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Research Article

OBSERVABLE UNIVERSE TOPOLOGY, HEISENBERG PRINCIPLE, SURFACE AREA OF EVENT HORIZON AND INFORMATION

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ABSTRACT

The standard cosmological model defines the *Observable Universe* as the region of the Universe observed from the earth at the present time; all the signals that have arrived to the earth since the beginning of the cosmological expansion. The fruitful formula of the Heisenberg uncertainty principle allow us to explore some issues concerning the observable universe. One of them is the possible topology of the universe according to recent cosmological data. The other one is the cosmological constant value, arising numerically from the Heisenberg principle. Finally will describe a numerical depiction about the evolution of the observable universe which involves the Hubble parameter, the number of stars, the hydrogen molecule, the degrees of freedom of the hydrogen mulecule related to the amount of information of ordinary matter as well as the surface area of the observable universe event horizon.

INTRODUCTION

Heisenberg's uncertainty principle states a fundamental limit of precision with which a pair of observable physical properties of a particle can be known. For example, when you confines to the minimum the time interval in the measurement, the energy of the particle take a broad range of possible values. From a statistical point of view we must apply the method of typical deviation.

The aim of this article consists in the application of the Heisenberg uncertainty principle at the observable universe level. Once we introduce some specific parameters in the Heisenberg equation will obtain some numerical values concerning the observable universe topology and dimensionless cosmological constant.

Now, is physically lawful the application of Heisenberg principle at cosmological level ? Allow us the scientific rules of plausibility and reality the use of the uncertainty principle when we want to analyze numerically the observable universe? According to theoretical knowledge about the early universe it is believed that the universe before inflation would have been a diameter about $\sim 10^{-30} m$[1]. Therefore we can analyze the uncertainty of an observational time range as well as the uncertainty in the measurements about the energy range in the first stages of the universe.

METHOD AND RESULTS

Let's start defining a dimensionless number

$$(N_{...}) = \frac{1}{2e}\frac{a_0}{L_P} = 6.0225\ x\ 10^{23} \qquad (1)$$

a_0 refers to Bohr radius (appendix)
L_P refers to Planck's length (appendix)
$e = 2.7182818 \ldots$, Euler number
We use this value $(N_{...})$ as a *quantifier* of items involved in any system. In the case at hand the system is the observable universe. Since Euler number is located in the denominator $(N_{...})$ could take a broad range of values. Here we apply the value

$n\ e^m$
For now we'll apply
$n = 2$ and $m = 1$

In the appendix (at the end of this paper)we've compiled the references of the physical constants used in this article.

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Heisenberg's formula reads [2]

$$\Delta p \, \Delta x \geq \frac{h}{2} \qquad (2)$$

Which means that the simultaneous determination of momentum and position in particle physics is not possible. There are alternative formulas that relates other physical variables. For instance the formula where time and energy are linked [3]is the one we are going to use here. In classical quantum mechanics time is used as a parameter

$$\Delta t \;\; \Delta E \geq \frac{h}{2} \qquad (3)$$

H is the quantum of action or Planck constant (appendix)

In physics exists a quantity termed *Surface tension*, usually represented by the symbol γ (greek letter gamma). In SI units is Joule per square meter

$$\gamma = \frac{E}{A} \; Jm^{-2} \qquad (4)$$

Based on that assumption will introduce a little change in the equation (3)

$$\Delta t \;\; \Delta E \;\; \frac{1}{U_A} \geq \frac{h}{2}\frac{1}{P_A} \qquad (5)$$

In the above equation we hypothesize that the *external surface* of the observable universe (universe's event horizon surface area) shows a toroidal shape [4] which means that the parameter A in the equation (4) would be defined as

$$U_A = 4\pi^2 \, rR \qquad (6)$$

Where r and R refers to the two radius that defines a torus (figure 1)

According to the standard cosmological model [5] the radius of the observable universe is about $10^{26}m$

Set the specific values for the two radius
$R = 1 \, x \, 10^{26}m$ and $r = 0.9999 \, x \, 10^{26}m$
Therefore

$$U_A \sim 4 \, \pi^2 \, x \; 0.9999 \; x10^{52}m^2$$

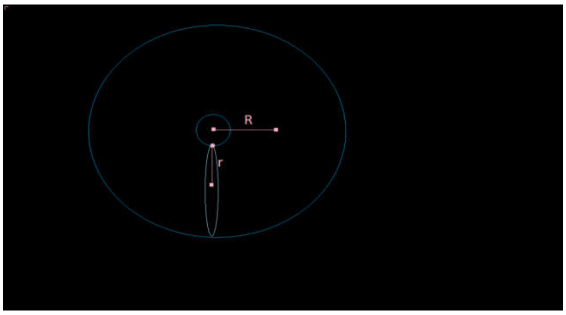

Figure 1 Torus radius R and r

As for the parameter P_A writed in the equation (5)

$$P_A = 4\pi L_P^2$$

refers to Planck's surface area, equivalent to the surface area of a sphere [6]

