Cosmological Scale Versus Planck Scale: As Above, So Below!

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Abstract

We will demonstrate that the mass (equivalent mass) of the observable universe divided by the universe radius is exactly identical to the Planck mass divided by the Planck length. This only holds true in the Haug universe model that takes into account Lorentz's relativistic mass, while in the Friedmann model of the universe the critical mass of the universe divided by the Hubble radius is exactly equal to $\frac{1}{2}\frac{m_p}{l_p}$. This is much more than just a speculative approximation, for the findings are consistent with a new, unified, quantum gravity theory that links the cosmological scale directly to the Planck scale.

Key Words: universe mass (energy), Hubble radius, Planck length, Planck mass.

1 Is there a relation between the cosmological scale and the Planck scale? A historical perspective

"*As above, so below*" is a saying from the ancient philosopher Hermes Trismegistus in a text known as the *Emerald Tablet*, as the original version was supposedly found on an emerald tablet, though the veracity of this is unclear. The saying reflects a philosophical ide holding that the smallest scales of the world were reflected in the largest scales of the cosmos, and the opposite. For example, Isaac Newton was clearly so fascinated by some of the work of Hermes Trismegistus that he even made his own translation of the *Emerald Tablet*; see, for example, Newman [1] and Chambers [2]. Today we know much more about the cosmos and more about the smallest possible length of the universe, the Planck length. However, little progress has been made on the Planck scale in relation to gravity for more than 100 years. Only recently has one been able to measure the Planck length indirectly without any knowledge of G, $\hbar$, or even c; see [3, 4]. We will here demonstrate that Trismegistus was actually right in his conjecture, for there is a direct link between the largest (observable) scales of the cosmos and the Planck scale.

A series of authors (including myself) have previously, and somewhat more speculatively, suggested there are likely potential relationships between the cosmological scale and the Planck scale; see Haug [5] and Bahth and Becker [6]. Actually, already in 1916, Einstein [7] suggested the next step in gravity theory would be to make a quantum gravity theory, something he tried to do for the rest of his life, but with little success. In 1918, Eddington [8] suggested that a new quantum gravity theory would likely be closely linked to the Planck length. Today, most physicists trying to develop a quantum gravity theory that can be unified with quantum mechanics assume the Planck scale will play an important role; see, for example, [9–11]. Quantum cosmology has garnered increased interest [12]. As general relativity theory combined with observations has been our main tool in also understanding the cosmological scales, one will expect that a quantum gravity theory similarly will also be able to explain the cosmological scale. Recently, a new quantum gravity theory has been published that claims to unify gravity with quantum mechanics; this is the so-called collision-space time; see [13–15]. This theory have further been linked to the cosmological scales [16].

An important recent step is that we [17] have shown one can extract the Planck length from cosmological observations with no prior knowledge of G or $\hbar$ and that cosmological observable phenomena can then again be predicted only from two constants, namely the Planck length and the speed of light (the speed of gravity), in addition to variables. This can basically be seen almost as proof that the Planck scale is directly related to the cosmological scale. It is more than speculation; it is testable and verifiable.

2 When working with kilogram mass

In the Haug [15, 18] model of the universe, the standard universe mass in kilograms is given by:

$$M_u = \frac{c^3}{H_0 G} \tag{1}$$

Further, we can solve the Max Planck length formula, $l_p = \sqrt{\frac{G\hbar}{c^3}}$, with respect to G we get $G = \frac{l_p^2 c^3}{\hbar}$; see [19–21].

