Progress in the Composite view of the Newton Gravitational Constant and its link to the Planck scale

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Abstract

The Newtonian gravity constant G plays a central role in gravitational theory. Researchers have since at least the 1980's tried to see if the Newton gravitational constant can be expressed or replaced with more fundamental units, such as the Planck units. However already in 1987 it was pointed out that this led to a circular problem, namely that one must know G to find the Planck units, and that it is therefore is of little or no use to express G through the Planck units. This is a view repeated in the literature in recent years, and is the view held by the physics community. However a few years ago we will claim the circular problem was solved. In addition when one express the mass from the Compton wavelength formula then this leads to that the three universal constants G, h and c can be replaced with only l_p and c to predict observable gravitational phenomena. This paper will review the history as well recent progress in the composite view of the gravitational constant.

Keywords: Newton gravitational constant, Planck units, composite constant, gravity, mass, quantum gravity, cosmology.

1 Short history on the Newton gravitational constant and the Planck units

Newton's gravitational constant play an important role in almost any gravity calculation. However Newton actually never introduced nor used a gravitational constant [1] in his gravitational force formula. His formula as stated by words in Principia [2] was $F = \frac{\bar{M}\bar{m}}{R^2}$. This is equivalent to today's gravitational force formula without the gravitational constant. Well almost so, as we on purpose are using the notation $\bar{M}$ and $\bar{m}$ for the two masses, rather than M and m, this because Newton had a quite different view on mass than today. Even without a gravity constant Newton was able to do many predictions such as to find the relative mass between planets and the Sun, see also Cohen [3]. He also found the relative density of the Earth relative to the Sun to a value very close to what is known today. What he tried to do, but not could do was to find the density of the earth relative to a known substance, such as water, lead or gold.

Cavendish [4] in 1798 is by modern physics often considered the first to measure the gravitational constant. However, Cavendish in his paper did not describe a gravitational constant nor used one. What he did was to measure the density of the Earth relative to the density of a known substance, what Newton not had been able to perform but tried to do. To do this Cavendish used a torsion balance, today also known as a Cavendish apparatus. Such an apparatus had been designed The main point in using such an apparatus is that one can measure the gravity effects from a human size object, that is the balls in the Cavendish apparatus where one easily can control what kind of substance they are made of, for example lead. Then next by comparing this with the gravitational effect of the Earth one can find the density of the Earth relative to the density of a known substance. That such an apparatus also can be used to extract the gravitational constant is true.

The so called Newton gravitational constant was first introduce in 1873 by [5] by the two French physicists Cornu and Baille. In their paper they gave the formula

$$F = f\frac{Mm}{R^2} \tag{1}$$

where f is the gravitational constant. Big G as the notation of the gravity constant was likely first introduced by Boys [6] in 1894. It took many years before the notation G became standard in the international physics community, for example Max Planck [7] used f for the gravitational constant as late as 1928, and Einstein used notation k in 1916. Naturally if one uses f, k or G as symbol for the gravitational constant is pure cosmetics. What is important to bear in mind is that the gravitational constant is relatively new (at least compared to Newton's Principia) and that it also came into existence at about the same time the kilogram became the international standard mass.

A few years after the invention of the Newtonian gravitational constant, Max Planck [8, 9] in 1899 introduced the Planck units. He assume there where three important universal constants, G, c and h, and then used dimensional analysis to derive a unique length $l_p = \sqrt{\frac{G\hbar}{c^3}}$, time $t_p = \sqrt{\frac{G\hbar}{c^5}}$, mass $m_p = \sqrt{\frac{\hbar c}{G}}$ and temperature $T_p = \sqrt{\frac{\hbar c^5}{G k_b^2}}$. Today known as the Planck units. Einstein [10] already in 1916 suggest that the next step forward in gravity would be quantum gravity. Eddington [11] was in 1918 suggesting that quantum gravity must be linked to the Planck scale, or in his own words

> *But it is evident that this length (the Planck length) must be the key to some essential structure. It may not be an unattainable hope that someday a clearer knowledge of the process of gravitation may be reached.?*

However, Eddington's idea was criticized by Bridgeman [12] in 1931. Bridgeman (that later got the Nobel prize in physics) thought of the Planck units where more likely mathematical artifacts coming out of dimensional analysis rather than something fundamental related to gravity. Today most researchers working with quantum gravity theory seems to think the Planck units will play an important role in a final unified theory, see for example [13–15]. Others are more critical, Meschini [16] points out that the "*the significance of Planck's natural units in a future physical theory of spacetime is only a plausible, yet by no means certain*". The lack of certainty in the significance of the Planck units comes from that the Planck scale at that time still only could had found very indirectly by dimensional analysis. For example Unzicker [17] still seems to hold on to the view of Bridgeman, that the Planck units are little more than mathematical artifacts from dimensional analysis that are of no use and can basically be seen as undetectable mathematical artifacts. The Planck units are almost a bit like the ether, if there are no ways to detect the Planck units then why not simply abandon the idea that they will play a central role in physics.

These opposing views on the Planck units we will see also plays an historically important role when it comes to the gravity constant itself. Okun [18] in 1991 pointed out that "*The status of G and its derivatives, m_p, l_p , t_p, is at present different from that of c and $\hbar$, because the quantum theory of gravity is still under construction.*". So a better understanding of G can perhaps also makes us get closer to understanding the Planck scale and even closer to a unified quantum gravity theory. So it is important to keep questioning the real meaning of G, something we will look at this paper, mainly by reviewing the existing literature of how G potentially can be linked to the Planck scale.

2 History of the composite view of G and the circular problem

The gravity constant has SI units of $m^3 \cdot kg^{-1} \cdot s^{-2}$. It would be strange if anything physical had units: meters cubed, divided by kilogram and seconds squared. We can all imagine something that has length, for example a cat, or something that has mass in terms of kilogram, for example a cat, and time we all have a feeling of is related to change, it can be measured with clocks. So, the output units of the Newtons gravitational constant is perhaps the first hint that it could be a universal composite constant that actually can be represented by some more fundamental constants that we can link more directly to something physically [19]. Still as we will see that G is a composite constant has been discussed for more than 60 years without a resolution, until perhaps very recently. We will here go through much of the important history and progress around how the gravitational constant can be expressed in form of Planck units.

