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God Time = Planck Time: Finally Detected!

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Abstract

Newton already mentioned indivisible time in *Principia*. In 1899, Max Planck derived a unique time period from three universal constants: G , c , and \hbar , and today this is known as the Planck time. The Planck time is of the order of about 10^{-44} seconds while the best atomic clocks are down to 10^{-19} seconds. An approach has recently been outlined that puts an upper limit on the quantization of time to 10^{-33} seconds; this is, however, still far away from the Planck time. We demonstrate that the Planck time can easily be measured without any knowledge of any other physical constants. This is remarkable as this means we have demonstrated that the Planck time and therefore the Planck scale is real and detectable. It has taken more than 100 years to understand this. The reason for the breakthrough in Planck scale physics in recent years comes from understanding that G is a composite constant and that the true matter wavelength is the Compton wavelength rather than the de Broglie wavelength. When this is understood, the mysteries of the Planck scale can be uncovered. In this paper we also show for the first time how to measure the number of Planck events in a gravitational mass without knowledge of any constants. We will claim this is directly related to quantization of gravity.

Key Words: Planck time, fundamental time, indivisible time, Newton, Planck length, quantum gravity.

1 The early forgotten history of the indivisible time interval

The Higgs boson was popularized partly because it was coined *The God Particle*, due to Nobel Laureate Lederman's [1] 1993 book with the same title about concepts related to the Higgs boson. Many physicists did not like the label *The God Particle* for the Higgs boson, but it is still often used. On the other hand, we see, surprisingly, that the possible first mention of an indivisible time interval seems to have been in the bible; something we soon will get back to. We are not mentioning this because we want to mix religion and physics, but simply because it is an interesting historical fact that has typically gone unnoticed.

Isaac Newton [2] in his 1686 book *Principia* wrote:

Since every particle of space is always and every indivisible moment of duration is everywhere certainly the Maker and Lord of all things cannot be never and nowhere Further, he mentioned: *"...then we conclude the least particles of all bodies to be also extended, and hard and movable, and endowed with their proper vires inertia. And this is the foundation of all philosophy.*—Isaac Newton (p. 505)

Newton clearly mentioned an indivisible time interval. If a time interval is indivisible, it cannot be broken down further and cannot be shorter. That Newton mentions an indivisible time interval has basically gone unnoticed by the physics community. It could naturally be that Newton came up with the idea of indivisible time himself, but he is mixing this in with some "religious talk" which was not uncommon among scientists back then. It is also well known that Newton, in addition to his physics, spent considerable time reading scriptures as well as the bible; some say in the hope of finding deeper and ancient wisdom, or perhaps to please the church; see, for example, Heberle-Bors [3] for a discussion on this. Interestingly, the first place an indivisible time interval is mentioned is in the New Testament. In the original Greek version, we find

ἐν ἀτόμῳ, ἐν ῥιπή ὀφθαλμοῦ

This has often been translated in the English translation of the New Testament as “*In an instant, in the twinkling of an eye*”. But we think all English translations we have seen miss an important point. “*ατομον*” is ancient Greek that in English means atom, and atom in ancient Greek means indivisible, or uncuttable, that is, something that cannot be divided further. So “atomic time” must, in our interpretation, have meant an indivisible time interval – not only an instant – and the difference in interpretation is large. The word “atom” meant indivisible particle since the time of Democritus, and Leuippicus [4, 5] introduced atomism about 500 B.C. and all the way up to the time when John Dalton introduced the periodic system. Dalton thought he had found the indivisible particles of the Greek philosophers, but some years later it was shown that what he thought were atoms (indivisibles) were composite particles, in other words, divisible. However, the word “atom” was maintained for these elements that had nothing to do with the original meaning of the word. Several scientists in the past did, in fact, point out that the Daltonian atom was not a true atom (an indivisible), even before this was fully proven. For example, in their book *A History of Science*, published in 1904, Williams and Williams [6] stated that:

There are, indeed, as we shall see, experiments that suggest the dissolution of the [Dalton] atom – that suggest, in short, that the Daltonian atom is misnamed, being a structure, under certain conditions, be broken asunder. When experiment shall have demonstrated the Daltonian atom is a compound, and that in truth there is a single true atom, which, combining with its fellows perhaps in varying numbers and in different special relations, produces the Daltonian atoms, then the philosophical theory of monism will have the experimental warrant which to-day it lacks.

