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Upsilon Constants and Their Usefulness in Planck Scale Quantum Cosmology

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Abstract

This paper introduces the two Upsilon constants to the reader. Their usefulness is described with respect to acting as coupling constants between the CMB temperature and the Hubble constant. In addition, this paper summarizes the current state of quantum cosmology with respect to the Flat Space Cosmology (FSC) model. Although the FSC quantum cosmology formulae were published in 2018, they are only rearrangements and substitutions of the other assumptions into the original FSC Hubble temperature formula. In a real sense, this temperature formula was the first quantum cosmology formula developed since Hawking's black hole temperature formula. A recent development in the last month proves that the FSC Hubble temperature formula can be derived from the Stephan-Boltzmann law. Thus, this Hubble temperature formula effectively *unites* some quantum developments with the general relativity model inherent in FSC. More progress towards unification in the near-future is expected.

Keywords

Quantum Cosmology, Hubble Constant, Planck Scale, Upsilon Constant, Flat Space Cosmology, Black Holes, CMB Temperature, ΛCDM Cosmology, Quantum Gravity, Unification

1. Introduction and Background

To the best of this author's knowledge, Planck scale quantum cosmology effectively originated with the publication of the seminal papers of Flat Space Cosmology (FSC) in 2015 [1] [2] [3] [4]. By incorporating our model Hubble constant definition and the Schwarzschild formula into our unique Hubble temperature formula, we *predicted* in 2015 a Hubble constant value of 66.89 km/s/Mpc. A subsequent study in 2023 [5] yielded a nearly identical result (66.87117) to a precision of ±0.00043.

The only input of our 2015 FSC Hubble constant determination formula was Fixsen's 2009 CMB temperature T_0 value of 2.72548 K [6]. Our particularly useful *scaling* cosmological black hole temperature formula is:

$$\left.\begin{array}{l} k_B T_t \cong \dfrac{\hbar c^3}{8\pi G\sqrt{M_t M_{pl}}} \cong \dfrac{\hbar c}{4\pi\sqrt{R_t R_{pl}}} \\ \left\{\begin{array}{ll} M_t \cong \left(\dfrac{\hbar c^3}{8\pi G k_B T_t}\right)^2 \dfrac{1}{M_{pl}} & \text{(A)} \\ R_t \cong \dfrac{1}{R_{pl}}\left(\dfrac{\hbar c}{4\pi k_B}\right)^2 \left(\dfrac{1}{T_t}\right)^2 & \text{(B)} \\ R_t T_t^2 \cong \dfrac{1}{R_{pl}}\left(\dfrac{\hbar c}{4\pi k_B}\right)^2 & \text{(C)} \\ t \cong \dfrac{R_t}{c} & \text{(D)} \end{array}\right. \end{array}\right\} \quad (1)$$

One can readily see that this FSC Temperature formula (top left equation) is a slight (but *important*) modification of Hawking's black hole temperature formula in terms of the product inside the radical of our denominator. It is also apparent that our FSC temperature formula and Hawking's temperature formula give the same value for the Planck mass epoch universe, presumably at or near the beginning of universal expansion. Both formulae would also agree if the half Planck mass (correlating to a single Planck length Schwarzschild radius) were inserted for both terms inside the radical. The half Planck mass can also be referred to as the "instanton".

It is of great interest that Haug and Wojnow [7] have recently confirmed the importance of the FSC temperature formula by deriving it from the Stephan-Boltzmann law! This is a tremendous breakthrough in further certifying FSC as a useful model of quantum cosmology. One can then realize that the FSC temperature formula is a major step forward in uniting the general relativity of black holes with their quantum physics, as Hawking attempted to do.

Since the October 23, 2023 pre-print of Haug and Wojnow as described above, Tatum *et al.* [8] have derived two useful formulae using the Greek and Latin versions of letter Upsilon as a compound constant coupling the Hubble constant to the CMB temperature. They employ the Greek Upsilon symbol ϒ and the Latin Capital Upsilon symbol Ʊ as new constants defined below.

In 2018, FSC quantum cosmology equations were fully derived by Tatum and published in several venues [9] [10] [11]. This was achieved by rearranging the FSC Hubble temperature formula and substituting *c/R* with the Hubble constant. Moreover, the Schwarzschild formula was used in order to substitute *R* with its definition in terms of *M*. The resulting quantum cosmology formulae are as follows, using only the standard cosmological and quantum symbols:

$$R \cong \frac{\hbar^{3/2} c^{7/2}}{32\pi^2 k_B^2 T^2 G^{1/2}} \qquad R_0 \cong \frac{\hbar^{3/2} c^{7/2}}{32\pi^2 k_B^2 T_0^2 G^{1/2}} \quad (2)$$

$$H \cong \frac{32\pi^2 k_B^2 T^2 G^{1/2}}{\hbar^{3/2} c^{5/2}} \qquad H_0 \cong \frac{32\pi^2 k_B^2 T_0^2 G^{1/2}}{\hbar^{3/2} c^{5/2}} \tag{3}$$