Thüring [20] in 1961 concludes that G has been introduced somewhat ad-hock and that it cannot be associated with a unique property of nature, see also Gillies [21]. Zee [22] in 1982 in a paper titled "*Calculation of Newton's Gravitational Constant in Infrared-Stable Yang-Mills Theories*" wrote

> *"Is Newton's gravitational constant G a, fundamental parameter or is it calculable in terms of other fundamental parameters? In this paper I would like to argue the latter view and to present a calculation of G, unfortunately not in the real world, but in a toy world, just to demonstrate that G is indeed calculable."*

Cahill [23, 24] in 1984 is likely the first to suggest that instead of calculating the Planck mass from G $\hbar$ and c, that perhaps G can be calculated from the Planck mass and suggest that G is given by

$$G = \frac{\hbar c}{m_p^2} \tag{2}$$

This is nothing more than solving the Planck mass formula, $m_p = \sqrt{\frac{\hbar c}{G}}$, with respect to G. Chaill comments

> *"The actual distribution of energy throughout space-time causes the tetrads to assume vacuum expected values of the order of the Planck mass, m_p. Thus the gravitational constant, $G = \frac{\hbar c}{m_p^2}$, may be viewed not as a fundamental constant, but as a mass scale that is dynamically determined by the large-scale structure of the Universe."*

Cohen [25] suggest the same formula in 1987, that he correctly points out also can be found from dimensional analysis or in his own words

> *"Dimensional analysis let us write $G = hc/m_{pl}^2$, where m_{pl} is the Planck mass 21.77×10^{-9} kg, but this is of no help of determining G since there are no independent determination of m_{pl}."* (page 74. Note that we will use notation m_p for the Planck mass, while several papers also use notation m_{pl})

This insight is of great importance and is what we will call the circular problem of the composite view of the Newton gravitational constant. Namely the view that to express G from Planck units is of little or no use if one need G to find the Planck units in the first place. Independently a series [18, 26–29] of researchers also later on suggest the same formula for G, likely without knowing about the paper of Cahill or Cohen, but non of these solve the circular problem. McCuloch [30] in 2016 again points out the circular problem with expressing the gravity constant from the Planck mass with the same formula as introduced by Cahill and Cohen, or in his own words

> *In the above gravitational derivation, the correct value for the gravitational constant G can only be obtained when it is assumed that the gravitational interaction occurs between whole multiples of the Planck mass, but this last part of the derivation involves some circular reasoning, since the Planck mass is defined using the value for G.*

Again this demonstrate that the circular problem of expressing G in form of Planck units has been there for a very long time, and this is in our view directly linked to that one in quantum gravity have had little or no progress in detecting the Planck scale, and therefore limited progress as we soon will discuss.

Clark [31] in 2003 suggest the gravitational constant is given by

$$G = \frac{a_g \hbar c}{u^2} \tag{3}$$

as $\frac{a_g}{U^2} = \frac{1}{m_p^2}$ this is in many ways just an indirect way of writing the Cahill and Cohen formula, as we have $G = \frac{a_g \hbar c}{u^2} = \frac{\hbar c}{m_p}$. Independently Zwiebach [32] and Nastasenko [33] both in 2004 describes the following formula to express G from the Planck units

$$G = \frac{l_p^3}{t_p^2 m_p} \tag{4}$$

Zwiebach describe this as a "*Planckian system of units*" but gives no indications that the Planck units can be found independent of G. Bruneton [34] in 2013 suggest the same formula, and the view that instead of G, $\hbar$ and c being the fundamental universal constants they are just composites and that the Planck units are much more fundamental, see also [35, 36]. This formula for G can for example be derived from dimensional analysis of G. The dimensions of G are $[G] = L^3 M^{-1} T^{-2}$, ande simply replace L with l_p and M with m_p and T with t_p and we get the formula $G = \frac{l_p^3}{t_p^2 m_p}$. However, if one need to find G first to find the Planck units then one can naturally question the usefulness of this. The same formula has later been suggested/used by for example Mercier [37] and Humpherys [38].

In natural units when first setting $c = h = 1$, we must have $G = 1/m_p^2$ as pointed out by Kiritsis [39] in 1997 as well as by Cerdeno and Munoz [40] in 1998 and later mentioned by for example [34, 41–46]. We find others like Peebles [47] that already in 1989 pointed out that $m_p = G^{-1/2}$ when $\hbar = c = 1$, so one could claim he then also pointed out $G = 1/m_p^2$, as it is natural very trivial to turn the equation around. Still by writing $G = 1/m_p^2$ rather than $m_p = G^{-1/2}$, gives a strong indication or even hint that perhaps we should think that the gravity constant is a function of the Planck units, and not only the Planck units can be a function of G as first suggested by Max Planck, and this is what this paper is all about. Further in the natural units system when $\hbar = c = 1$ we will then have $G = l_p^2$ as pointed out by Schwarzschild [48] 2000 and also [44, 46, 49]. And since $t_p = \frac{l_p}{c}$ we must naturally also have $G = t_p^2$ when $\hbar = c = 1$. When only $c = 1$ then we must have $\hbar = m_p l_p$ and we get $G = \frac{l_p}{m_p}$ as pointed out by Casadio [50] in 2009, and also discussed/used by [34, 51–56].

We also have

$$G = \frac{t_p^2 c^5}{\hbar} = \frac{c^5}{v_p^2} \tag{5}$$

where v_p is the Planck frequency, this was likely first mentioned by Nastasenko [57] in 2013. Haug in 2016 [19, 58, 59] suggest that G is a universal composite gravitational constant of the form

$$G = \frac{l_p^2 c^3}{\hbar} \tag{6}$$

This he get from dimensional analysis assuming the more fundamental constants are l_p, $\hbar$ and c and that the gravitational constant simply is a composite constant. His argument is that the complex output units of G indicates it is a composite constant and further that the gravity constant came before the Planck length do not mean the gravity constant is more fundamental than the Planck length. It is natural that we first understand the world more from the surface, before we understand the deeper aspects of it. Further he shows how many of the Planck units can be simplified when one assume G is such a composite. Still non of the above-mentioned papers has solved the circular problem, so they are at best hypotheses that perhaps G can be expressed in form of Planck units, but that there are unsolved problems to do so.

As we have seen a series of ways to express the G in form of Planck units have been expressed in the literature. Some have done this because they think G is a composite constant and that the Planck units are more real and fundamental, others have mention G as a function of Planck units just for the use in some calculations they have been done to get to some other results not directly related to the view that G is a composite constant or not.

Table 1 shows a series of ways to write G from Planck units that we have found in the literature, and additional many more ways. All these ways are valid mathematically, but again it is assumed one need to know G to find the Planck units. A series of the formulas are marked with that they first are presented in this paper, we do not do this to indicate we have done any new important inventions, but simply to demonstrate that there is many ways to express G from Planck units. Basically any Planck unit related formula can be simply solved with respect to G. This is trivial mathematically, the big question is if it can lead to some significant new insight or not.

