_{qvE}} e^{-\frac{\Delta Q_{hf}}{kT}} \qquad (26)$$

where k is Boltzmann's constant, T is the reservoir temperature and ΔQ_{hf} is the heat that describes and regards the interaction between the living organism and its environment. By requiring that the average kinetic energy of the living organism turns out to be equal to the average kinetic energy associated with the vibratory states of the 3D DQV, namely

$$\frac{kT}{2} = \frac{\hbar\omega}{2} \qquad (27)$$

one obtains

$$f_\omega = \frac{\Delta\rho_{qvE}}{\rho_{qvE}} e^{-\frac{\Delta Q_{hf}}{\hbar\omega}} \qquad (28)$$

In this way, always following Grossing's mathematical treatment, the quantum potential of the 3D DQV (11) for the RS processes of creation in the relativistic domain becomes

$$Q = \frac{\hbar^2 c^2}{V^2(\Delta\rho_{qvE})^2} \frac{\nabla^2 Q_{hf}}{\hbar\omega} \qquad 29)$$

while in the non-relativistic domain is

$$Q = -\frac{\hbar^2 c}{2V\Delta\rho_{qvE}} \frac{\nabla^2 Q_{hf}}{\hbar\omega} \qquad (30)$$

Now, if in Grössing's thermodynamic approach to the quantum potential, the "form" of the quantum potential and its geometrodynamic features are ultimately connected with a Helmholtz-type dependence $-\nabla^2 Q_{hf}$ of a thermal energy Q_{hf} defining a fundamental vacuum and this thermal energy is associated with wave-diffusion waves and is distributed "non-locally" throughout the environment of the experimental arrangement into consideration, in analogous way in our approach of a 3D timeless non-local DQV as fundamental origin of physical processes and of the evolution of life, the interaction between a living organism and its environment, which shows how an "additional density" of physical space is present in a living organism (living matter) with respect to inert matter, is determined by a quantum potential of the 3D DQV which acts as a heat reservoir, as a thermal energy which appear then as bio-photons which act non-locally in the environment itself.

The instantaneous action of the bio-photons produced by the thermalized quantum potential of the vacuum imply that the distributions of the vibratory states in the environment under consideration contribute in their totality to the form of the heat distribution in the overall system and thus to the evolution of the living organism. As a consequence, the infinite propagation of the diffusion-wave fields associated with the bio-photons generated by the interaction between the living organism and the thermalized 3D DQV leads therefore to a promising perspective for a deeper understanding of the origin of life in the universe.

As regards the term $\langle n_o \rangle$, in order to find a plausible expression for it, since it is linked with the aliveness of a set of building blocks, we consider that several experiments seem to suggest that functioning of living systems is related to the gravitational field and thus to the universal space. In particular, experiments carried out by Amrit Sorli at the university of Ljubljana in 1987-1988 with Californian earthworms show that gravity works on a living organism stronger than on the same dead organism. The weight of the living organism is bigger than the weight of the same dead organism. This means just that there is an active relation between life and gravitational force of physical space. Gravitation works stronger on the living neurones than on the same dead neurones [43]. Moreover, it is important to underline that Kaoru Kawada in 1998 obtained similar results in Japan using rats as living organisms.

In all these experiments, we deal with an isolated system inside which there are initially a determined mass of living matter (for example, worms) and a determined mass of inert matter; the result is that the mass of the whole system always tends to increase during a first time interval and remains constant in a second time interval. The fact that during the first step we have an increase of the mass of an isolated system cannot be explained in the standard interpretation of the thermodynamic theory: the increase of mass of an isolated system partially composed by living matter is not possible inside the standard interpretation of the thermodynamic theory because the mass of an isolated system should be always constant.

In order to explain the results of these experiments, which seem to suggest that an active relation exists between life and space, one must consider the possibility that an energy can be created inside a system, which in particular can be generated from properties of the 3D DQV characterizing the environment.

In order to face the problems encountered by the standard interpretation of the thermodynamic theory, Tane suggested in some papers [44-48] that it is possible to give to the basic equation of thermodynamics the form

$$dU_* = dU_{ext} + dU_{int} \tag{31}$$

which states that, for a thermodynamic system, the total change in energy (labelled dU_*) is the sum of the energy exchanged with the surroundings (external energy labelled dU_{ext}) and of the energy created inside the system (internal energy labelled dU_{int}), where the precise meaning of the energy created inside the system is

$$dU_{int} = -mc^2 \tag{32}$$

According to equation (32), an increase in energy is correlated to a decrease in mass and conversely. By substituting equation (32) into equation (31) one obtains:

$$dU_* = dU_{ext} - dmc^2 \tag{33}$$

Moreover, in Tane's extended thermodynamic conception, a change in entropy is nothing but a change in energy per unit of temperature, one deals with the other fundamental equation

$$T_e dS = dQ_{ext} - c^2 dm \tag{34}$$

where dQ_{ext} is the heat changed by the system with the environment and

$$dQ_{int}=-c^2 dm \qquad (35)$$

is the internal thermal energy created in the system.