Next we solve the reduced Compton [22] wavelength formula, $\bar{\lambda} = \frac{\hbar}{Mc}$ with respect to M, and this gives $M = \frac{\hbar}{\bar{\lambda}}\frac{1}{c}$. Now replace G and M_u with these expressions and solve with respect to H_0, and this gives:

$$H_0 = \frac{c\bar{\lambda}_u}{l_p^2} \tag{2}$$

We use subscript u on the reduced Compton wavelength here just because we got it from the universe mass M_u. The Hubble radius in the Haug universe is given by:

$$R_H = \frac{c}{H_0} = \frac{l_p^2}{\bar{\lambda}_u} \tag{3}$$

Next, the Haug universe mass divided by this radius to give:

$$\frac{M_u}{R_H} = \frac{\frac{\hbar}{\bar{\lambda}_u}\frac{1}{c}}{\frac{l_p^2}{\bar{\lambda}_u}} = \frac{1}{l_p}\frac{\hbar}{l_p}\frac{1}{c} = \frac{m_p}{l_p} \tag{4}$$

The same naturally holds true for energy, as the rest-mass energy of the universe is simply this multiplied by c^2, so multiplying by c^2 on both sides would naturally not change this finding. We are not distinguishing here between energy and mass, so with the universe mass we mean all energy and mass in the universe on a mass equivalent form.

In other words, the Haug universe mass divided by the Haug observable universe radius is exactly identical to the Planck mass divided by the Planck length. This result is more important than one might at first think. There is considerable uncertainty in the Planck length (see 2018 NIST CODATA) measures and therefore in the Planck mass divided by the Planck length numerical value. However, since the Hubble constant is directly linked to the Planck length and also the universe mass and the universe radius, then the exact same uncertainty is in the numerical ratio of the observable universe mass divided by the universe radius. This means the more accurately we know the Hubble radius, the more accurately we know the Planck length, and the more accurately we know the Planck length, the more accurately we know the universe radius (the Hubble radius). They are two aspects of the same thing. As we have recently demonstrated, the Planck length can be extracted from a series of gravity phenomena without knowledge of G, also without knowledge of G and $\hbar$, and even with no knowledge of G, $\hbar$ and c; see [23]. We can even extract the Planck length from cosmological red shift. From only two constants, the speed of gravity that we can easily extract from gravity observations only (without the need of LIGO or any very advanced apparatus) and the Planck length, in addition to variables related to the specific situation, we can predict all observable gravity phenomena and also cosmological phenomena.

The observable universe is the largest structure we can know something about, or at least observe. Similarly, the Planck length and the Planck time are the shortest possible length and time.

In the Friedman [24] model, the critical mass (mass equivalent of all the energy and mass in the critical universe) is given by:

$$M_c = \frac{c^3}{2H_0 G} \tag{5}$$

In this model we must have:

$$M_c = \frac{\hbar}{\bar{\lambda}_c}\frac{1}{c} \tag{6}$$

where $\bar{\lambda}_c$ is the reduced Compton wavelength of the Friedmann critical universe mass (energy). The Hubble constant in the Friedmann model from a quantum perspective must be given by [16]:

$$H_0 = \frac{c\bar{\lambda}_c}{2l_p^2} \tag{7}$$

The predicted Hubble constant is the same in the Friedmann universe as the Haug universe because the reduced Compton wavelength of the mass in the Friedmann universe is twice that in the Haug universe.

This means we must have the following relation:

$$\frac{M_c}{R_H} = \frac{1}{2}\frac{m_p}{l_p} \tag{8}$$

In other words, this is off by a half compared to that of in the Haug universe. The reason for this is that general relativity theory ignores Lorentz's [25] relativistic mass. That the followers of general relativity theory, for example [26–28] have strongly ignored relativistic mass, even without first investigating all the things including relativistic mass, leads to.

In a working paper, Haug [5] speculatively indicates one could have $\frac{M_u}{R_u} = \frac{m_p}{2\pi l_p}$. We now know this is not fully correct as there is a π too much in the denominator to be correct for the Friedmann model; secondly, it is a 2π too much to be correct for the Haug model.

Bahth and Becker [6] suggest $\frac{M_H}{\theta} = \frac{m_p}{2l_p}$ where θ, according to them, is the diameter of the particle horizon, further M_H is the mass (or energy equivalent mass) inside this horizon. Bahth and Becker suggest $\Theta = 2\frac{c}{H_0}\left(\frac{3}{2}\right)^3 \approx 8.8 \times 10^{26}$ m (when $H_0 \approx 70.95$). This can be seen as the radius of the universe including expanding space since the time of the Big Bang. There is no expanding of space in the Haug model of the universe. If one sets $\theta = R_H$ and M_H equal to the Haug mass, then their somewhat speculative suggestion corresponds to the exact result of the Haug model.