Our point is that until Dalton the word “*atom*” was always interpreted as indivisible, the true ancient Greek meaning of the word. So, we are quite convinced that the original New Testament talked about an indivisible time and not just an instant, or a short time interval. The indivisible time is, however, according to recent findings, the Planck time, so it is also an instant, or the shortest possible instant of time that exists. Yet, to call it just an instant of time is an incomplete description. Indivisible (atomic) time, on the other hand, gives a complete description of perhaps one of the most important things in physics. An instant period is just a very short time period; it could even be a second or a millisecond. Naturally other time units existed back then as the second was not yet invented. Atom (indivisible) time on the other hand is the very shortest time interval that can exist, so it is likely linked to the very foundation of time.

One possibility, and we would even say a likelihood, is that Isaac Newton therefore had the idea of indivisible time from the New Testament, when he mentioned indivisible time in his book Principia. This we will likely never know for sure; what we do know is that Isaac Newton studied the Bible in detail. Newton likely reading the Greek version; in his time the word “*atom*” was not misinterpreted, at least not by scientists, as the only meaning of the word then was indivisible. It was first with Dalton that the word “atom” lost its original meaning when attached to elements which he thought were indivisibles, but which were actually divisible composite particles.

2 Planck time, quantum time, and quantum gravity

In 1899 Max Planck [7, 8] introduced 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: $T_p = \sqrt{\frac{\hbar c^5}{Gk_b}}$. Planck got to these by assuming there were three important universal constants: the gravitational constant G , the Planck constant h , and the speed of light, then he combined these with dimensional analysis one get these units. These units are today known as the Planck units [9] or just natural units. However, until recently, it has been assumed it is almost impossible to detect the Planck scale (see for example [10–12]) and therefore also to measure the Planck time. For example, the most accurate atomic and optical clocks can measure a time interval of about 10^{-19} seconds; see [13]. Wendel, Martínez, and Bojowald [14] who have recently found a strong upper boundary of the fundamental period of time of approximately 10^{-33} seconds, which is still not even close to the Planck time that is only approximately

$$t_p = \sqrt{\frac{G\hbar}{c^5}} = \frac{l_p}{c} \approx 5.4 \times 10^{-44} \text{ s}$$

The Planck time is, by most physicists [15, 16], considered the shortest possible, even hypothetically measurable, time interval. Some think it is an invariant indivisible time interval. The Planck time is the time it takes for the speed of light to travel the Planck length, and the Planck length is, among most physicists, considered the minimum length interval, and some even think it is an indivisible length. The reduced Compton wavelength of a Planck mass is the Planck length. A better understanding of the Planck time and the other Planck units can be an important

step towards a unified quantum gravity theory. Ball [17] summarized nicely in one sentence the importance of better understanding the Planck time:

A physics to match the Planck timescale is the biggest challenge to physicists in the coming century.
– Philip Ball, 1999

This because the Planck time scale (the Planck length, the Planck time, and other Planck units) are likely linked to quantum gravity that is needed to unify gravity with quantum mechanics; see, for example [18, 19].

In 1984, Cohen suggested that the Planck units were likely more important than the gravitational constant and that the gravitational constant perhaps therefore could be expressed as $G = \frac{\hbar c}{m_p^2}$, which is simply the Planck mass formula solved with respect to G . However, in 1987, Cohen [20] pointed out that no one had shown a way to find the Planck mass or any other Planck units without first knowing G , so that to express G from Planck units would just lead to a circular problem. This view has been held until very recently and was, for example, repeated in 2016 by McCulloch [21] who also expressed the Newton gravitational constant as $G = \frac{\hbar c}{m_p^2}$.

Eddington [22] in 1918 was likely the first to suggest the Planck length would have to play a central role in a future quantum gravity theory, but without suggesting how. Actually, already in 1931, Nobel Laureate Percy Bridgman [23] ridiculed the Planck units. For him, they were more like some artificial mathematical units that simply came out of dimensional analysis from other constants. They were, in his view, likely not linked to anything fundamental physical. We will claim little progress has been made for more than 100 years on the Planck scale, except until very recently.