$$t \cong \frac{\hbar^{3/2} c^{5/2}}{32\pi^2 k_B^2 T^2 G^{1/2}} \qquad t_0 \cong \frac{\hbar^{3/2} c^{5/2}}{32\pi^2 k_B^2 T_0^2 G^{1/2}} \tag{4}$$

$$M \cong \frac{\hbar^{3/2} c^{11/2}}{64\pi^2 k_B^2 T^2 G^{3/2}} \qquad M_0 \cong \frac{\hbar^{3/2} c^{11/2}}{64\pi^2 k_B^2 T_0^2 G^{3/2}} \tag{5}$$

$$Mc^2 \cong \frac{\hbar^{3/2} c^{15/2}}{64\pi^2 k_B^2 T^2 G^{3/2}} \qquad M_0 c^2 \cong \frac{\hbar^{3/2} c^{15/2}}{64\pi^2 k_B^2 T_0^2 G^{3/2}} \tag{6}$$

As per convention, the T_0 equations in the right-hand column are for currently observed cosmological values, where the current and most precise value of the CMB temperature (Fixsen's 2.72548 K) is used as the sole T_0 input. The 2018 NIST CODATA values for the constants are updated, in place of the 2014 NIST CODATA values used in 2015. These 2018 values are either identical (as in most cases) or minimally different (as for G) in comparison to those used in 2015. Therefore, the calculated results of the standard cosmological parameters remain essentially of the same values (see Section 3).

2. The Upsilon Formulae for Calculating H_0

One can readily recognize that the H_0 value calculated above can also be expressed as:

$$H_0 = \Upsilon T_0^2 \tag{7}$$

wherein all of the constants on the right-hand side of the H_0 Equation in (3) can be replaced with the Greek Upsilon term. Thus, it becomes quite clear that *there is an extremely interesting and simple relationship between the Hubble constant and the current CMB temperature in FSC which dates back to* 2015. *One can think of them as essentially two sides of the same cosmological coin*! *Given this new insight*, H_0 *can be reconsidered as a scaling cosmic thermodynamic parameter*.

Equation (7), which we refer to as the first of our cosmological "Upsilon equations", expresses the current Hubble constant in reciprocal seconds (s^{-1}). Using the 2009 Fixsen CMB temperature value T_0 of 2.72548 K, one gets a Hubble constant value of:

$$H_0 = 2.167899530268314 \times 10^{-18}\ \mathrm{s}^{-1} \tag{8}$$

The value for Υ in Equation (7) reduces to:

$$\Upsilon = 2.91845601539730127466404708016 \times 10^{-19}\ \mathrm{s}^{-1} \cdot \mathrm{K}^{-2} \tag{9}$$

One can then use the conversion factor for arriving at H_0 in units of km/s/Mpc by multiplying Υ by $3.08567758149137 \times 10^{19}$ km/Mpc. A further simplification of the Υ term, intended for immediate conversion of CMB temperature T_0 to H_0 in units of km/s/Mpc, utilizes the most precise km/Mpc conversion number used by the IAU (International Astronomical Union). The Latin Capital Upsilon term Ʊ is then used instead of the Greek Upsilon term Υ so that the second Upsilon formula is:

$$H_0 = \mho T_0^2 \tag{10}$$

The value for H_0 is then *converted directly to km/s/Mpc*, without requiring an intermediate km/Mpc multiplication step.

$$H_0 = \mho T_0^2 = 66.894389794746\ \mathrm{km/s/Mpc} \tag{11}$$

The value for $\mho$ in Equation (11) reduces to:

$$\mho = 9.005414299280081\ \mathrm{km/s/Mpc/K^2} \tag{12}$$

Or, if one chooses, the units of $\mho$ can be expressed in $\mathrm{km \cdot s^{-1} \cdot Mpc^{-1} \cdot K^{-2}}$

So, a quick and useful approximation of H_0 can be obtained by simply multiplying the square of the CMB temperature by 9. If anyone among our modern cosmologists has already found this quick rule-of-thumb CMB temperature-to-Hubble constant conversion method to km/s/Mpc, this paper provides, for the first time, the theoretical basis for this conversion method. Even using a $\mho$ conversion value of 9.0054143 km/s/Mpc/K^2 gives an almost exact Hubble constant value. In such case, the extra decimal places in the above numbers add relatively little more value. The strength of the current paper is simply to provide the FSC rationale for generating such precise and accurate Hubble constant values from knowing only the best modern measurement of the CMB temperature.