Also from the Haug model of the universe, we have:

$$\hbar = M_u H_0 l_p^2 \tag{9}$$

or

$$\hbar = \frac{M_u}{R_H} l_p^2 c \tag{10}$$

and in the Friedmann critical universe model

$$\hbar = 2M_c H_0 l_p^2 \tag{11}$$

or

$$\hbar = \frac{2M_c}{R_H} l_p^2 c \tag{12}$$

Bahth and Becker [6] suggested

$$\hbar = \frac{2M_H}{\Theta} l_p^2 c \tag{13}$$

This does not correspond directly to the Friedmann critical universe model or the Haug model of the universe; still, it was an early similar suggestion.

Since we can extract the Planck length from a long series of gravity phenomena without knowing G and $\hbar$, as demonstrated by Haug in recent years, then the relations above are more than just some fancy re-writing of some math, replacing some constants with others. Instead, it shows the quantum parameters of the universe are directly linked to the cosmological scales. We have strong reasons to think the Haug model of the universe is the correct model, because it does not need dark energy [29] to give very accurate supernova predictions; further, it matches all the properties of the Planck scale for a micro black hole with a mass equal to the Planck mass. General relativity theory cannot do that.

3 Compton wavelength of the universe

The reduced Compton wavelength of the observable universe in the Haug model is given by:

$$\bar{\lambda}_u = \frac{\hbar}{M_u c} \tag{14}$$

but this can also be found from the radius of the universe since we must have

$$\bar{\lambda}_u = \frac{l_p^2}{R_H} \tag{15}$$

or since $R_H = \frac{c}{H_0}$ we naturally also have

$$\bar{\lambda}_u = \frac{l_p^2 H_0}{c} \tag{16}$$

In the Friedmann universe we must have

$$\bar{\lambda}_c = \frac{2l_p^2}{R_H} \tag{17}$$

and

$$\bar{\lambda}_c = \frac{2l_p^2 H_0}{c} \tag{18}$$

Again, we see there is a link between the largest and the smallest. The Compton wavelength of the universe mass can be measured independent of any knowledge of G or $\hbar$, see [16].

Further, the universe density in the Haug model is related to the Planck density, $\rho_p = \frac{m_p}{\frac{4}{3}\pi l_p^3}$ in the following way:

$$\rho_u = \frac{M_u}{\frac{4}{3}\pi R_H^3} = \frac{m_p}{\frac{4}{3}\pi l_p^3}\frac{\bar{\lambda}_u^2}{l_p^2} = \rho_p \frac{\bar{\lambda}_u^2}{l_p^2} \tag{19}$$

This means we also have the somewhat interesting result:

$$\frac{\bar{\lambda}_u}{l_p} = \sqrt{\frac{\rho_u}{\rho_p}} \tag{20}$$

where ρ_u is the mass density in the Haug universe and ρ_p is the Planck mass density. That is, the ratio of the reduced Compton wavelength of the universe divided by the reduced Compton wavelength of the Planck mass is equal to the square root of their densities. Similarly, in the Friedmann model for the critical universe we must have:

$$\rho_c = \frac{M_c}{\frac{4}{3}\pi R_H^3} = \frac{m_p}{\frac{4}{3}\pi l_p^3}\frac{\bar{\lambda}_c^2}{2l_p^2} = \rho_p \frac{\bar{\lambda}_c^2}{2l_p^2} \tag{21}$$

and in the Friedmann critical universe:

$$\frac{\bar{\lambda}_c}{l_p} = \sqrt{\frac{2\rho_c}{\rho_p}} \tag{22}$$

where ρ_c is the density of the critical Friedmann universe (inside the Hubble sphere) and ρ_p is the Planck mass density. It is important to be aware these are not speculative approximations but exact results from an extensive framework for quantum gravity and quantum cosmology.