From	Gravity constant formula	Likely first described:[a])
Planck mass $m_p=\sqrt{\frac{\hbar c}{G}}$	$G=\frac{\hbar c}{m_p^2}$	Cahill [23] 1984 and Cohen [25] 1987
Planck time $t_p=\sqrt{\frac{G\hbar}{c^5}}$	$G=\frac{t_p^2c^5}{\hbar}$	Nastasenko [57]
Planck length $l_p=\sqrt{\frac{G\hbar}{c^3}}$	$G=\frac{l_p^2c^3}{\hbar}$	Haug [19] 2016
Planck energy $E_p=\sqrt{\frac{\hbar c^5}{G}}$	$G=\frac{\hbar c^5}{E_p^2}$	Haug [60] 2020
Planck temperature $T_p=\sqrt{\frac{\hbar c^5}{Gk_b^2}}$	$G=\frac{\hbar c^5}{T_p^2k_b}$	this paper
Planck mass $a_g=\frac{m^2}{m_p^2}$	$G=\frac{a_g\hbar c}{u^2}=\frac{\hbar c}{m_p^2}$	Clark [31] 2003
Planck frequency $f_p=\sqrt{\frac{c^5}{G\hbar}}$	$G=\frac{c^5}{f_p^2\hbar}$	Nastasenko 2013
Planck acceleration $a_p=\sqrt{\frac{c^7}{G\hbar}}$	$G=\frac{c^7}{a_p^2\hbar}$	this paper
Planck density $\rho_p=\frac{c^5}{\hbar G^2}$	$G=\sqrt{\frac{c^5}{\rho_p\hbar}}$	this paper
Planck momentum $p_p=\sqrt{\frac{\hbar c^3}{G}}$	$G=\frac{\hbar c^3}{p_p^2}$	this paper
Planck force $F_p=\frac{E_p}{l_p}$	$G=\frac{c^4}{F_p}$	this paper
Planck length, time and mass	$G=\frac{l_p^3}{m_pt_p^2}$	Zwiebach [32] and Nastasenko [33] 2004
Planck length and Planck time	$G=\frac{l_pc^2}{m_p}$	Haug [61] 2017 and Eldred [62] 2019
Planck mass and Planck time	$G=\frac{t_pc^3}{m_p}$	Eldred [62] 2019
Planck length, time and Planck energy	$G=\frac{l_p^3c^2}{E_pt_p^2}$	this paper
Planck time and Planck length	$G=\frac{t_pl_pc^4}{\hbar}$	this paper
Planck frequency Planck mass	$G=\frac{c^3}{f_pm_p}$	this paper
Planck acceleration and mass	$G=\frac{c^4}{a_pm_p}$	this paper
Planck charge and Planck length	$G=\frac{l_p^2c^210^7}{q_p^2}$	this paper
Planck charge and Planck mass	$G=\frac{10^7}{m_p^2q_p^2}$	this paper
Planck charge and Planck time	$G=\frac{t_p^2c^410^7}{q_p^2}$	this paper

Table 1: The table show various ways we can express the gravity constant from Planck units.

[a]It is impossible for anyone today to know the full littrature of physics so there could be others coming first with these formulas, we have done a very serious attempt to search and find who published these results first.

Table 2 show how to write G from Planck units when $h=c=1$ and when $c=1$ and $\hbar=m_plp$. So these formulas are simplified cases of the formulas in table 1.

From	Gravity formula	Likely first described
when $\hbar = c = 1$	$G = 1/m_p^2$	Kiritsis 1997 [39] and Cerdeno and Munoz 1998 [40]
when $\hbar = c = 1$	$G = l_p^2$	Schwarzschild 2000 [48]
when $\hbar = c = 1$	$G = t_p^2$	this paper
when $\hbar = c = 1$	$G = 1/a_p^2$	this paper
when $\hbar = c = 1$	$G = 1/E_p^2$	this paper
when $\hbar = c = 1$	$G = 1/p_p^2$	this paper
when $c = 1$	$G = l_p/m_p$	Casadio 2009 [50]
when $c = 1$	$G = t_p/m_p$	this paper
when $c = 1$	$G = l_p/E_p$	this paper
when $c = 1$	$G = t_p/E_p$	this paper
when $c = 1$	$G = l_p/a_p$	this paper
when $c = 1$	$G = t_p/a_p$	this paper

Table 2: The table show various ways we can express the gravity constant from Planck units.

3 The break through in the circular problem

We have just looked at a long series of ways to express G in form of Planck units. However as long as one need to know G to find the Planck units this just lead to a circular problem as have been pointed out by a series of researchers, so at first glance this do not seem to help us understand G better. Still we will claim that in recent years there has been a breakthrough in the circular problem. Haug [63] in 2017 shows a reliable way of find the Planck length independent of G, but still dependent on knowledge of $\hbar$ and c. This by using a Cavendish apparatus as described in the appendix of that paper. That one need to use a Cavendish apparatus has nothing to do with that one need to know G. Haug derives the formula

$$l_p = \sqrt{\frac{\hbar 2\pi^2 L r^2 \theta}{M T^2 c^3}} \tag{7}$$

where r is the distance between centers of the large and small balls (when the balance is deflected), further L is the distance between the small balls in the apparatus. M is the kilogram mass of the large ball in the apparatus that can be found for example with a standard letter weight as compared to the one-kilogram prototype mass. θ is the angle of deflection measured and T is the measured period of oscillation of the torsion balance. In other words, this way of finding the Planck length is only dependent on $\hbar$ and c and not on prior knowledge of G. The formula above can be simplified further so we get rid of the Planck constant also, and then only depend on knowledge of c, this we will soon get back to.

In 2020 Haug [64, 65] shows it is possible to find the Planck length and the Planck time without knowledge of both G and $\hbar$, but that to find the Planck mass (in kilogram) one need to know $\hbar$ and c. Further in 2021 Haug [64] shows an approach combined with a long list of gravity phenomena that can be used to find the Planck length independent of G and $\hbar$. In another paper [66] his main focus is on how to find the Planck time independent of G and $\hbar$. If one know how to find the Planck length independent of G and $\hbar$ one naturally know how to find the Planck time independent on G and $\hbar$ as the Planck time is simply the Planck length divided by the speed of light.

That the Planck units can be found without any knowledge of G means the gravity constant indeed can be expressed in form of the Planck units. This alone is a break through in our view. Still what dose it mean, this we will look more closely at in the next sections.