For example, Das and Modak [24] have as recently as 2021, pointed out what is likely still the main view among physicists in relation to the Planck scale detection:

The Planck or the quantum gravity (QG) scale, being 16 orders of magnitude greater than the electroweak scale, is often considered inaccessible by current experimental techniques.

We will claim that the Planck scale being considered inaccessible by current experimental techniques by most of the physics community is simply due to a lack of understanding of the Planck scale and the lack of progress in understanding quantum gravity using standard theory, as well as such failed attempts as super string theory. The reason for this, we will claim, is that very few physicists are still aware of the enormous progress made in relation to the Planck scale in the past few years. This is mostly because research about how to detect and understand the Planck scale has mainly been published in low- ranked journals and in a step-by-step process.

We have, in recent years, demonstrated that the Planck length and other Planck units can remarkably be found without any knowledge of G and h , and even without c ; see [25–28]. This is in strong contrast to what was first pointed out by Cohen and that has been the view until recently, and still is the view among most researchers. What is new in this paper is both a more solid historical background on the indivisible time interval and its link to the Planck time, and also that here we employ even more ways that will show how one can easily measure the Planck time with no prior knowledge of G , \hbar or c . That is, one needs to know no constants to measure the Planck time. All we need is to combine two gravitational measurements, as will be demonstrated in the next few sections.

The reason we can easily detect the Planck scale is that quantum gravity is remarkably hidden and already embedded in even Newtonian gravity, not by purpose but by calibration. To detect most gravitational effects is to detect the Planck scale. The reason this has not been discovered until recently is that one has, for more than 100 years, used a somewhat ad hoc inserted gravity constant, namely G , that first came into use in 1873. We have gained a new understanding of the Newton gravitational constant now that we can find the Planck units independent of G , as will be demonstrated below.

3 Compton wavelength for any mass

Essential for a recent breakthrough in understanding the Planck scale has been understanding that the Compton wavelength is likely the true matter wavelength, and that the de Broglie wavelength is likely only a mathematical derivative of the Compton wavelength. Since Einstein was able to describe the photo electronic effect, it has been known that light has particle-wave properties. Louis de Broglie suggested also that matter has a wave property in addition to particle properties; in other words, that matter also has particle wave duality. Broglie suggested in his PhD thesis [29] that he presented in 1923/1924, that the matter wavelength was likely given by:

$$\lambda_b = \frac{h}{mv} \quad (1)$$

or in relativistic form [30]

$$\lambda_b = \frac{h}{mv\gamma} \quad (2)$$

where γ as usual is the Lorentz factor, $\gamma = \sqrt{1 - v^2/c^2}$.

In 1927, Davisson and Germer [31] reported that they had experimentally observed wavelike properties in electrons. This was quickly interpreted as the de Broglie hypothesis where correct. However, physicists forgot to distinguish between de Broglie's idea that matter had wavelike properties, which indeed was confirmed, and his formula that gave a precise prediction of the length of these waves. The experiment only confirmed the wavelike properties and not any direct measurement on if the length of these waves were the same as predicted by de Broglie's formula.

In 1923, Arthur Holley Compton [32] reported that to scatter electrons with photons also led to a wavelength linked to matter, today known as the Compton wavelength, that is given by:

$$\lambda = \frac{h}{mc} \quad (3)$$

and the reduced Compton wavelength is given by $\bar{\lambda} = \frac{\lambda}{2\pi}$.

Compton assumed the electrons, when scattered by photons, were standing still when initially hit by photons. This has recently been extended to also hold true when the electron is initially moving; see [33]. The relativistic Compton wavelength is given by:

$$\lambda = \frac{h}{mc\gamma} \quad (4)$$

Now let us compare the de Broglie wavelength with the Compton wavelength. If the particle is at rest, then the de Broglie wavelength is not even mathematically defined as it is not mathematically allowed to divide by zero. Alternatively, one can assume a particle never stands fully still, but still then when v approaches zero the de Broglie wavelength approaches infinite. This has led to absurd predictions, such as an electron is everywhere in the universe at the same time, or until observed. On the other hand, the Compton wavelength is always mathematically well defined, and for an electron it always has a length that is of the order of the atomic scale, which makes sense as the electron is very small.