4 Collision space-time mass

The kilogram mass was well accepted in the physics' communities in Europe around 1870. The kilogram mass is clearly a human arbitrarily-chosen clump of matter. It is not a natural fundamental quantity of matter. The laws and forces of nature do not care if we call a clump of a given quantity of mass a kilogram or a pound. Not only that, the kilogram mass is an incomplete mass that does not take into account the collision-time between photons making up the mass. Please read up on collision-space time, for example [14]. For this and other reasons, we have come to the conclusion that a much more complete mass definition, which we have coined collision-time, it is given by:

$$\bar{m} = t_p \frac{l_p}{\bar{\lambda}} = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}} \tag{23}$$

This is the same as the kilogram mass multiplied by G/c^3 that again is the same as multiplying with $l_p^2/\hbar$. So standard theory already hidden have this mass in all of gravity, as one always have GM in all observable gravitational phenomena. GMm we only have in the gravity force formula itself, but m always cancels out in derivations to calculate something that also can be observed. In terms of collision-time, the Planck mass is simply:

$$\bar{m} = \frac{l_p}{c}\frac{l_p}{l_p} = t_p \tag{24}$$

Yes, that is, the Planck mass is simply the Planck time. So the Planck mass divided by the Planck length is now:

$$\frac{\bar{m}}{l_p} = \frac{t_p}{l_p} = \frac{\frac{l_p}{c}}{l_p} = \frac{1}{c} \tag{25}$$

Further, the universe mass is now given by:

$$\bar{M}_u = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}_u} \tag{26}$$

Quantization is normally linked to the Planck constant and there is no Planck constant in our mass. However, the term $\frac{l_p}{\bar{\lambda}_u} \approx 8.05 \times 10^{60}$ should, in this theory, be interpreted as the number of collisions between photons making up matter (and energy) in an observational window equal to the Planck time; see [30]. For masses smaller than the Planck mass, this factor will be less than one and then represents the probability for the particle in question to be in a collision state in the Planck time window.

The universe mass divided by the Hubble radius is now:

$$\frac{\bar{M}_u}{R_H} = \frac{\frac{l_p}{c}\frac{l_p}{\bar{\lambda}_u}}{\frac{l_p^2}{\bar{\lambda}_u}} = \frac{1}{c}$$

So we have:

$$\frac{\bar{M}_u}{R_H} = \frac{\bar{m}_p}{l_p} = \frac{1}{c} \tag{28}$$

and naturally also

$$\frac{R_H}{\bar{M}_u} = R_H H_0 = \frac{l_p}{\bar{m}_p} = \frac{l_p}{t_p} = c \tag{29}$$

When linking length and time through the speed of light, we have $c = 1$ and then these two unique ratios are one. In the Friedmann model, when converting the mass to collision-time mass, we would get:

$$\frac{\bar{M}_c}{R_H} = \frac{\bar{m}_p}{2l_p} = \frac{1}{2c} \tag{30}$$

and when linking length and time through the speed of light we have $c = 1$ and this ratio is $\frac{1}{2}$. This is directly related to that the Friedmann model cannot fully match the Planck scale for micro black holes, as pointed out recently; see [31, 32].

5 Conclusion

We have demonstrated that in the Haug universe the mass of the universe (the mass inside the Hubble sphere) divided by the Hubble radius is exactly equal to the Planck mass divided by the Planck length. Further, the critical mass in the Friedmann model divided by the Hubble radius is exactly half of the Planck mass divided by the Planck length. We think the Friedmann model is incomplete since it is rooted in general relativity theory that does not take into account Lorentz's relativistic mass. Further, when we use the more complete mass definition of collision-time, then the Planck mass divided by the Planck length is simply $\frac{1}{c}$ and also the universe mass (inside the Hubble sphere) divided by the Hubble radius is then also $\frac{1}{c}$. If linking length and time through the speed of light, we have to set $c = 1$ and then both these ratios are exactly 1. We must conclude that the conjecture of Hermes Trimegistus was correct: we indeed have *as above, so below*!

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