4 Putting the pieces together

We now know that the Planck units can be found without any knowledge of G. Table 3 shows a series of predictions from Newton and Einstein gravity simply re-written when we replace G with $G = \frac{\hbar c}{m_p^2}$. For example the gravitational acceleration that can be predicted by $g = \frac{GM}{R^2}$ can now be re-written as

$$g = \frac{GM}{R^2} = \frac{\hbar c}{m_p^2}\frac{M}{R^2} \tag{8}$$

This in our view gives little if any new intuition or important results, one could even argue the formula now is even less intuitive than before. We can claim that this show that gravity is related to the Planck mass and that it therefore give some new intuition, but it is not obvious why this should be the case. Still G is replaced with an expression containing the Planck mass, and the Plank mass can be found independent of G, so this is a big step ahead from the view since the time of Max Planck and until recently where researchers though the Planck units cannot be found without knowing G first. We could argue that this approach replaces three universal constants G, $\hbar$ and c with three new ones, namely m_p, $\hbar$ and c. Still so so far it seems that even after we have solved the circular problem in this composite view of G, this simply means we can replace G with another constant, namely m_p. This could be interesting on its own, as it indeed could indicate G is more of a human construct rather than something representing directly physical aspects of the depth of reality. The many formulas in table

3 when re-written $G = \frac{\hbar c}{m_p^2}$ do not seem to make things more intuitive, or we could argue it looks perhaps even less intuitive. It still looks like we still need three constants, but we have replaced G with m_p.

We could choose any of the other ways to express G form Planck units as shown in table 1 or 2, for example we could choose Haug's formula $G = \frac{l_p^2 c^3}{\hbar}$, this would at least at first eye sight just lead to that G, $\hbar$ and c could be replaced with l_p, $\hbar$ and c. In other words after we know that the Planck units can be found without G we can replace the three universal constants G, $\hbar$ and c with a chosen Planck unit plus c and $\hbar$. So then one can question if this is just a change of unit systems? This alone is interesting, but not obviously a big break through, we could even claim trivial.

	Gravity with $G = \frac{\hbar c}{m_p^2}$:
Mass	M and m (kg)
Gravity force	$F = G\frac{Mm}{R^2} = \frac{\hbar c}{m_p^2}\frac{Mm}{R^2}$ $(kg \cdot m \cdot s^{-2})$
Gravity acceleration	$g = \frac{GM}{R^2} = \frac{\hbar cM}{m_p^2 R^2}$
Orbital velocity	$v_o = \sqrt{\frac{GM}{R}} = \frac{1}{m_p}\sqrt{\frac{\hbar cM}{R}}$
Orbital time	$T = \frac{2\pi R}{\sqrt{\frac{GM}{R}}} = \frac{2\pi R m_p}{\sqrt{\frac{\hbar cM}{R}}}$
Periodicity pendulum[a] (clock)	$T = 2\pi\sqrt{\frac{L}{g}} = 2\pi R\sqrt{\frac{L}{GM}} = 2\pi R m_p\sqrt{\frac{L}{\hbar cM}}$
Frequency Newton spring	$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi R m_p}\sqrt{\frac{\hbar cM}{x}}$
Velocity ball Newton cradle[b]	$v_{out} = \sqrt{2\frac{GM}{R^2}H} = \frac{1}{Rm_p}\sqrt{2\hbar cMH}$
Predictions from GR:	
Advance of perihelion	$\sigma = \frac{6\pi GM}{a(1-e^2)c^2} = \frac{6\pi\hbar cM}{a(1-e^2)c^2 m_p^2}$
Gravitational redshift	$z = \frac{\sqrt{1-\frac{2GM}{R_1c^2}}}{\sqrt{1-\frac{2GM}{R_2c^2}}} - 1 = \frac{\sqrt{1-\frac{2\hbar M}{R_1cm_p^2}}}{\sqrt{1-\frac{2\hbar M}{R_2cm_p^2}}} - 1$
Time dilation	$T_R = T_f\sqrt{1 - \sqrt{\frac{2GM}{R}}^2/c^2} =$
Deflection	$\delta = \frac{4GM}{c^2R} = \frac{4\hbar M}{cRm_p^2}$
Microlensing	$\theta_E = \sqrt{\frac{4GM}{c^2}\frac{(d_S-d_L)}{d_Sd_L}} = \sqrt{\frac{4\hbar M}{cm_p^2}\frac{(d_S-d_L)}{d_Sd_L}}$

Table 3: The table shows the standard gravitational prediction formulas re-written when we assume $G = \frac{\hbar c}{m_p^2}$. We can see that the end results likely are perhaps even less intuitive than the existing and that we basically just have swapped one constant for a new one (G for m_p).

[a] The formula is a very good approximation when the angle of the pendulum is small, as it is in most pendulum clocks. It is not accurate for large angles, but is again exact for an angle of 360; that is to say, for full circle, see [67].

[b] Where H is the height of the ball drop.

Another important step is needed before we can discover the great utility of the composite view of the gravitational constant. The mass in kilogram of any mass can be described as

$$m = \frac{\hbar}{\bar{\lambda}}\frac{1}{c} \tag{9}$$

where $\bar{\lambda}$ is the reduced Compton wavelength. This expression for mass we simply get by solving the Compton [68] wavelength formula $\bar{\lambda} = \frac{\hbar}{mc}$ with respect to mass. One could claim that only elementary particles have Compton wavelength and not composite masses or at least not such large objects as planets or suns. Only elementary particles likely have a "physical" Compton wavelength that can be measured by Compton scattering, but larger masses consist of elementary particles and the aggregated Compton wavelength in the composite mass is is given by [1, 65]

$$\bar{\lambda} = \frac{1}{\frac{1}{\bar{\lambda}_1} + \frac{1}{\bar{\lambda}_2} + \frac{1}{\bar{\lambda}_3} + \cdots \frac{1}{\bar{\lambda}_n}} \tag{10}$$

This aggregation is fully consistent with standard mass aggregation $m = m_1 + m_2 + m_3 + \cdots + m_n$, and can even be derived form it. It is also important to understand that one can find the Compton wavelength of any mass without knowing $\hbar$ and G. Lets start with an electron, the Compton wavelength can be found by shooting a photon at an electron, and by measuring the photon wavelength before and after the impact with the electron, and also the angle between the incoming and outgoing photon, we have

$$\lambda_e = \frac{\lambda_2 - \lambda_1}{1 - \cos\theta} \tag{11}$$

The reduced Compton wavelength of the electron is simply this divided by 2π as is well known. Next we can find the reduced Compton wavelength of the proton by utilizing that the cyclotron frequency ratio is proportional to the Compton wavelength ratio. This because the charge on the electron and proton is the same, and the cyclotron frequency is given by

$$f = \frac{qB}{2\pi m} \tag{12}$$

So we must have

$$\frac{f_e}{f_P} = \frac{\frac{qB}{2\pi m_e}}{\frac{qB}{2\pi m_P}} = \frac{\bar{\lambda}_P}{\bar{\lambda}_e} \approx \frac{1}{1836.15} \tag{13}$$

So if we know the electron Compton wavelength we know the Proton Compton wavelength as it is just to take the electron Compton wavelength and divide it by 1836.15. Next we can find the Compton wavelength of any larger mass by "simply" counting the number of atoms in the object of interest and then divide the Compton wavelength of the proton by this count. To count atoms in a clump of matter is not easy, but fully possible. One way is to construct a precise silicon (^{28}Si) sphere. As one know the crystal structure here very well and since it is very uniform one can accurately calculate the number of atoms in such a sphere. This way of counting atoms have even been one of the recent suggested methods to re-define the kilogram, see [69–71]. There also exist other methods to count atoms [72, 73], so this is fully possibly in practice, even if it take some effort.