Now, in our model based on a 3D timeless non-local DQV, since the origin of the events are the vibratory states generated by the RS processes of creation/annihilation of quanta corresponding to opportune fluctuations of the quantum vacuum energy density, the crucial point lies in the fact that the energy exchanged with the surroundings (external energy labelled dU_{ext}) in equation (31) and, in the same way, the heat changed by the system with the environment dQ_{ext} can be associated to the quantum potential of the vacuum acting as a heat reservoir that produces an "additional density" of physical space in a living organism (living matter) with respect to inert matter, as a thermal energy which appear then as bio-photons which act non-locally in the environment itself. In analogous way, the energy or the heat created inside the system (namely the second term appearing at right hand-side of equations (33) and (34)) can be associated to the same vibratory states of the 3D DQV, in other words to the fluctuations of the quantum vacuum energy density. This means, by taking the differential of equation (11), that one has:

$$dmc^2 = -d\rho_{qvE}V \qquad (36)$$

In this way, in our 3D DQV model, on the basis of equation (36), equations (33) and (34) respectively become:

$$dU_* = Q + d\rho_{qvE}V \qquad (37)$$

$$T_e dS = dQ_{hf} + d\rho_{qvE}V \qquad (38)$$

where dQ_{hf} is the differential of the thermal energy of the 3D DQV.

Now, the formalism based on equations (37) and (38) suggests us relevant clues towards a possible determination of the term $\langle n_o \rangle$ appearing in equation (24). The aliveness character of the building blocks can be in fact associated with the negative values of $d\rho_{qvE}$ (which in turn determine an increase of the mass of living systems with respect to the same dead systems). Therefore, by considering equation (38) in the situation in which $d\rho_{qvE}$ is negative, we can assume that $\langle n_o \rangle$ is given by the fraction of the energy $dQ_{hf} + d\rho_{qvE}V$ with respect to the Planck energy:

$$\langle n_o \rangle = \frac{dQ_{hf} + d\rho_{qvE}V}{E_p} \qquad (39)$$

where

$$E_p = m_p c^2 \qquad (40)$$

is the Planck energy.

In the light of the fundamental equation (28) regarding fractional availability of vibratory states provided by the environment able to give origin to potential building blocks necessary for the development of life associated with the RS processes of the 3D DQV, as well as the fundamental equation (39) regarding the Mean Number of elementary vibratory states per "Organism", which

is capable of homeostasis, reproduction and open-ended evolution and therefore characterized by aliveness, the frequency (20) of planetary "origin of life"-type events may be expressed as

$$\langle N_{abiogenesis}(t) \rangle = N_\omega \cdot \frac{1}{\frac{\Delta Q_{hf} + \Delta \rho_{qvE} V}{E_p}} \cdot \frac{\Delta \rho_{qvE}}{\rho_{qvE}} e^{-\frac{\Delta Q_{hf}}{\hbar\omega}} \cdot P_a \cdot t \qquad (41)$$

and the Drake equation of the 3D DQV (21) thus reads

$$N = R f_p n_e f_i f_T L \; N_\omega \frac{1}{\frac{\Delta Q_{hf} + \Delta \rho_{qvE} V}{E_p}} \frac{\Delta \rho_{qvE}}{\rho_{qvE}} e^{-\frac{\Delta Q_{hf}}{\hbar\omega}} P_a t \qquad (42)$$