Pay attention to the fact that the de Broglie wavelength is always equal to the Compton wavelength multiplied by $\frac{c}{v}$. Why would matter have two different wavelengths and light only one wavelength? In our view, the de Broglie wavelength is nothing more than a mathematical derivative of the true matter wavelength, namely the Compton wavelength; see also [34, 35]. There is nothing mathematically wrong with the de Broglie wavelength; it is just it is a mathematical function of a real physical matter wavelength, and so using it instead of the Compton wavelength will complicate interpretations. Also, the de Broglie wavelength is not valid for rest-mass particles.

It's also important that any mass, not only an electron, has a Compton wavelength. If we solve the Compton wavelength formula with respect to m , we get:

$$m = \frac{h}{\lambda c} = \frac{\hbar}{\bar{\lambda} c} \quad (5)$$

where \hbar is the reduced Planck constant ($\frac{h}{2\pi}$).

To rewrite the Compton wavelength formula in terms of mass is trivial, but it seems it was first done and used in 2018 by Haug [36]. Some will likely protest here and say we cannot simply solve the Compton wavelength formula with respect to m , in particular not for masses that are not electrons. Actually, the idea that also protons have Compton wavelength goes back to at least 1958 with the paper of Levitt [37], and recently attention to the Compton wavelength of the proton increased; see Bohr and Trinhammer [38].

We think only fundamental particles have a physical Compton wavelength. Still, all larger masses are composites of fundamental particles, and their aggregates of reduced Compton wavelengths can be found by the following aggregation formula:

$$\bar{\lambda} = \frac{1}{\sum_i^n \frac{1}{\bar{\lambda}_i}} \quad (6)$$

This way to find the Compton wavelength of a composite particle is fully consistent with aggregating masses in the standard way:

$$m = \sum_i^n m_i \quad (7)$$

The formula above is strictly only valid for non-bound masses. For bound masses, the mass is typically slightly lower than the mass aggregates of its individual components due to the release of binding energy [39]. This can easily be adjusted for, as energy can be treated as mass equivalent from Einstein's principle of $m = \frac{E}{c^2}$.

If we know the Planck constant and the kilogram mass of any mass in question, even the kilogram mass of large objects like, for example, the Earth or the sun, then we can easily find its reduced Compton wavelength. It is simply given by $\bar{\lambda} = \frac{\hbar}{mc}$. For masses larger than the Planck mass, the reduced Compton wavelength will be shorter than the Planck length. No physical Compton wavelength can likely be shorter than the Planck length, but the aggregates of Compton wavelengths that are all larger than the Planck length can be shorter than the Planck length. This is related to the fact that the aggregated Compton wavelength is given by formula 6.

However, to find the kilogram mass of the Earth or the sun, we typically need to know G . Later on, we will need to find the Compton wavelength of larger masses without knowing G and also without knowing \hbar . This is fully possible. First, one can find the Compton wavelength from an electron, as it also can be described by the following formula (see [26, 33]):

$$\lambda = \frac{\lambda_{1,\gamma} - \lambda_{2,\gamma}}{1 - \cos \theta} \quad (8)$$

where θ is the angle between the ingoing and outgoing photon from photon scattering. Further, $\lambda_{1,\gamma}$ and $\lambda_{2,\gamma}$ are the wavelength of the photon when sent towards the electron and when reflected from the electron. All these are measurable without knowledge of \hbar or G .

