Holographic Principle and Darwin's Time

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ABSTRACT – The Holographic Principle (HP) is used as a means to put the concept of Darwin's Time (DT) in a sound basis. We find again that DT is proportional to certain volume of the memory device (MD). Interestingly enough, applying HP to the oxygen nucleus, we obtain a horizon-time which reproduces the DT related to a typical volume (1.8 cm^3)of the memory device.

1 – Introduction

Taking in account Darwin's Theory of Evolution it seems to be a plausible hypothesis, the idea that each living being brings with it a memory of the first form of life, perhaps a unicellular organism.

Meanwhile, as was pointed out by Chaplin [1], water has a central role in life's machinery. According to him [1], liquid water is not a 'bit player' in the theatre of life – it's the headline act. The importance of water to life also was discussed by Chaplin in reference [2]. Besides this hydrogen bond kinetics [3] plays an essential role in the establishment of the transport properties of this liquid.

A paper by Morrone and Car [4] has discussed the nuclear quantum effects in water and the present author [5] advanced the hypothesis that protons in water behaves as a Fermi gas, having an important role in the transport properties of this liquid. On the other hand protonic currents seem to be essential in writing or deleting the information encoded in the memory of the living beings (please see reference [6] for more detailed discussion about this feature).

Inspired in Tononi's work [7], Tegmark [8] pointed out that: "Natural selection suggests that self-reproduction information processing systems will evolve integration if it is useful for them, regardless of whether they are conscious or not."

In references [5] and [6] the averaged time between collisions (τ) was calculated. The integrability given by the simple addition of unit-base time τ grows linearly with N, and we have called it Darwin's Time [6,9].

2 – Holographic Reasoning

In previous works [6,9] we have considered that as was pointed out by Tegmark [8]: self-reproducing information processing systems evolve integration. Then the Darwin's time was estimated by doing the sum over the N unit-base time τ composing the whole volume of the memory device. However it seems that this idea deserves deeper investigation.

As information and entropy are correlated concepts, we propose that the results obtained in the previous works [6,9] can also be derived starting from the Holographic Principle (HP). This principle was first proposed by G. 't Hooft in 1993 [10] (please see also [11]). Here we will consider the two postulates of the Holographic Principle as quoted by Mc Mahon [12]. They are:

. The total information content in a volume of space is equivalent to a theory that lives only on the surface area that encloses the region.

. The boundary of a region of the space-time contains at most a single degree of freedom per Planck area.

As a first proposal let us consider the memory device as being a sphere of radius R, and by taking in account the HP we suppose that the information content lives on its surface. We remember that the gravitational interaction is very feeble, but the sum of it over a great number of particles renders important effects over astronomical scales. The HP was first employed to deal with the information content of a system described by a curved space-time. Meanwhile the integrability present in the memory device leads to the addition of unit-time base. Besides this quantum chromodynamics, which describes strong interactions inside protons, is a non-abelian field theory and general relativity is also a non-linear theory. Now let us go to the calculations.

In applying the HP to discuss the Darwin's time, we are going to use the thermodynamics approach. We write the free energy F as

$$F = U - TS. \qquad (1)$$

In (1), U is the internal energy, T is the temperature and S is the entropy. We look at a isothermic process which maintains F stationary. We have

$$\Delta F = \Delta U - T\Delta S = 0. \qquad (2)$$

Now let us describe the quantities appearing in (2).

$$\Delta U = pc = (hc)/(2R). \qquad (3)$$

In (3), p is the relativistic momentum of an excitation and the uncertainty principle relating p and R was used. Once each water molecule contains two protons, in evaluating the entropy of the event horizon we will take the area of the unit cell as (being M the proton mass)

$$A_0 = [\hbar/(2Mc)]^2. \qquad (4)$$

Therefore the Bekenstein-Hawking-like entropy will be given by

$$\Delta S = ¼\,(A/A_0) = [4\pi(Mc)^2 R^2]/\hbar^2. \qquad (5)$$

Next we are going to associate the temperature of the event horizon to the horizon's time or Hawking time (τ_H). we write

$$h\upsilon = \hbar/\tau_H = 3T. \qquad (k_B = 1) \qquad (6)$$

In (6) we have identified $h\upsilon$ with the energy of a 3-dimensional harmonic oscillator and we also have used the energy equipartition principle, besides putting the Boltzmann constant k_B equal to the unity.