Let's assign observational values:

$\Delta t \sim 4.4 \, x \, 10^{17}s$ refers to the Universe life time [7], equivalent to an *observational interval of time*
Will estimate the broad range of energy values about

$$\Delta E \sim (N_{...})M \, C^2 \qquad (7)$$

$(N_{...}) = 6.0225 \, x \, 10^{23}$already defined above

$$M = N_S m_p \qquad (8)$$

$N_S = 10^{57}$ approximate number of hydrogen atoms [8]required to ignite a star

$m_p$refers to the mass of a proton (appendix)
$C$is the speed of light in vacuum (appendix)
Check the arithmetic of calculations

$$[4.4 \, x \, 10^{17}s][(N_{...})(\,10^{57})(1.673 \, x10^{-27}kg)(c)^2]\frac{4\pi(2.612 \, x \, 10^{-70}m^2)}{4\,\pi^2 x0.999 \, x \, 10^{52}m^2} \geq \frac{h}{2} \qquad (9)$$

Note that we avoided to cancel the factor 4π in the above equation so that the underlying topology associated with both surface areas (sphere and torus)appears obvious (figure 2)
Write the surface area ratio

$$A_r = \frac{P_A}{U_A} \sim \frac{1}{10^{123}} \qquad (10)$$

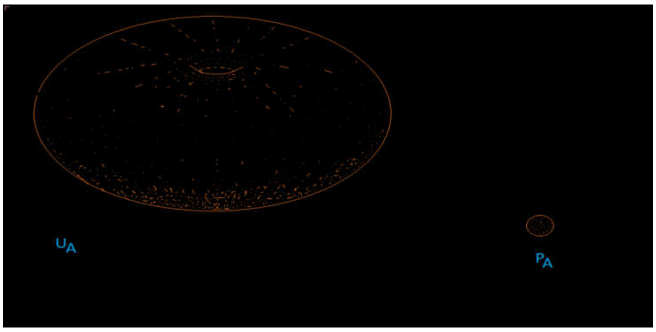

Figure 2 Universe event horizon surface area and Planck area

Therefore

$$\Delta t \; x \; A_r \Delta E \;\; \geq \frac{h}{2} \qquad (11)$$

By the way the parameter A_r matches the estimated dimensionless value for the effective cosmological constant [9]

$$\Lambda_{eff} \sim 10^{-123} \qquad (12)$$

Finally we could represent the Heisenberg uncertainty principle at a cosmological level in the figure 3.

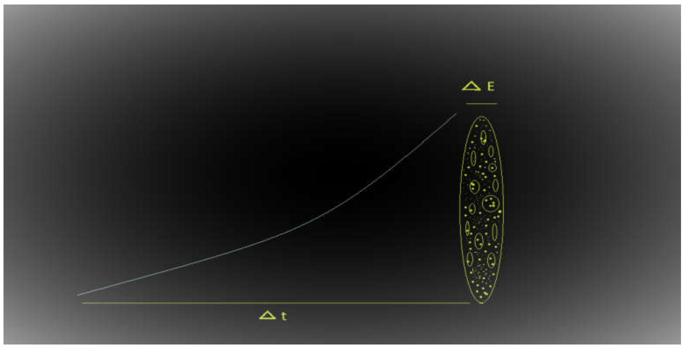

Figure 3 Observable Universe and Heisenberg uncertainty.

Observable universe evolution

Getting back to the definition of the parameter $(N_{...})$

$$(N_{...}) = \frac{1}{2e}\frac{a_0}{L_P} = 6.0225 \, x \, 10^{23}$$

According to that, we'll explore a numerical relationship between the Newtonian constant of gravitation (appendix), speed of light in vacuum, the ratio megaparsec-Hubble parameter, parameter $(N_{...})$ defined above, the mass of hydrogen molecule, degrees of freedom of such diatomic molecule, the number of hydrogen atoms required to ignite a star and finally the surface area of the observable universe

$$\frac{G_N}{C}\frac{M_{pc}}{3H_0}(N_{...})N_S\,H_2\,f \;= U_A \qquad (13)$$

$G_N$refers to the newtonian constant of gravitation. C refers to the speed of light in vacuum.