3. Results: Using FSC Formulae to Calculate Parameters

Standard cosmological formulae are typically calculated using the current Hubble constant H_0 customarily given in S.I. units. Thus, the Hubble constant value in reciprocal seconds ($\mathrm{s^{-1}}$) is used. Below are the most commonly-used formulae in ΛCDM and FSC:

$$t_0 \cong \frac{1}{H_0} = 4.61275989 \times 10^{17}\ \mathrm{s} = 14.617\ \text{billion years} \tag{13}$$

$$R_0 \cong \frac{c}{H_0} = 1.38287063 \times 10^{26}\ \mathrm{m} = 14.617\ \text{billion lt-yrs} \tag{14}$$

$$M_0 = \frac{c^3}{2GH_0} = 9.3108051513 \times 10^{52}\ \mathrm{kg} \tag{15}$$

$$M_0 c^2 = \frac{c^5}{2GH_0} = 8.3681343479 \times 10^{69}\ \mathrm{J} \tag{16}$$

$$\rho_0 = \frac{3H_0^2}{8\pi G} = 8.40531461467 \times 10^{-27}\ \mathrm{kg \cdot m^{-3}} \tag{17}$$

$$\rho_0 c^2 = \frac{3H_0^2 c^2}{8\pi G} = 7.554320039 \times 10^{-10}\ \mathrm{J \cdot m^{-3}} \tag{18}$$

The above results are similar to the ΛCDM values, allowing for some theoretical differences and observational uncertainties. ΛCDM apparently doesn't use the exact cosmological time formula given above, unless they are using a different H_0 value than that obtained from the Planck satellite CMB observations. It is particularly puzzling that standard model cosmologists insist on a cosmic age of approximately 13.8 billion years, despite the current best estimate of the age of the Milky Way's "Methuselah star" (HD 140283). This estimate has a reported value of 14.27 ± 0.38 billion years [12]. Furthermore, astrophysicists are deeply puzzled as to how the early galaxies could have become so large, if the universe was actually only 13.8 billion years old. Nevertheless, the difference between the "observed" cosmic age of about 13.8 billion years and the FSC calculation of about 14.6 billion years is only about 5.8%, which could well be within the margin of observational error (thinking again of the Methuselah star!).

4. Discussion

This paper has been written with several purposes in mind. First, in light of recent breakthroughs having to do with uniting quantum physics with general relativity, this paper provides a wider historical perspective which places the FSC model at the center of these developments. Our 2015 FSC papers introduced readers to our new cosmological model which incorporates formulae representing reasonable speculations concerning the fact *that our expanding universe has a number of parameter relationships not unlike a* Schwarzschild *black hole*. First and foremost among these is the mass-to-radius ratio of our visible universe, which is very close to, if not exactly, the ratio of a *Schwarzschild* black hole, once one adds in the dark matter, which is at least five times the visible matter. In addition, it is almost unimaginable that the average density measurement of our universe is essentially that of a black hole with a radius of about 14 billion light-years. One only has to plug the numbers in and calculate *M/R* ratio and the average mass density calculated in this paper. If one compares these two figures with those of a Schwarzschild black hole of similar mass and radius, it certainly raises a number of interesting questions. These observations, among many others, led to our development of the FSC model. We were curious as to what a model of reasonable black hole assumptions might produce. The result was the eventual development of what we believe are the first useful quantum cosmology formulae, some of which are repeated in this paper. Later publications [13] [14] [15] have suggested similar lines of development, perhaps inspired by the success of FSC. As for any possible significance of the Upsilon constants with respect to quantum symmetry in cosmology, or implications concerning a bouncing quantum cosmology, this is unknown at the present time.

Second, this paper introduces to readers the discovery by Tatum *et al.* [8] concerning the use of the two Upsilon compound coupling constants relating the Hubble constant to the square of the CMB temperature in a surprisingly simple way. In a sense, the Hubble constant and the CMB temperature *appear* to be permanently bound together by our Upsilon constants. Apparently, one cannot consider one without considering the other. If this turns out to be true, then the Hubble constant is no more a cosmic constant (over time) than the CMB temperature is a cosmic constant. Unless they violate the perfect cosmological principle (*i.e.*, no particular cosmic time is *particularly special* for us as observers), they are *both* most likely better regarded as *scaling thermodynamic cosmic parameters*. Maybe it is true that "only time will tell".

5. Summary and Conclusion

To summarize, this paper clearly defines a fascinating relationship between the CMB temperature and the Hubble constant. With the aid of FSC quantum cosmology formulae (in particular, the formula for the current Hubble constant value), it is apparent that there is a compound constant which couples these two universal parameters at present, and most likely for other cosmic times since the decoupling epoch. Tatum *et al.*, in a recent paper [8], have named the first coupling constant Upsilon, using the Greek symbol ϒ. At about the same time, Tatum independently arrived at a different coupling constant which automatically gives the Hubble constant in km/s/Mpc, without having to convert reciprocal seconds to km/s/Mpc. This conversion is already accomplished with the use of the second Upsilon symbol, the Latin Capital Upsilon symbol Ʊ. Since the reader might be interested in the historical development of quantum cosmology to the present, this paper has also provided some context concerning the FSC model and its extremely useful Hubble temperature equation with much resemblance to the Hawking black hole temperature formula. In retrospect, and in a real sense, our slightly modified formula appears to be the very first *useful* quantum cosmology formula.

Comment: It should be noted here that this paper in no way attempts to address the current "Hubble tension" problem. Because of dramatically different methods for measuring the Hubble constant value, there are a myriad of factors to consider before usefully comparing the CMB method and the nearby universe methods employed by the SHoES project [16] and Freedman [17].

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Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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