Inserting information from relations (3), (5) and (6) into relation (2) and solving for τ_H, we find

$$\tau_H = [(M^2 c)/(\pi \hbar^2)]\,(4/3)\,\pi R^3. \qquad (7)$$

We observe that τ_H given by (7) coincides with τ_D, the Darwin's time (please see ref. [9]), once $(4/3)\,\pi R^3$ corresponds to the volume of a spherical memory device.

3 – Micro Memory Devices: Proton and Oxygen Nucleus

3A – The Proton as a Memory Device

In this section we advance the idea that the proton (nucleon) and the oxygen nucleus may be though as a micro-memory device. First let us consider the proton of radius R_p and its volume $V_p = (4/3)\pi R_p^3$. But now, the area of the unit cell at the proton's "surface horizon" will be taken as the Planck length squared. Applying the HP to this particle of surface horizon area $A_p = 4\pi R_p^2$, and performing calculations analogous to that done in a previous section we obtain

$$\tau_p = [(M_{Pl}^2 c)/(4\pi \hbar^2)]\, V_p. \qquad (8)$$

In (8) M_{Pl} is the Planck mass and V_p is given by

$$V_p = (4/3)\pi R_p^3 = (4/3)\pi[(4\,\hbar)/(Mc)]^3. \qquad (9)$$

In (9) we have used the proton radius $R_p = (4\,\hbar)/(Mc)$, as quoted in references [13,14]. By using (9) and putting numbers in relation (8), we get

$$\tau_p \cong 2.52 \times 10^{15} \text{ s} \cong 8 \times 10^{7} \text{ years.} \qquad (10)$$

3B – The Oxygen Nucleus as a Memory Device

Being the water molecule constituted by an oxygen atom plus two hydrogen atoms it would be important, as we have done in section 3A, to seek at the role played by the oxygen nucleus also behaving as a micro memory device. In order to do this we consider the very simplified version of the liquid drop model of the nucleus, and we write

$$V_O = 16\, V_p. \qquad (11)$$

Above, we took the volume of the oxygen nucleus as sixteen times the volume of the nucleon, approximately 16 times the volume of the proton.

Taking in account relation (8), we have

$$\tau_O = [(M_{Pl}^2 c)/(4\pi\,\hbar^2)]\, V_O \cong [(M_{Pl}^2 c)/(4\pi\,\hbar^2)]\, 16\, V_p. \qquad (12)$$

In (12) τ_O stands for the time of retention of the memory of the oxygen nucleus. Putting number in (12) we get

$$\tau_O \cong 1.28 \times 10^{9} \text{ years.} \qquad (13)$$

We observe that coincidentally, this time τ_O is very close to the Darwin's time that we have estimated in ref. [9].

4 – Concluding Remarks

As quoted by A. Damineli and D. Daminely [15] and also by Joyce [16], the origins of life trace back to approximately 3.9 billion of years ago (please see figure 7 of their paper [15]). The results we have obtained here both for the Darwin's time (relation (7) of this paper) and the memory time of the oxygen nucleus (relation (13)) differ from the above value by a factor of approximately three. But this can be improved if we take in account that we can consider the one-dimensional version of the harmonic oscillator, instead of the three-dimensional one, using the relation (6) to determine the temperature of the event horizon. It is also interesting to verify that apparently not fortuitously, nature's design made the choice of take the oxygen nucleus containing 16 nucleons as a means to combine with two protons to accomplish the water molecule. Eighteen electrons complete this task.

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