Moreover, in the picture of Maccone's statistical version of the Drake equation (4), each of these factors becomes variables (many of them associated with specific values of the fluctuations of the quantum vacuum energy density) and, by taking the natural logarithm, one finds:

$$lnN = lnR + lnf_p + lnn_e + lnf_i + lnf_T + lnL + lnN_\omega + ln\frac{1}{\frac{\Delta Q_{hf} + \Delta \rho_{qvE} V}{E_p}} + ln\frac{\Delta \rho_{qvE}}{\rho_{qvE}} - \frac{\Delta Q_{hf}}{\hbar\omega} \; P_a t$$

$$(43)$$

and thus, taking account of (5), one finds that *N* will approach the distribution

$$N = \frac{1}{n} \frac{1}{\sqrt{2\pi}} e^{-\frac{(ln(n)-\mu)^2}{2\sigma^2}} \cdot N_\omega \cdot \frac{1}{\frac{\Delta Q_{hf} + \Delta \rho_{qvE} V}{E_p}} \cdot \frac{\Delta \rho_{qvE}}{\rho_{qvE}} e^{-\frac{\Delta Q_{hf}}{\hbar\omega}} \cdot P_a \cdot t \quad (n \geq 0, \sigma \geq 0) \qquad (44)$$

whose mean value μ is the sum of the input mean values, each being of the type (6) and whose variance σ is the sum of the input variances, each being of the type (7), where a_i is the real and positive number representing the lower limit of the range of the ith uniform input random variable, b_i is is the real and positive number representing the upper limit of the range of the ith uniform input random variable.

Now, the approach based on equations (26)-(44), according to our opinion, suggests some considerations of extraordinary relevance from the epistemological point of view. In fact, on one hand, this approach allows us to reproduce and justify, at a fundamental level, in what sense life is present on our planet Earth. In particular, by following Scharf's and Cronin's treatment in the paper "Quantifying the origins of life on a planetary scale" [32], one finds that the abiogenesis probability per unit time per set of suitable vibratory states, through the assembly of the building blocks associated with these vibratory states, ranges from $P_a \approx 10^{-36}$ to $P_a \approx 10^{-30}$, with a value of $P_a < 10^{-33}$ being broadly compatible with the specific case of our planet. On the other hand, above all, the non-local action of the quantum potential of the vacuum makes life as a property that ultimately has a global feature, namely acts non-locally itself. In other words, we can say that, in the light of equations (26)-(44), life is a property of all universe, is a cosmic property, namely is not limited only to what we know about Earth, thus implying that abiogenesis indeed refers to a nonlocalized series of assembly steps or processes that lead directly and irreversibly to an evolvable living universe.

The non-local features of life may also be characterized by introducing a Bell length associated with the quantum potential of the vacuum (29):

$$L_{Bell} = \sqrt{\frac{\hbar^2 c^2}{2\Delta\rho_{qvE}VQ}} \qquad (45)$$

namely

$$L_{Bell} = \sqrt{-\frac{c\hbar\omega}{\nabla^2 Q_{hf}}} \qquad (46)$$

namely, taking account of (17),

$$L_{Bell} = \sqrt{-\frac{2c\Delta\rho_{qvE}V}{n\nabla^2 Q_{hf}}} \qquad (47)$$

The condition Q=0, i.e. $L_{Bell} = \infty$ provide the points where the action of the additional density of physical space is delocalized, thus implying the evolution of life and equation (47) shows that this happens when

$$\left|2c\Delta\rho_{qvE}V\right| \ll \left|n\nabla^2 Q_{hf}\right| \qquad (48)$$

Equation (48) is a plausible physical condition which, for a great number of RS processes of creation/annihilation of quanta corresponding to a great number *n* of virtual particles/ antiparticles of the vacuum, practically occurs in a specific macroscopic volume V. This means in other words that the propagation of life in the universe, owed to the action of the thermalized DQV which functions as a heat reservoir, as a thermal energy which appear then as bio-photons which act non-locally in the environment itself, occurs instantaneously in all the points of the universe, namely that life is indeed a global property which is able to transmit itself in the entire universe [49].

5. Cosmobiology in the three-dimensional timeless quantum vacuum model

According to our current knowledge, there are two main trends as regards evolution: one goes downwards, i.e. towards higher entropy, and is the thermodynamic evolution concerning matter, the other is directed upwards, i.e. towards higher organization, and concerns life and consciousness. In other words, we can say that the difference between inert matter and living organisms lies in the fact that, while as regards inert matter the evolution goes towards a decrease of mass, an increase of internal energy and an increase of entropy, instead as regards living systems the growing phase is characterized by an increase of mass, an increase of internal energy and a decrease of entropy.

Here, the crucial result is that our approach based on equations (37) and (38) can be utilized in order to describe the evolution both of inert matter and of living systems. More precisely, as regards inert matter the mass tends to decrease, *dm* is negative and thus $d\rho_{qvE}$ is positive and, as a consequence, equation (38) imply that the entropy of inert matter tends to increase, while for living systems *dm* is a positive quantity, $d\rho_{qvE}$ is negative and thus the entropy of living systems tends to decrease. Equations (37) and (38) provide therefore a comprehensive unification of the behaviour of inert matter and living matter, reproducing correctly their behaviour. In other words, equations (37) and (38) may be considered as the basis which lead to a suggestive unification of the thermodynamic evolution towards higher entropy regarding matter and the

evolution towards higher organizational states concerning life and consciousness, which here emerge just as two distinct aspects of a one universal process.

