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Adaptation of the Entropic Gravity Formula for a Generalization to Cosmology Rh=ct in Accordance with the Law of Conservation of Energy

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Abstract

We found, then we demonstrated an exact heuristic adaptation of the entropic gravity formula with a simple factor for adaptation to the quantum linear thermodynamic cosmology of type Rh=ct=c/H, which is in the field of classical mechanics, at the apparent horizon universe. This factor, which is a simple change of bits numbers, is imposed by the law of conservation of energy, when is applied to the Hubble volume, as was recently demonstrated. This formula could shed new light on gravitational entropy, refine the standard cosmological model, and bring us closer to a theory of everything that unifies the fields of relativity and quantum mechanics. Next, we propose a precise definition of quantum gravity that complies with the laws of thermodynamics.

Keywords: thermodynamics; entropic gravity; cosmology; temperature of CMB; law of conservation of energy; quantum gravity

1. Introduction

Einstein said about thermodynamics: "A theory is the more impressive the greater the simplicity of its premises is, the more different kinds of things it relates, and the more extended is its area of applicability. Therefore, the deep impression which classical thermodynamics made upon me. It is the only physical theory of universal content concerning which I am convinced that within the framework of the applicability of its basic concepts, it will never be overthrown." [1]

Entropy is a measure of the disorder or randomness of a system. According to the second law of thermodynamics, the entropy of an isolated system increases over time, or at best remains constant. This law gives time a fundamental direction, often referred to as the 'arrow of time'.

Contemporary cosmology and modern physics take different approaches to entropy. We find that, when adapted to the quantum thermodynamic cosmology of type Rh=ct=c/H in a heuristic way, Erick Verlinde's entropic gravity [2] is consistent with the law of energy conservation for the Hubble volume. This study complements the work of Fu-Wen Shu and Yungui Gong. [3]

2. Background

In 2010, Erick Verlinde proposed his vision of gravity entropic [2]. His gravity entropic formulas derived from the holographic principle are very easy and are as follows:

$$N = \frac{A}{l_{Pl}^2} \tag{1}$$

Where N is the number of bits encoded on a surface, A is the area, $l_{Pl} = \sqrt{\frac{\hbar G}{c^3}}$ is the Planck length, G is the gravitational constant and c the speed light in vacuum.

$$N = \frac{A\, c^3}{\hbar\, G} \tag{2}$$

Gravity Holographic energy, E_{GH}, is expressed as follows:

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$$E_{GH} = \frac{1}{2} N\, k_B T \tag{3}$$

In 2015, Tatum et al. [4] proposed an equation for the CMB temperature, noted T_{cmb}, that has since been formally derived from the Stefan-Boltzmann law by Haug and Wojnow [5,6]

$$T_{cmb} = T_{Rh} = \frac{\hbar c}{4\pi k_b \sqrt{R_h\, 2\, l_{Pl}}}\, K \tag{4}$$

Where $T_{Rh} = T_{cmb}$ is the temperature of the Hubble sphere.
This can be derived as follows:

$$Rh = \frac{\hbar^2 c^2}{16\pi^2\, k_b^2 T_{cmb}^2\, 2\, l_{Pl}}\, m \tag{5}$$

This can also be derived as follows:

$$l_{Pl} = \frac{\hbar^2 c^2}{16\pi^2\, k_b^2 T_{cmb}^2\, 2\, Rh}\, m \tag{6}$$

Where k_b is Boltzmann's constant, the Hubble radius is defined by $R_h = \frac{c}{H} = c\, t_{Rh}$, where H is the Hubble parameter and t_{Rh} the Hubble time,

These interdependent values with the Planck temperature, $T_{Pl} = \frac{1}{k_B}\sqrt{\frac{\hbar c^5}{G}}$ are necessary and sufficient to lead us to the formulation of quantic gravity, compatible with the energy contained in the Hubble sphere, i.e. at the apparent horizon, in accordance with the law of conservation of energy.

In 2025, Wojnow demonstrated the law of conservation of energy applied to the Hubble volume in the field of the quantum linear thermodynamic cosmology [9].