Next, we can find the Compton wavelength by utilizing cyclotron frequencies. The cyclotron frequency is given by:

$$f = \frac{qB}{m2\pi} \quad (9)$$

and since electrons and protons have the same absolute value of the charge, $|q|$, then the cyclotron frequency ratio of electrons and protons are proportional to their mass ratio. That is, we must have:

$$\frac{m_p}{m_e} = \frac{f_e}{f_p} = \frac{\frac{qB}{m_p 2\pi}}{\frac{qB}{m_e 2\pi}} = \frac{\bar{\lambda}_e}{\bar{\lambda}_p} \quad (10)$$

So, when we have measured the cyclotron frequency of electrons and protons, we can find the proton electron mass ratio (without knowing \hbar). It has experimentally been found to be approximately 1836.15 by indeed using the cyclotron method; see [40–42]. All we now need in order to find the Compton wavelength of the proton is to divide the Compton wavelength of the electron by the cyclotron ratio of 1836.15. For any larger masses, one will now get a very accurate approximation of the Compton wavelength of that mass by counting the number of protons in it and dividing by that number. For simplicity, we do not need to distinguish between neutrons and protons as they have almost the same mass, or we can do the small mass adjustment. This method will lead to the estimated Compton wavelength being off by less than one percent. The up to 1% error is because we have not considered binding energy. However, we can also easily estimate the binding energy and adjust for it. However, for our purpose that we will come to later, we can do well enough without even adjusting for binding energy.

To count the number of atoms in a mass is, however, not trivial. For macroscopic masses that we can hold in our hand, it is however practically possible. Actually, one of the competing methods for the 2019 redefinition of the kilogram mass consisted of counting very accurately the number of atoms in silicon spheres; see [43–46]. Silicon crystals have a very uniform structure (^{28}Si), so by counting a few of them and knowing the volume of, for example, a silicon sphere very accurately, one can easily estimate the number of atoms in it.

Still, what about large masses like the Earth or the sun? Also, here we can easily find the Compton wavelength as we must have the following relation:

$$\frac{g_1 R_1^2}{g_2 R_2^2} = \frac{\bar{\lambda}_2}{\bar{\lambda}_1} \quad (11)$$

So, we can easily find the gravitational acceleration of a small silicon sphere that we have counted the number of atoms in and therefore also know the Compton wavelength of; this we can do in a Cavendish apparatus. Some will possibly think that if we use a Cavendish apparatus then we need to know G , but this is not the case. Actually, Cavendish himself never used nor suggested a gravitational constant when he measured the density of the Earth; see [47]. The gravitational acceleration in the Cavendish apparatus is given by:

$$g = \frac{L4\pi^2\theta_c}{T^2} \quad (12)$$

where L is the length of the arm between center to center of the two small balls in the apparatus. Further, θ_c is the angle of deflection of the arm and T is the measured oscillation period. Clearly no G or \hbar are needed to measure this also. Next, to find the gravitational acceleration field of the Earth, for example, one can simply drop a ball from height H to the ground. The gravitational acceleration is then given by $g = \frac{2H}{T^2}$ where T is the time it took for the ball to fall to the ground. We now have all we need to also calculate the Compton wavelength of large objects like the Earth, independent of G or \hbar .

In the next section we will see how the Compton wavelength plays a critical role in finding the Planck time from simple gravitational measurements.

4 Measuring the Planck time independent of knowledge of G , c and \hbar

To find the Planck length without knowledge of G or \hbar or c , we can measure the gravitational bending of light, for example from the sun, and the gravitational acceleration, for example from the Earth. That is, we need to combine two gravitational measurements. These two gravitational measurements can be from the same object, for example both from the sun, or they can be from two different objects, for example the sun and the Earth, something that is more practical. The general formula for the Planck time is then given by (as first presented here):

$$t_p = \frac{\delta}{4\sqrt{g}} \frac{R_1 \bar{\lambda}_1}{R_2 \sqrt{\lambda_2}} \quad (13)$$

where θ is the measured light bending at radius R_1 from the gravitational object, g is the measured gravitational acceleration from the other gravitational object at radius r_2 , and $\bar{\lambda}_1$ and $\bar{\lambda}_2$ are the reduced Compton wavelength of, respectively, the mass affecting the gravitational deflection of light and the mass we measure the gravitational acceleration from. We will get back to how to derive it in the next section.