Based on that we can write the formula of a mass as $M = \frac{\hbar}{\bar{\lambda}}\frac{1}{c}$ we can replace the mass in equation 7 with this mass and this gives us

$$l_p = \sqrt{\frac{\hbar 2\pi^2 L r^2 \theta}{M T^2 c^3}} \tag{14}$$

$$l_p = \sqrt{\frac{\hbar 2\pi^2 L r^2 \theta}{\frac{\hbar}{\bar{\lambda}}\frac{1}{c} T^2 c^3}} \tag{15}$$

$$l_p = \sqrt{\frac{2\pi^2 L r^2 \theta \bar{\lambda}}{T^2 c^2}} \tag{16}$$

That is the two Planck constants cancel each other out to find the Planck length. In other words we do not need to know $\hbar$ or G to find the Planck length, all the other parameters in the formula we can easily find without knowledge of G or $\hbar$ using a Cavendish apparatus. The reason we use a Cavendish apparatus is because we can deal with sizes of matter where we can count the number of atoms, but similar methods for even much larger masses can be used [1].

Haug [1, 65] have recently shown a practical feasible way to find the Compton wavelength independent on G and $\hbar$ even for planets, stars and galaxies. The main point here is that any mass in terms of kilogram can be expressed by the formula 9. Next let us multiply the composite $G = \frac{l_p^2 c^3}{\hbar}$ with the composite mass $M = \frac{\hbar}{\bar{\lambda}}\frac{1}{c}$ and we get

$$GM = \frac{l_p c^3}{\hbar} \times \frac{\hbar}{\bar{\lambda}}\frac{1}{c} = c^2 \frac{l_p^2}{\bar{\lambda}} \tag{17}$$

What is important to pay attention to here is that the two Planck constant actually cancel each other out, we are left with two constants c and l_p, and both these can be found without knowledge of G and $\hbar$. Table 4 shows a series of predicted gravitational phenomena that actually can be observed. As we see, in all the observable phenomena, we have GM and not GMm. The small mass m in the Newton gravitational force formula is only used in derivations of observable gravitational phenomena and then one of the two masses always cancels out. In real two mass gravity phenomena we have gravity parameter $\mu = G(M_1 + M_2) = GM_1 + GM_1 = c^2 \frac{l_p^2}{\bar{\lambda}_1} + c^2 \frac{l_p^2}{\bar{\lambda}_2}$ so also in real two body gravitational phenomena the Planck constant cancel out.

It is evident from table 4 that a long series of observable gravity phenomena can be predicted by knowing only two constants, namely l_p and c and naturally a variable which is linked to the mass size, namely the reduced Compton wavelength of the gravitational object. As seen from the table some observable gravity phenomena only need one constant, namely the Planck length. And again it has in recent years been demonstrated how to find the Planck length independent off G so this is a fully practical way to do gravity predictions, it is not just a hypotheis.

As all predictions of observable gravity phenomena contains GM and this leads to $GM = c^3 \frac{l_p}{c}\frac{l_p}{\bar{\lambda}}$. Haug has in a series of papers suggested that c^3 can be used as a gravity constant and that real gravity mass should be re-defined as $\bar{m} = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}}$ something we soon will get back to. This view gives us table 5, which gives all the exact same predictions as the standard gravity formulas, but without any G and also without no need for $\hbar$. Well one exception is for the gravity force itself, but the gravity force can not be measured directly, we can only observe consequences from it. Our new way of representing the gravity force formula gives exactly the same predictions for observable phenomena, and it is only linked to the Planck length and the speed of light. The speed of light is in this context the same as speed of gravity ("gravitons"?). For example Abbot et. al. [74] has in 2017 has constrained "*the difference between the speed of gravity and the speed of light to be between* -3×10^{-15} *and* $+7 \times 10^{-16}$ *times the speed of light.* ".

Mass	$M = \frac{\hbar}{\bar{\lambda}_M}\frac{1}{c}$ (kg)
Non observable (contains GMm)	
Gravitational constant	$G, \left(G = \frac{l_p^2 c^3}{\hbar}\right)$
Gravity force	$F = G\frac{Mm}{R^2}$ $(kg \cdot m \cdot s^{-2})$
Observable predictions: (contains only GM)	
Gravity acceleration	$g = \frac{GM}{R^2} = \frac{c^2}{R^2}\frac{l_p^2}{\bar{\lambda}_M}$
Orbital velocity	$v_o = \sqrt{\frac{GM}{R}} = cl_p\sqrt{\frac{1}{R\bar{\lambda}_M}}$
Orbital time	$T = \frac{2\pi R}{\sqrt{\frac{GM}{R}}} = \frac{2\pi\sqrt{\bar{\lambda}_M R^3}}{cl_p}$
Periodicity pendulum[a] (clock)	$T = 2\pi\sqrt{\frac{L}{g}} = 2\pi R\sqrt{\frac{L}{GM}} = \frac{2\pi R}{cl_p}\sqrt{L\bar{\lambda}_M}$
Frequency Newton spring	$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi R}\sqrt{\frac{GM}{x}} = \frac{cl_p}{2\pi R}\sqrt{\frac{1}{\bar{\lambda}_M x}}$
Velocity ball Newton cradle[b]	$v_{out} = \sqrt{2\frac{GM}{R^2}H} = \frac{cl_p}{R}\sqrt{\frac{2H}{\bar{\lambda}_M}}$
Observable predictions (from GR): (contain only GM)	
Advance of perihelion	$\sigma = \frac{6\pi GM}{a(1-e^2)c^2} = \frac{6\pi}{a(1-e^2)}\frac{l_p^2}{\bar{\lambda}_M}$
Gravitational redshift	$z = \frac{\sqrt{1-\frac{2GM}{R_1 c^2}}}{\sqrt{1-\frac{2GM}{R_2 c^2}}} - 1 = \frac{\sqrt{1-\frac{2l_p^2}{R_1\bar{\lambda}_M}}}{\sqrt{1-\frac{2l_p^2}{R_2\bar{\lambda}_M}}} - 1$
Time dilation	$T_R = T_f\sqrt{1-\sqrt{\frac{2GM}{R}}^2/c^2} = T_f\sqrt{1-\frac{2l_p^2}{R\bar{\lambda}_M}}$
Deflection	$\delta = \frac{4GM}{c^2 R} = \frac{4}{R}\frac{l_p^2}{\bar{\lambda}_M}$
Microlensing	$\theta_E = \sqrt{\frac{4GM}{c^2}\frac{(d_S-d_L)}{d_S d_L}} = 2l_p\sqrt{\frac{d_S-d_L}{\bar{\lambda}_M(d_S d_L)}}$

Table 4: The table shows that any observable gravity phenomena contain GM and not GMm and further than when assuming G is a composite, then we end up that we can predict all observable gravity phenomena only from l_p and c.

