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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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 and we demonstrate an exact heuristic adaptation of the entropic gravity formula an adaptation to the quantum linear thermodynamic cosmology of type Rh=ct=c/H, which is in the field of classical mechanics, at the apparent universe horizon. We change the bits numbers and definition of area formula. This is imposed by the law of conservation of energy, when it is applied to the Hubble volume, as has been 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. Furthermore, we propose a precise definition of quantum gravity that complies with the laws of thermodynamics.

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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 entropic gravity [2]. His entropic gravity formulas derived from the holographic principle are simple and begin with:

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

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, $\hbar$ is the reduced Planck constant, G is the gravitational constant and c the speed light in vacuum.

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

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

 doi:10.20944/preprints202508.1839.v4

$$E_{GH} = \frac{1}{2} N k_B T \quad (3)$$

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]

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

where $T_{Rh} = T_{cmb}$ is the temperature of the Hubble sphere, k_b is Boltzmann's constant, the Hubble radius is defined by $R_h = \frac{c}{H} = c \, t_{Rh}$, H is the Hubble parameter and t_{Rh} is the Hubble time, and l_{Pl} the Planck length.

This can be rearranged as follows:

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

This can also be rearranged with $l_{Pl} = c \, t_{Pl}$ where t_{Pl} the Planck time, as follows:

$$t_{Rh} = \frac{\hbar^2}{T_{cmb}^2 \, k_b^2 \, 16\pi^2 \, 2 \, t_{Pl}} s \quad (6)$$

These interdependent values with the Planck temperature, $T_{Pl} = \frac{1}{k_B}\sqrt{\frac{\hbar c^5}{G}}$ in a way that is 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 which follow $Rh = c \, t_{Rh} = \frac{c}{H}$ model, wherein $E_{Rh} = \frac{c^4 \, Rh}{2 \, G}$ is the total energy contained in the Hubble volume. Accordingly, it is necessary that the geometric mean of Rh^2 and l_{Pl}^2 be applied to the spherical area formula in the following manner:

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

Indeed, geometric means are commonly used in similar models; for example, see [4,7]. The utilization of the factor $\frac{T_{Pl}}{8 \, \pi \, T_{Rh}}$ is also a component of our methodology, which incorporates the ratio of the Planck temperature and the cosmic temperature T_{Rh}. See also where we count the number $\frac{t_{Rh}}{2 \, t_{Pl}}$ of Planck times in quantum thermodynamic cosmological models [8].

Assuming double universe theories, i.e., we add a universe of antimatter with a negative arrow of time, or mirror universe theories, we have $N_{Rh} = 2 \, N_{GH}$ and derive Eq.2 and Eq.7, as follows:

$$N_{Rh} = 2 * 4\pi \, Rh \, c \, t_{Pl} \frac{T_{Pl}}{8\pi \, T_{Rh}} \frac{c^3}{\hbar \, G} \quad (8)$$

 doi:10.20944/preprints202508.1839.v4

$$E_{GH} = \frac{1}{2} N_{Rh} \frac{c^3}{\hbar G} k_B \tag{9}$$

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

With $l_{Pl} = c\, t_{Pl}$, where t_{Pl} is the Planck time is; then we derive Eq.10 as follows:

$$E_{GH} = E_{Rh} = \frac{1}{2} c\, t_{Pl} \frac{T_{Pl}}{T_{Rh}} \frac{c^3 Rh}{\hbar G} k_B T_{cmb} \tag{11}$$

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

$$E_{GH} = E_{Rh} = \frac{1}{2} t_{Pl} \frac{c^4 Rh}{\hbar G} k_B T_{Pl} \tag{12}$$

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.12 as follows:

$$E_{GH} = E_{Rh} = \frac{1}{2} \frac{c^4 Rh}{G} = \frac{c^4 Rh}{2\, G} \tag{13}$$

We have proven that this consistent adaptation of N_{GH} and A_{GH}, the holographic energy holographic is now equal to the energy content of the Hubble volume, i.e., at the apparent horizon, specifically, $\frac{c^4 Rh}{2\, G}$.

It is important to emphasize that, in this approach, T_{Rh} and t_{Rh} are interdependent:

$$T_{cmb} = T_{Rh} = \frac{\hbar c}{4\pi k_b \sqrt{R_h\, 2\, l_{Pl}}} K \tag{14}$$

and

$$t_{Rh} = \frac{\hbar^2}{T_{cmb}^2\, k_b^2\, 16\pi^2\, 2\, t_{Pl}} s \tag{15}$$

4. Resulting Quantum Gravity Formulae

Using Eq. 12, we can now derive a formula for quantum gravity G_{Pl} in our isolated, spheric black body system that complies with the laws of thermodynamics as follows:

$$G_{GH} = G_{Pl} = \frac{1}{2} \frac{c^4\, t_{Pl}\, c\, t_{Rh}}{\hbar\, E_{Rh}} k_B T_{Pl} \tag{16}$$

$$G_{GH} = G_{Pl} = \frac{1}{2} \frac{c^4\, t_{Pl}\, Rh}{\hbar\, E_{Rh}} k_B T_{Pl} \tag{17}$$

As $k_B T_{Pl} = E_{Pl}$, we have:

$$G_{GH} = G_{Pl} = \frac{1}{2} \frac{c^4\, Rh\, t_{Pl}}{\hbar} \frac{E_{Pl}}{E_{Rh}} = 6.674300\ kg^{-1} m^3\, s^{-2} \tag{18}$$

$$G_{GH} = G_{Pl} = G \tag{19}$$

where G_{GH} is the gravity entropic of E. Verlinde. We valid it's gravity entropy at the apparent univers, i.e. at the Hubble radius in this classic mechanics framework.

5. Conclusions

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 string theory. Furthermore, it offers a new perspective on the issues faced by contemporary standard cosmological model. Indeed, there is a

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potential link between the $Rh = ct = \frac{c}{H}$ models and the cosmological standard model with the formula of observable radius: $R_{Obs} = \frac{c}{H_0}\int_{a=0}^{a=1} \frac{da}{a^2\sqrt{\Omega_r a^{-4}+\Omega_m a^{-3}+\Omega_k a^{-2}+\Omega_\Lambda}}$. This could precision and refine the standard cosmological model. We can propose that we live inside a black hole which can be considered as an isolated system [9].

This contribution is also based upon Lavoisier's law of conservation of mass written in energy terms as $E = mc^2$: "Nothing is lost, nothing is created, everything is transformed." In other words, our origin comes from nothingness, or in modern physics, from a simple quantum fluctuation resulting from a flat space infinite universe with no beginning and no end of time. Finally, this document provides additional evidence in support of Pascual Jordan's hypothesis concerning the zero-energy universes.

Note: Since Haug proved the link between H and Tcmb [5][6], all of Tatum et al.'s subsequent publications on FSC [4] could be considered accurate after careful verification. See for example https://doi.org/10.4236/jmp.2018.98091 on the same subject.

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