Let's take a numerical example. The gravitational acceleration we can measure on the surface of the Earth; it is approximately 9.84 m/s^2 . Be aware that to measure it we need no knowledge of G or \hbar . We can, for example, measure it by simply dropping a ball from height H above the ground and simply measuring the time it takes from when we dropped it until it hits the ground. The gravitational acceleration is then given by $g = \frac{2H}{T^2}$. It is only when we want to predict the gravitational acceleration from Newton or general relativity theory that we need to know G , not to measure it. In the Planck time formula 13 above, we need the radius of the Earth; this is approximately $R_2 = 6371000$ meters. The deflection of a light beam passing the sun has been measured to be approximately 1.75 arcseconds. This corresponds to approximately 85×10^{-7} radians. The radius of the sun is approximately $R_1 = 696340000$ meters. The reduced Compton wavelength of the sun and the Earth are respectively 1.77×10^{-73} m and 5.89×10^{-68} m. Inputting this in equation 13 gives:

$$t_p = \frac{85 \times 10^{-7}}{4\sqrt{9.84}} \frac{696340000 \times 1.77 \times 10^{-73}}{6371000\sqrt{5.89 \times 10^{-68}}} \approx 5.4 \times 10^{-44} \text{ s}$$

This is the Planck length found without any knowledge of G , \hbar , and c . Or actually, it can be discussed if we need to know c when finding the Compton wavelength, but we definitely do not need any knowledge of G or the Planck constant.

In the special case where the gravitational acceleration is measured from the same gravitational object and the same mass as the light bending, then equation 13 can be simplified to:

$$t_p = \frac{\delta\sqrt{\bar{\lambda}}}{4\sqrt{g}} \quad (14)$$

Alternatively, for gravitational acceleration we could, for example, have used orbital velocity to find the Planck time. Then we have the following relation:

$$t_p = \frac{\delta}{4v_o} \frac{R_1 \bar{\lambda}_1}{\sqrt{R_2 \lambda_2}} \quad (15)$$

That is, again to find the Planck time independently of G , \hbar , and c , we need to do two gravitational measurements: the bending of light and the orbital velocity. Or we can find the Planck time from only one gravitational measurement if we know the speed of light. The Planck time is equal to:

$$t_p = \frac{R\sqrt{g\lambda}}{c^2} \quad (16)$$

where R is the distance from the center of the gravitational object to where the measurements of the gravitational acceleration g take place.

The breakthrough in understanding that we can measure any Planck units without knowledge of G or h basically came with the understanding that matter ticks at the reduced Compton frequency and then the reduced Compton wavelength is the true matter wavelength, while the de Broglie wavelength [29, 30] is only a mathematical derivative of the Compton wavelength.

Table 1 shows a series of ways to find the Planck time with no knowledge of G or h , and some ways to find it without knowledge of G , h , and c . To find the Planck time from a pendulum clock has recently been described in [48] and from a Cavendish apparatus in [28], but the other methods are basically described for the first time here.

From	Formula	Comments
Not dependent on G, h or c :		
Light deflection and orbital velocity	$t_p = \frac{\delta}{4v_o} \frac{R_1 \lambda_1}{\sqrt{R_2 \lambda_2}}$	
Light deflection and gravitational acceleration	$t_p = \frac{\delta}{4\sqrt{g}} \frac{R_1 \lambda_1}{R_2 \sqrt{\lambda_2}}$	
Not dependent on G or h, but on c:		
Gravitational acceleration	$t_p = \frac{R\sqrt{g\lambda}}{c^2}$	
Orbital velocity	$t_p = \frac{v_0 \sqrt{R\lambda}}{c^2}$	
Orbital time	$t_p = \frac{2\pi \sqrt{R^3 \lambda}}{T c^2}$	
Periodicity pendulum clock	$t_p = \frac{2\pi R \sqrt{L\lambda}}{T c^2}$	L is length pendulum.
Velocity ball Newton cradle	$t_p = \frac{R \sqrt{v_{out} \lambda}}{c^2 \sqrt{2H}}$	H hight of ball drop.
Light deflection	$t_p = \frac{\sqrt{\delta R \lambda}}{c}$	δ light deflection.
Advance of perihelion	$t_p = \frac{\sqrt{\sigma \lambda a (1-e^2)}}{c \sqrt{6\pi}}$	σ Advance of perihelion
Micro lensing	$\theta \sqrt{\lambda \frac{d_S d_L}{d_S - d_L}}$	θ micro lensing.
Cavendish apparatus	$t_p = \frac{2c}{L 4\pi^2 R^2 \theta_c}$	R distance from small to large ball. L distance between small balls, θ_c angle, T pendulum periodicity.