[a] The formula is a very good approximation when the angle of the pendulum is small, as it is in most pendulum clocks. It is not accurate for large angles, but is again exact for an angle of 360; that is to say, for full circle, see [67].

[b] Where H is the height of the ball drop.

5 Is the inertial mass really identical to the gravitational mass?

As shown for all the observational gravitational phenomena reported in table 4 and 5 we have GM and not GMm. And again $GM = \frac{l_p^2 c^3}{\hbar}\frac{\hbar}{\bar{\lambda}}\frac{1}{c} = c^3 t_p \frac{l_p}{\bar{\lambda}}$, where Haug has claimed in a series of papers [65, 75] that c^3 then can be seen as a gravitational constant and $t_p\frac{l_p}{\bar{\lambda}}$ as a more complete mass definition. This mass definition he has coined collision-time, which again can be seen as the gravitational mass. And yes this mass definition has dimensions of simply time. This mass one already indirectly have embedded in standard gravity theory since one are multiplying the kilogram mass with the gravitational constant. But here the traditional view is that this is a gravity constant multiplied by a mass, and that they are two seprate things. One have never figured out exactly why this has to be done from a deeper perspective. Well, what is a gravitational mass and what is an inertial mass. A gravitational mass is linked to the mass caused by and acted on a body by the force of gravity, so it has always been assumed that both the masses in Newton's formula represent gravitational masses. However, we will challenge that view here. This because if the small mass m has insignificant impact on M then it cancels out in all derivations of direct observable gravitational phenomena, so we could even write

$$ya = G\frac{My}{R^2} \tag{18}$$

and we would still get the correct predictions about measurable gravitational phenomena from this equation, that is y on both sides of the equation could be replaced with basically anything, we could even define y as money. Money has naturally nothing to do with gravity, but since y is on both sides of the equation we can divide by y on both sides and we get $a = GM/R^2$, and we can measure both a and the gravitational acceleration. Our point is that even when putting in a completely wrong mass definition for m on both sides of $ma = G\frac{Mm}{R^2}$ these two m masses will cancel out in the derivation of anything observable. This is the case for derivation of any observable gravity phenomena, except for real two body problems where one have $GM_1 + GM_2$, not GMm. The reminding kilogram mass M is always multiplied by the gravity constant. We will claim this is done (unknowingly) to correct an incomplete mass definition (the kilogram mass) into a more complete mass definition, so the real gravitational mass is $\frac{G}{c^3}M = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}} = \bar{M}$, this is discussed in detail by Haug [65, 75]. Newton naturally did not have this in mind when he developed his gravity theory, and as we have pointed out he also never used a

Mass	$M = \frac{\hbar}{\bar{\lambda}_M}\frac{1}{c}$ (kg)
Non observable	
Gravitational constant	c^3
Gravity force	$F = c^3\frac{\bar{M}\bar{m}}{R^2}$ $(kg \cdot m \cdot s^{-2})$
Observable predictions:	
Gravity acceleration	$g = \frac{c^3\bar{M}}{R^2} = \frac{c^2}{R^2}\frac{l_p^2}{\bar{\lambda}_M}$
Orbital velocity	$v_o = \sqrt{\frac{c^3\bar{M}}{R}} = cl_p\sqrt{\frac{1}{R\bar{\lambda}_M}}$
Orbital time	$T = \frac{2\pi R}{\sqrt{\frac{c^3\bar{M}}{R}}} = \frac{2\pi\sqrt{\bar{\lambda}_M R^3}}{cl_p}$
Periodicity pendulum[a] (clock)	$T = 2\pi\sqrt{\frac{L}{g}} = 2\pi R\sqrt{\frac{L}{c^3\bar{M}}} = \frac{2\pi R}{cl_p}\sqrt{L\bar{\lambda}_M}$
Frequency Newton spring	$f = \frac{1}{2\pi}\sqrt{\frac{k}{M}} = \frac{1}{2\pi R}\sqrt{\frac{c^3\bar{M}}{x}} = \frac{cl_p}{2\pi R}\sqrt{\frac{1}{\bar{\lambda}_M x}}$
Velocity ball Newton cradle[b]	$v_{out} = \sqrt{2\frac{c^3\bar{M}}{R^2}H} = \frac{cl_p}{R}\sqrt{\frac{2H}{\bar{\lambda}_M}}$
Observable predictions (from GR):	
Advance of perihelion	$\sigma = \frac{6\pi c^3\bar{M}}{a(1-e^2)c^2} = \frac{6\pi}{a(1-e^2)}\frac{l_p^2}{\bar{\lambda}_M}$
Gravitational redshift	$z = \frac{\sqrt{1-\frac{2c^3\bar{M}}{R_1c^2}}}{\sqrt{1-\frac{2c^3\bar{M}}{R_2c^2}}} - 1 = \frac{\sqrt{1-\frac{2l_p^2}{R_1\bar{\lambda}_M}}}{\sqrt{1-\frac{2l_p^2}{R_2\bar{\lambda}_M}}} - 1$
Time dilation	$T_R = T_f\sqrt{1-\sqrt{\frac{2c^3\bar{M}}{R}}^2/c^2} = T_f\sqrt{1-\frac{2l_p^2}{R\bar{\lambda}_M}}$
Deflection	$\delta = \frac{4c^3\bar{M}}{c^2R} = \frac{4}{R}\frac{l_p^2}{\bar{\lambda}_M}$
Microlensing	$\theta_E = \sqrt{\frac{4c^3\bar{M}}{c^2}\frac{(d_S-d_L)}{d_Sd_L}} = 2l_p\sqrt{\frac{d_S-d_L}{\bar{\lambda}_M(d_Sd_L)}}$

Table 5: The table shows that we can write the gravitational constant as c^3 when using in our view a more complete mass definition, $\bar{m} = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}}$. That is mass is related to time, or what Haug has called collision-time. Different mass sizes then only differs in different Compton wavelength. Writing the gravitational force formula this way we get the same predictions as standard Newton gravity except we only relay on two constants l_p and c to describe mass and any observable gravity phenomena. Also in general relativity predictions we can replace the mass with this mass definition if we replaces G with c^3. The reason we can do this is that $c^3\bar{M} = GM$, this is clear when we understand that G is a composite constant and in addition understand that the kilogram mass can be written by simply solving the Compton wavelength formula with respect to m.

[a] The formula is a very good approximation when the angle of the pendulum is small, as it is in most pendulum clocks. It is not accurate for large angles, but is again exact for an angle of 360; that is to say, for full circle, see [67].