Moreover, the approach based on equations (26)-(44) allows us to make some fundamental considerations from the epistemological point of view in a global picture. If until XX century the fundamental scientific paradigm was the so called geocentric approach where human beings occupy a special, privileged place in the universe, now our model of 3D timeless non-local DQV defined by a fundamental quantum vacuum energy density, allows us to go beyond the geocentric approach towards a "cosmobiology", a real "cosmic view" of the evolution.

Our model implies that evolution of life can be considered as a consistent part of cosmic evolution, as a continuation of the evolution of the universe. In other words, we can say that, in virtue of the global feature of life which derives from the non-local action of the quantum potential of the vacuum, namely on the basis of the fact that as a consequence of the non-local action of the quantum potential of the vacuum life emerges as a nonlocalized series of assembly steps or processes that lead directly and irreversibly to an evolvable living universe, evolution on the planet Earth is only a part of a wider universal process and, all over the universe, life is developing towards the conscious species. In all the areas that have similar physical circumstances to the Earth, the development of life and its consequent evolution towards the conscious species can happen. Evolution of life can be understood as a process that is continuously developing towards a total entropy that tends to zero [50, 51].

Since last century we know that universal space is homogeneous and isotropic. This means that physical properties of the universal space are equal into the whole universe. Physical homogeneity determined by the properties of the 3D timeless non-local DQV implies "biological homogeneity": by virtue of the non-local action of the quantum potential of the vacuum, physical circumstances for the development of life are equal into the whole universe. On the other hand, spectroscopy allowed us to discover the basic organic molecules necessary for the development of life in the whole observable space [52]. Moreover, astronomical observations show that the whole observable space is permanently in a phase of chemical evolution. This means that biological evolution and chemical evolution are in a certain sense parallel processes. In other words, one can say that chemical evolution is the beginning of the negentropic process of biological evolution: the formation of cellules, pluricellular beings and living organisms happens together with the process of the chemical evolution. On the planets similar to Earth chemical evolution develops into "biological evolution".

On the basis of equations (37) and (38), one can explain and reproduce both the increase of entropy concerning matter and the decrease of entropy concerning the evolution of living organisms. It allows us to explain and reproduce the increase of entropy of matter after fresh gas begins to form from vast outer space (i.e. during the evolution of the universe corresponding to the formation of nuclei, atoms, stars and planets); at the same time, it allows us to explain and reproduce the decrease of entropy concerning the evolution of life and conscious species in the regions of the universe which have similar physical circumstances to the Earth. In other words, it shows that the two main tendencies that one can single out in the universe can be, in a certain sense, "unified" into a one universal process: here chemical evolution and biological evolution (characterized by a decrease of entropy) are a direct continuation of the "physical" evolution, i.e.

of the processes of formation of nuclei, atoms, stars and planets (characterized by an increase of entropy).

Now, as underlined before, chemical evolution is the beginning of the negentropic process of biological evolution: with the process of chemical evolution we have also the formation, in the whole observable space, of the basic organic molecules necessary for the development of life. According to the model proposed by the authors, one can say that organic molecules that are needed for the development of life are permanently generated in the whole observable space because of the ground state of the 3D timeless non-local DQV defined by the Planck energy density (8) which corresponds to the so-called "basic frequency" of space

$$\omega_p = \frac{2\pi}{t_p} = \frac{6,28}{5,3906 \cdot 10^{-44}} Hz = 1,16499 \cdot 10^{44} Hz \tag{49}$$

that build up empty space. "Basic frequency" of space (49) can be considered here as a physical environment for chemical evolution (it "generates" formation of organic molecules) that on the Earth and the planets similar to the Earth develops into life.