3. Heuristic Formulation and Demonstration of the Gravity Holographic of Our Apparent Universe

Firstly, we are in the field of classical mechanic quantum thermodynamic cosmological models $Rh = c\, t_{Rh} = \frac{c}{H}$ model. Where $E_{Rh} = \frac{c^4\, Rh}{2\, G}$ is the energy contained in the Hubble volume. So, it is imperative that the geometric mean be applied to the area sphere in the following manner:

$$A_{Rh} = 4\pi\, Rh\, l_{Pl}\, \frac{T_{Pl}}{8\pi\, T_{Rh}} \tag{7}$$

Indeed, geometric means are commonly used in our particular approach to Rh=ct quantum thermodynamic cosmological models between unit quantum values and Rh=ct model values, see [4,7]. The utilization of the factor $\frac{T_{Pl}}{8\,\pi\, T_{Rh}}$, is also a component of our methodology. $\frac{T_{Pl}}{8\,\pi\, T_{Rh}}$, and count the inverse of number Planck temperature over the cosmic time t_{Rh}. See for example when we count the number $\frac{t_{Rh}}{2\, t_{Pl}}$ of Planck time in quantum thermodynamic cosmological models [8].

From Eq.2 and Eq.6, we derived N_{Rh} as follows:

$$N_{Rh} = 4\pi\, Rh\, c\, t_{Pl}\, \frac{T_{Pl}}{8\pi\, T_{Rh}}\, \frac{c^3}{\hbar\, G} \tag{8}$$

$$E_{Rh} = \frac{1}{2}\, N_{Rh}\, \frac{c^3}{\hbar\, G}\, k_B\, T_{cmb} = \frac{c^4\, Rh}{2\, G} \tag{9}$$

With $l_{Pl} = c\, t_{Pl}$, where t_{Pl} is the Planck time we derived Eq.9 as follows

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$$E_{Rh} = \frac{1}{2} 4\pi\, Rh\, l_{Pl} \frac{T_{Pl}}{8\pi\, T_{Rh}} \frac{c^3}{\hbar\, G} k_B\, T_{cmb} = \frac{c^4\, Rh}{2\, G} \quad (10)$$

$$E_{Rh} = \frac{1}{2}\, c\, t_{Pl} \frac{T_{Pl}}{8\pi\, T_{Rh}} \frac{c^3 Rh}{\hbar\, G} k_B\, T_{cmb} = \frac{c^4\, Rh}{2\, G} \quad (11)$$

Since we have $T_{cmb} = T_{Rh}$ we derive Eq.11 as follows:

$$E_{Rh} = \frac{1}{2}\ t_{Pl} \frac{c^4 Rh}{\hbar\ G} k_B T_{Pl} = \frac{c^4\, Rh}{2\, G} \quad (12)$$

With $t_{Pl} = \sqrt{\frac{\hbar\, G}{c^5}}$ and $T_{Pl} = \frac{1}{k_B}\sqrt{\frac{\hbar c^5}{G}}$, we derive Eq.11 as follows:

$$E_{GH} = E_{Rh} = \frac{1}{2}\frac{c^4 Rh}{G} = \frac{c^4\, Rh}{2\, G} \quad (12)$$

4. About the Quantum Gravity

Using Eq.12, we can derive an exact deterministic formula for quantum gravity G_{Pl} that complies with the laws of thermodynamics as follows:

$$G_{Pl} = \frac{1}{2}\ \frac{c^4\, t_{Pl}\, c\, t_{Rh}}{\hbar\ E_{Rh}}\ k_B T_{Pl} \quad (12)$$

$$G_{Pl} = \frac{1}{2}\frac{c^5\, t_{Pl}\, t_{Rh}}{\hbar\ E_{Rh}} k_B\, T_{Pl} \quad (13)$$

5. Conclusion

The contribution of the gravity universe entropy formula Rh=ct to this emerging quantum thermodynamic cosmological model is an important advance. It provides a reliable formula in this field of research, paving the way for new developments in the string theory. In another hand, its provided perspectives on the issues faced by the contemporary standard cosmological model. Indeed, there is a potential link between the $Rh = ct = c/H$ models and the cosmological standard model with the formula: $\frac{c}{H_0}\int_{a=0}^{a=1} \frac{da}{a\sqrt{\Omega_r a^{-4} + \Omega_m a^{-3} + \Omega_k a^{-2} + \Omega_\Lambda}}$. This could precision and refine the standard cosmological model. See, for example [8]. This contribution is based on Lavoisier's law of conservation of mass written in energy terms as $E = mc^2$. We are living in the interior of a black hole which can be considered as an isolate system [9]. Nothing is lost, nothing is created, everything is transformed. In other words, our origin comes from nothingness, or from a simple quantum fluctuation in a flat, infinite universe with no beginning and no end of time.

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