$M_{pc} = 3.0857\,x\,10^{22}m$ astronomical unit of distance measurement called megaparsec

$H_0 \sim 70630\;ms^{-1}$current value of Hubble parameter that fits best in the equation (13)

$N_S \sim 10^{57}$approximate number of hydrogen atoms required to ignite a star

$H_2 = 3.37\,x\,10^{-27}kg$ the mass of the hydrogen molecule ,sum of the mass of the proton and the mass of the electron (appendix) multiplied by two
$f = 6$ refers to the effective degrees of freedom (dof) of a molecule of hydrogen wich means 3 translational dof + 2 rotational dof + 1 vibrational dof.

The set [$(N_{...})N_S\,H_2\,f$] involved in the equation (13) represents the amount of information about most of ordinary matter in the observable universe represented by the hydrogen molecule.

In cosmology, the event horizon of the observable universe is the largest comoving distance from which light emitted can ever reach the observer in the future. An example of a cosmological model with an event horizon is an universe dominated by the cosmological constant. We have hypothesized that the surface area of the event horizon of the observable universe has the topological shape of a torus. Thus the value U_A has been included in the equation (13). Analyzing such equation it's worth to note the inverse dependence of some parameters associated with the dynamics of the observable universe. According to the standard model of cosmology, the Hubble parameter is actually thought to be decreasing with time. Besides, Euler number which is explicitly involved in the definition of the parameter $(N_{...})$matches withan exponential behaviour observed in the dynamics of the universe evolution and the increase of entropy over time.

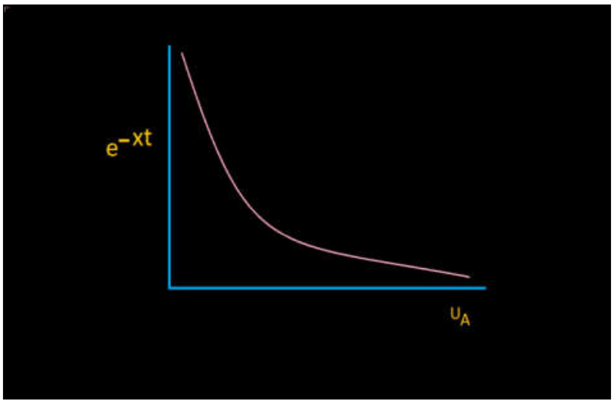

Figure 4 Universe's surface area evolutionover time

Therefore the value of the surface area of the observable universe $U_A$varies over time also .According to that we could schematize an evolutionary setting represented in the figure 4

Whatever the physical meaning of variable x in the exponential formula e^{-xt} only note that for theexisting observable universeat $t_0 \sim 10^{17}s$ and universe's event horizon surface area next to$U_A \sim 10^{52}m^2$the likely value of $(-xt)$ is obviously next to one.

DISCUSSION

From a numerical point of view, Heisenberg uncertainty principle contains fruitful derivations. Here we have used the broad range of mass-energy of the stars, the universe life time, the topology of the observable universe and the cosmological constant dimensionless value. There are different alternatives about the topology or possible shape of the observable universe. Supposing a toroidal topology for the observable universe it leads to assume a numerical correlation between the Heisenberg uncertainty principle and the cosmological constant dimensionless value.

On the other hand we've analyzed a relationship between the cosmic event horizon surface area in the equation (13) with respect to other parameters like Hubble constant, the amount of information based on the number of stars and the degrees of freedom of the hydrogen molecule. Thus we've connected numerically some concepts like information, entropy and event horizon surface area.

CONCLUSION

We have used the Heisenberg uncertainty principle at a cosmological level .The use of the parameter $(N_{...})$ relating to the average number of stars in the observable universe .The inclusion of topological concepts in the Heisenberg uncertainty equation. The evolution of the observable universe related to the increase of entropy over time, Hubble parameter variation over time and the surface area of the observable universe varying over time.

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Appendix

Table of physical constants [10]
Bohr radius:$a_0 = 5.291772 \ x \ 10^{-11} m$
Planck length :$L_P = 1.6162 \ x \ 10^{-35} m$
Proton mass :$m_p = 1.67262 \ x \ 10^{-27} kg$
Electron mass :$m_e = 9.11 \ x \ 10^{-31} kg$
Planck constant :$h = 6.62607 \ x \ 10^{-34} \ Js$
Speed of light in vacuum :$c = 299792458 \ ms^{-1}$
Newtonian constant of gravitation :$G_N = 6.674 \ x \ 10^{-11} m^3 kg^{-1} s^{-2}$

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