[b] Where H is the height of the ball drop.

gravity constant. The gravity constant is a missing value constant simply found by calibration to observable gravitational phenomena when one have decided upon using the kilogram definition off mass. This is also at least part of the reason why the gravity constant came into existence about at the same time as the kilogram mass became popular in Europe.

The mass linked to non-gravitational acceleration is often thought of as the inertial mass and since it has been shown experimentally that the following relation seems to hold

$$m_i a = G\frac{Mm}{R^2} \tag{19}$$

we assume that the inertial mass m_i must be equal to the gravitational mass m since it seems to be an equivalence between standard acceleration (for example in a elevator) and in a gravitational acceleration field, and we do not doubt this, we simply claim the mass m is not used directly for any predictions of any observable gravitational phenomena. That is one are not measuring ma nor $G\frac{Mm}{R^2}$, one are observing a and $g = a = G\frac{M}{R^2}$, in other words after the two small masses has canceled each other out in derivations for predictions of observable phenomena. In our view there is only one type of mass and we have just defined it as $\bar{M} = \frac{G}{c^3}M$ and inputted this mass definition in all parts in the Newton formula would lead to

$$\frac{G}{c^3}ma = c^3\frac{\frac{G}{c^3}M\frac{G}{c^3}m}{R^2} \tag{20}$$

and we would also now end up with $a = \frac{GM}{R^2}$, since $\frac{G}{c^3}m$ is on both sides and cancel out. And since $\bar{M} = \frac{G}{c^3}M$ (and $\bar{m} = \frac{G}{c^3}m$ we can write this as

$$\bar{m}a = c^3\frac{\bar{M}\bar{m}}{R^2} \tag{21}$$

Our point is that in the standard Newton gravity formula in its modern form invented in 1873, one are likely unknowingly using two different masses, one is the standard kilogram mass multiplied by G, that is GM which combined can be seen as the gravitational mass (collision-time mass) multiplied by c^3, that is $GM = c^3\bar{M}$ and the other non-gravitational mass m is a incomplete kilogram mass that says nothing about gravity. When we just want to know for example the relation between mass and energy then the standard kilogram mass will have enough information to do so. So, we can still use m, that is the kilogram mass definition without adjustments in relations such as $E = mc^2$ or in $E = mc^2\gamma$, but the same mass definition cannot be used for calculating gravity effects from that mass without multiplying it with G, or better by understanding that GM actually represent the real gravitational mass (divided by c^3). There is only one mass, but to describe gravity needs additional information that is lacking in the kilogram mass definition. The kilogram mass is incomplete, but good enough for calculations related to just energy and mass, but it is incomplete when also taking into account gravity. We can then either fix this mass ad-hock by using G or we can understand that G is a composite constant, and when combined with M it gives a deeper insight in mass also related to gravity.

So the real gravitational mass even of the small mass is $\bar{m} = \frac{G}{c^3}m = t_p\frac{l_p}{\bar{\lambda}} = \frac{l_p^2}{\bar{\lambda}c}$, while the kilogram mass is given by $m = \frac{\hbar}{\bar{\lambda}}\frac{1}{c}$. Since the Planck length and the speed of light and the Planck constants are constants, and the only thing changing is the mass size in both the gravitational mass (collision-time mass) and in the kilogram mass they are proportional. So the weak equivalence principle holds also under this view. This view do not changes the output from predictions of observable phenomena, but it shows us how the Planck scale is already directly linked to gravity. Detection of gravity is in our view detection of the Planck scale. This view is new and controversial, but we think it should be taken seriously enough to be carefully investigated also by other researchers before rejected prematurely.

6 The Gravity Constant Calculated from Cosmological Entities

Another line of thought in relation to the composite view of G has been that the Newtonian gravitational constant perhaps can be calculated from cosmological entities or constants. Already in 1951 Bleksley [76] suggest that the gravitational constant can be expressed as

$$G = \frac{R_u c^2}{M_u} \tag{22}$$

where R_u is the radius of the observable universe and M_u is the mass of the observable universe. As the mass of the universe from the Friedmann equation requires to know G, Bleksley could not use this mass to find G, but instead comes up with his own way to calculate the universe mass, a way we think look a bit like numerology or at least very speculative. For example he suggest that the number of protons in the universe must be $R_u^2/(4\rho^2)$ where ρ is the diameter of the proton. It is far from clear how he get to this formula, so we are questioning the validity of this approach. Mercier [37] in 2020 basically gives the same formula for G, he uses a universe mass rooted in a paper by Carvalho [77]. Carvalho starts with a relation between mass density and the Hubble constant that he claims is given by Weinberg [78]

$$G\rho_0 = H_0^2 \tag{23}$$

and from this get

$$M_u \approx \frac{c^3}{GH} \tag{24}$$

Carvalho in addition derive a universe mass to be the same as given by this formula, but independently from G by some assumptions of π mesons, however his derivation here seems quite speculative. Carvalho further claims "*This is identical to expression derived in the context of Friedmann's cosmological model.*". This claim is not fully correct or at least not precise enough. Both the formula he present: the one he claim is from the Friedman model and the other universe mass he derive from π mesons are both actually twice that one get from the Friedmann model. The universe mass one get from the Friedmann model is

$$M_c = \frac{1}{2}\frac{c^3}{H_0 G} \tag{25}$$

as one also find indirectly in the book of Weinberg as well as in a series of other independent sources (see for example [79, 80]). Several authors (for example Cook in 2011 [81] and Mercier [37]) have suggested that G can be expressed as

$$G = \frac{c^3}{HM_u} = \frac{T_H c^2}{M_u} \tag{26}$$

First of all this formula is naturally equal to $G = \frac{R_H c^2}{M_u}$, as the Hubble radius is given by $R_H = \frac{c}{H_0}$, and $T_H = \frac{R_H}{c} = \frac{1}{H_0}$. Actually this formula is not fully consistent with the Friedmann model, as that would require $G = \frac{c^3}{2HM_u}$ and since the Hubble time is given by $T_H = \frac{1}{H_0}$ this is naturally the same as $G = \frac{T_H c^2}{2M_u}$, but equation

26 is consistent when using the Haug [82] universe mass which is predicted to be twice that of the Friedmann critical mass of the universe.