Table 1: The table shows various ways we can find the Planck time without knowledge of G , h , and c , as well as without knowledge of G and h .

5 How did we come up with these formulas?

Anyone can input values in the formulas above from experiments and test that what comes out is the Planck time. Still, how did we come up with these formulas? Do they have a proper foundation? Anyone can ad-hoc put together some crackpot formulas by trial and error and get some output similar to the value of the Planck length; that would be numerology. It is hard to see from the formulas how we got to them. The way we got to them is, however, rooted in a solid foundation and deep understanding of the Planck scale and other quantum aspects of matter and gravity. One of the keys is the Compton wavelength formula. It is given by:

$$\lambda = \frac{h}{mc} \quad (17)$$

The key is to solve this with respect to m , and this gives:

$$m = \frac{h}{\lambda c} = \frac{\hbar}{\lambda c} \quad (18)$$

The second insight is that we can solve the Planck length formula for G , and this gives $G = \frac{l_p^2 c^3}{\hbar}$. In all observable gravitational phenomena, we have GM and not GMm , as discussed in [49]. This means \hbar always cancels out, as it is not needed for gravity. Further, by now using the conventional formulas, for example for gravitational deflection, $\delta = \frac{4GM}{c^2 R} = \frac{4l_p^2}{\lambda R}$ and gravitational acceleration, $g = \frac{c^2 l_p^2}{R^2 \lambda}$ we can now see that we can combine these to get $t_p = \frac{l_p}{c}$. If we take the gravitational deflection and divide it by the square root of the gravitational acceleration, we can see we get:

$$\frac{\delta}{\sqrt{g}} = \frac{\frac{4l_p^2}{\lambda R}}{\sqrt{\frac{c^2 l_p^2}{R^2 \lambda}}} = \frac{4l_p}{c\sqrt{\lambda}} \quad (19)$$

In other words, this must be multiplied by $\sqrt{\lambda}$ and divided by four to be left with only the Planck time, $t_p = \frac{l_p}{c}$, so we end up with:

$$t_p = \frac{\delta\sqrt{\lambda}}{4\sqrt{g}}$$

which is our equation number 14.

Similarly, all the other formulas can be simply derived. We can ensure all the formulas given above are not just some approximation or randomly put together formulas, but they are exact and it is suddenly possible to easily find the Planck time and other aspects of the Planck scale from a few gravitational observations and without any knowledge of G . This because we now understand both G and m from a deeper perspective. The Newton gravitational constant, which actually was first invented in 1873 by Cornu and Baily [50]¹ is, in reality, a composite constant (see [52]) and the matter wavelength is the Compton wavelength. When combining these simple insights, it is easy to detect the Planck scale. This again has led us to a recent quantum gravity theory.

We can even build up a full quantum gravitational theory without relying on G or \hbar ; this has recently been done [19, 35], but it is naturally up to others to scrutinize and investigate.

6 The hidden quantization in gravity

In standard physics, we have quantization of energy linked to the Planck constant h as pure electromagnetic energy can be described as $E = h\frac{c}{\lambda}$. In gravity, we do not need the Planck constant to get quantization.

The hidden Planck constant in the mass and in G always cancel each other out, as we, in “all” observable gravitational phenomena, have:

$$GM = \frac{l_p^2 c^3}{\hbar} \times \frac{\hbar}{\lambda} \frac{1}{c} = c^3 \frac{l_p}{c} \frac{l_p}{\lambda} = c^3 t_p \frac{l_p}{\lambda} \quad (20)$$