On the basis of equations (37) and (38), one can predict that, during the processes of formation of subatomic particles, nuclei, atoms, molecules, stars and planets (i.e. until the beginning of chemical evolution), the entropy of the generic region of the universe increases and reaches its maximum at the beginning of chemical evolution. In this phase, the energy density of the 3D DQV decreases and, as a consequence, also the average frequency of vibration of the elementary grains composing the generic region of the universe tends to decrease. Then, with the process of chemical evolution the formation of organic molecules begins at the same time: therefore in the universe we have also the biological evolution and cellules, pluricellular beings and living organisms form (in the regions which have similar physical circumstances to the planet Earth). In this phase, entropy decreases and the energy density of the 3D DQV increases and thus the average frequency of vibration of the grains of space tends to increase: living organisms have a tendency to develop into systems characterized by a higher frequency. On the basis of the model of the authors, one can predict that, since consciousness is linked with higher Hilbert spaces associated with the infinite frequency modes $g_{Q,i}(v)$ and $h_{Q,i}(v)$ characterizing the creation and destruction events of quanta in the 3D quantum vacuum, with the evolution of human being and of his consciousness, the frequency of the elementary grains of space tends to become bigger and bigger.

On the basis of the model of the 3D timeless non-local DQV developed by the authors of this article, the ground state of the 3D DQV defined by the Planck energy density (8) and consequently by the basic frequency of space (49) can be therefore considered as the "elementary background" which drives the evolution. One can say that the ground state of the 3D timeless non-local DQV is a "physical environment" in which matter has a continuous tendency to develop towards conscious species. Physical evolution, chemical evolution, biological evolution and conscious evolution of man can be considered as processes generated by the ground state of the 3D timeless non-local DQV.

Universe is physically homogeneous. Space has the same physical properties in the whole universe. In the 3D timeless non-local DQV life on the Earth occurs in the whole universe, evolution can be understood as an universal process, as an integral part of cosmic dynamics. This

new "cosmic approach" goes beyond the "geocentric" approach. It sees evolution as an universal negentropic process that develops towards the "basic frequency" of space [52, 53].

6. Conclusions

Forty years after the pioneering work of Frank Drake and its famous equation, the question "Are we alone?" has had increasingly better prospects of being scientifically investigated and the search for extraterrestrial intelligence (SETI) is going through a renaissance, due to the discovery of thousands of exoplanetary systems, many of them of terrestrial size and in the habitable zone of their host star. Most discussions on extraterrestrial intelligence focus on estimating the average number of communicating species existing in a given volume of the universe surrounding our location, in line with the modified recent versions of the Drake equation. However, this kind of approach meets the problem that the key factors quantifying the probability that life might appear on a suitable planetary habitat and develop intelligence, communication and technology are largely uncertain and unpredictable and neglects the important role played by evolutionary processes, both astrophysical and biological.

In this paper, we have introduced a new version of the Drake equation based on fundamental properties of a three-dimensional timeless non-local dynamic quantum vacuum defined by RS processes of creation/annihilation of quanta corresponding to elementary fluctuations of the quantum vacuum energy density. In particular, our model introduces an equation which expresses the abiogenesis probability at time t in a planet, namely the frequency of planetary "origin of life"-type events in terms of specific quantities characterizing the vibratory states associated to the fluctuations of the energy density of the three-dimensional timeless quantum vacuum.

In this equation, which exhibits a consistency with the results about life on planet Earth, two fundamental terms appear: on one hand, a quantity which measures the fractional availability of vibratory states able to give origin to potential building blocks necessary for the development of life, which thus can be considered as the ultimate term responsible of the interconnection, mutual interaction and link between living organism and environment (namely between life and space), showing how an "additional density" of physical space is present in a living organism (living matter) with respect to inert matter, thus suggesting that physical space plays an active role into evolution of life; and, on the other hand, a term measuring the mean number of elementary vibratory states per "organism," or biochemically significant system, which is capable of homeostasis, reproduction, and open-ended evolution, and thus associated to the "aliveness" features of a set of building blocks.

In particular, we have found that, as regards the first term, the interaction between a living organism and its environment is determined by a quantum potential of the three-dimensional dynamic quantum vacuum which acts as a heat reservoir, as a thermal energy which appear then as bio-photons which act non-locally in the environment itself, thus producing an "additional density" of physical space in a living organism (living matter) and determining the evolution of the same living organism. The non-local action of the quantum potential of the vacuum, which can also be characterized by introducing an appropriate Bell length of the vacuum, makes life as

a property that ultimately has a global feature, namely acts instantaneously in the entire universe. The fundamental result of this approach lies in the fact that it predicts that life is a property of all universe, is a cosmic property, namely is not limited only to what we know about Earth, thus implying that abiogenesis events indeed refer to a nonlocalized series of assembly steps or processes that lead directly and irreversibly to an evolvable living universe. The ground state of the three-dimensional timeless non-local dynamic quantum vacuum is a "physical environment" in which matter has a continuous tendency to develop towards conscious species, thus leading to a new "cosmic paradigm" which goes beyond the "geocentric paradigm".

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