Non of these authors have shown how to find the universe mass without already knowing G, except from what we would call very speculative approaches where we think there lack a solid foundation, even if this naturally can be discussed further. Still there is as we will see a way to find this critical mass of the universe without knowing G. First if we solve the Friedmann critical mass equation (Eq. 25) with respect to H_0 then this gives the formula

$$H_0 = \frac{1}{2}\frac{c^3}{M_c G} \tag{27}$$

And since any mass in kilogram can be written as $m = \frac{\hbar}{\bar{\lambda}}\frac{1}{c}$, and also because G can be written as $G = \frac{l_p^2 c^3}{\hbar}$, this means we have

$$H_0 = \frac{1}{2}\frac{c^3}{\frac{\hbar}{\bar{\lambda}_c}\frac{1}{c}\frac{l_p^2 c^3}{\hbar}} = \frac{\bar{\lambda} c}{2 l_p^2} \tag{28}$$

Where $\bar{\lambda}_c$ is the reduced Compton wavelength of the critical mass in the Friedmann universe (the critical universe). This also means we must have

$$G = \frac{\bar{\lambda}_c c^4}{2 H_0 \hbar} \tag{29}$$

The Hubble constant can be found with no knowledge of G as also the Compton wavelength of the universe mass can be found without this knowledge of G as we [83].recently demonstrated. Further as $H_0 = \frac{c\bar{\lambda}_c}{2l_p^2}$ this means equation 29 can be simplified further to

$$G = \frac{\bar{\lambda}_c c^4}{2 H_0 \hbar} = \frac{l_p^2 c^3}{\hbar} \tag{30}$$

which is the same composite formula for G that one get by solving Max Planck's Planck length formula for G.

For G times the critical mass of the universe (the gravitational parameter of the universe), we must have

$$\mu_c = G M_c = \frac{l_p^2 c^4}{\hbar}\frac{\hbar}{\bar{\lambda}_c}\frac{1}{c} = c^2 \frac{l_p^2}{\bar{\lambda}_c} \tag{31}$$

where $\bar{\lambda}_c$ is the reduced Compton wavelength of the mass in the critical universe. To predict gravitational phenomena related to the mass of the critical universe all we need is the Planck length and the speed of light, that is two constants, and the reduced Compton wavelength of the critical mass of the universe. All these can be found with no knowledge off G or even $\hbar$. Actually the Hubble constant is given by

$$H_0 = \frac{1}{\frac{l_p}{c}\frac{l_p}{\bar{\lambda}_u}} = \frac{1}{t_p \frac{l_p}{\bar{\lambda}_U}} \tag{32}$$

where λ_u is the reduced Compton wavelength of the Mass in the Haug universe. Pay attention to that $t_p \frac{l_p}{\bar{\lambda}_c}$ is identical to what we call the collision-time mass. So the Hubble constant in this view is nothing more than one divided by the collision-time mass of the observable (critical) universe.

If one know the collision-time mass of the universe, then there is no need to multiply it with G to do gravitational predictions. This is why cosmological red-shift can be predicted by simply

$$Z = \frac{Hd}{c} = \frac{d}{c\bar{M}_c} \tag{33}$$

where $\bar{M}_c = t_p \frac{l_p}{\bar{\lambda}}$ is the collision-time of the observable universe. If we use the critical mass of the universe in terms of kilogram, then we need to multiply it with G divided by c^3 to convert it into the real gravitational mass, so we have

$$Z = \frac{d}{c\frac{G}{c^3 M_c}} = \frac{d}{c\bar{M}_c} = \frac{H_0 d}{c} \tag{34}$$

This means we also can predict cosmological phenomena from the Planck length and the speed of light. This strongly indicates there is a link between the largest and the smallest scales of the universe, this is not a very big surprise as the largest scales are built from the smallest. The rules of the smallest (quantum) somehow gives us the rules for even the cosmic scales. Our view is that the Planck scale actually is indirectly detected in any (or at least most) gravitational observation, including also cosmological red-shift.

Table 6 shows some ways to express the gravity constant in form of cosmological entities. All these are at the deepest level nothing else than $G = \frac{l_p^2 c^3}{\hbar}$. Pay also attention to how closely the formulas linked to the Hubble scale is linked to the formulas presented linked to the Schwarzschild radius and Haug radius, the reason for this is that the Hubble radius is identical to the Schwarzschild radius for the observable universe, why it also have been papers considered if the Hubble sphere actually is a gigantic black hole, see for example [84, 85].

From	Gravity formula	Comments
From universe mass, Hubble radius	$G = \frac{R_u c^2}{M_u}$	Bleksley 1951 [76]
Hubble constant, Friedmann critical mass	$G = \frac{c^3}{2H_0 M_c}$	
Hubble radius, Friedmann critical mass	$G = \frac{R_H c^2}{2M_c}$	
Hubble constant, Friedmann critical mass	$G = \frac{T_H c^3}{2M_c}$	
Hubble time, Friedmann critical mass	$G = \frac{c^3}{2H_0 M_c}$	
Hubble radius, Hubble time and Friedmann critical mass	$G = \frac{R_H^3}{2M_c T_H^2}$	
Hubble constant, Haug universe mass	$G = \frac{c^3}{H_0 M_u}$	
Hubble radius Hubble time and Haug universe mass	$G = \frac{R_H c^2}{M_u}$	
Hubble radius, Haug universe mass	$G = \frac{T_H c^3}{M_u}$	
Hubble time, Hubble time and Haug universe mass	$G = \frac{T_H c^3}{M_u T_H^2}$	
Hubble constant, Friedmann critical mass	$G = \frac{c^3}{2H_0 M_c}$	
Hubble Time and Haug universe mass	$G = \frac{T_H c^3}{M_u}$	
Schwarzschild radius, mass,	$G = \frac{R_s c^2}{2M}$	$R_s = \frac{2GM}{c^2}$
Schwarzschild time, mass,	$G = \frac{T_s c^3}{2M}$	$T_s = \frac{R_s}{c}$
Haug escape velocity radius, mass,	$G = \frac{R_h c^2}{M}$	$R_h = \frac{GM}{c^2}$
Haug radius time, mass,	$G = \frac{T_h c^3}{M}$	$T_h = \frac{R_h}{c}$

Table 6: The table show various ways we can express the gravity constant from cosmological units, as well as from units related to black holes.

7 Conclusion

The idea that the gravitational constant can be a composite constant that again is related to more fundamental Planck units goes at least back to 1984. However already in 1987 it was pointed out that expressing the gravitational constant through Planck units lead to a circular problem, that one had to know the gravity constant to find the Planck units. This view has been repeated by researchers as late as 2016. However, in recent years a series of papers have shown how one clearly can find the Planck units without knowledge off G, and even without knowledge of G and $\hbar$, so the circular problem around G and the Planck units has been is solved. An in-depth study shows that this leads to a reduction in universal constants from G, $\hbar$ and c to only c and l_p, in addition one need other constants like the fine structure constants when describing electromagnetic phenomena, but the traditional three universal constants Max Planck used can be reduced from three to two. To predict all observable gravity phenomena, one only need knowledge of l_p and c and both can be found without knowledge of G and $\hbar$. The implications of this should be worth study further as this seems to open doors of insight between macroscopic gravity phenomena and the Planck scale.

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