Therefore, there are no Planck constants needed to predict any gravitational phenomena, as it always cancels out. Still, it is expected that a final gravitational quantum theory will have quantization of gravity. To our own surprise, the quantization is already hidden in standard gravity if one just digs deep enough. That is, when one expresses G as a composite constant and M as $M = \frac{\hbar}{\lambda} \frac{1}{c}$ and calculates out the various gravitational formulas, then GM can be seen as a way to turn the incomplete kilogram mass, which is a human arbitrarily chosen unit, and construct a more complete mass, namely $M_g = \frac{l_p}{c} \frac{l_p}{\lambda} = t_p \frac{l_p}{\lambda}$. This new mass definition can also be found by simply taking $\frac{GM}{c^3}$, so it is basically already embedded in standard gravitational physics. It is just that G was inserted ad hoc in 1873, and was never derived from deeper principles, and has therefore not been understood until recently. The gravitational constant is found, from calibration, to fix the incomplete kilogram mass so the gravitational formulas can be used to accurately predict gravitational phenomena. The gravitational constant, by calibration to gravity phenomena, is able to capture what is missing in the incomplete kilogram mass.

Pay attention to the fact that our new mass definition (collision-time mass) that is embedded (and concealed) in standard gravitational theory, it is given by:

$$\frac{G}{c^3} M = M_g = \frac{l_p}{c} \frac{l_p}{\lambda} = t_p \frac{l_p}{\lambda} = t_p n_p \quad (21)$$

This mass² is simply equal to the Planck time multiplied by $\frac{l_p}{\lambda}$. This last part $\frac{l_p}{\lambda}$ corresponds to the number of Planck mass events, n_p , in the gravitational mass M_g per Planck time. This is discussed in detail in a new unified quantum gravity theory that is rooted in the Planck scale and an indivisible time interval; see [18, 19, 35]. And as we have clearly demonstrated in the previous section, there is no need to know G or \hbar to find the Planck time, so we can also find this collision-time mass directly without knowledge of such constants. In other words, we do not need to know G and multiply it with M to find this new mass, as we have also demonstrated in other papers.

For a Planck mass, this last term $\frac{l_p}{\lambda}$ is one. So, in a Planck mass particle there is one Planck mass event per Planck time, and its duration is only the Planck time. For a mass smaller than the Planck mass, it is less than one;

¹They used the notation f for the gravity constant, while Boys [51] in 1894 is likely the first to use the notation G .

²In some previous papers we have used symbol notation \bar{M} for what we here use symbol M_g for.

that is, it is then the probability for a Planck mass event to happen in the observational time interval of the Planck time. For large macroscopic masses, this factor will be an integer plus a small fraction. The integer part then represents the number of Planck events per Planck time happening in that mass, and the remaining fraction part is the probability for one more such event. For the sun, we have that this factor is approximately $\frac{t_p}{\lambda} \approx 9.15 \times 10^{37}$ events per Planck time. That is, the gravity is quantized. So, what we actually measure is the enormous amount of Planck times aggregated, but we are able to separate them and even find the one Planck time as matter can be seen as clocks ticking at the Compton frequency. However, these clocks have two properties. The time between each Planck event is the Compton time, that is $\frac{\lambda}{c}$ while the Planck event itself lasts the Planck time. You can think of it as a clock that every hour says: *Ding*. The Compton time is the time between each ding, but what is the duration of the ding itself? That is the Planck time, and it is the ding itself that is a Planck mass event that is the cause of gravity; see [18, 19, 35]. See the papers just referred to for an in-depth discussion and for a suggestion for a unified quantum gravity theory.

Table 2 shows how to find the number of Planck events inside the gravitational mass per Planck time.

From	Formula	Comments
Not dependent on G, \hbar or c :		
Light deflection	$\frac{t_p}{\lambda} = n_p = \frac{\sqrt{\delta R}}{\lambda}$	δ light deflection.
Advance of perihelion	$\frac{t_p}{\lambda} = n_p = \frac{\sqrt{\sigma a(1-e^2)}}{\lambda}$	σ Advance of perihelion
Micro lensing	$\frac{t_p}{\lambda} = n_p = \frac{\sqrt{6\pi\lambda}}{\theta \sqrt{\frac{d_S d_F}{d_S - d_L}}}$	θ micro lensing
Not dependent on G or \hbar, but on c:		
Gravitational acceleration	$\frac{t_p}{\lambda} = n_p = \frac{R\sqrt{g}}{c\sqrt{\lambda}}$	
Orbital velocity	$\frac{t_p}{\lambda} = n_p = \frac{v_0\sqrt{R}}{c\sqrt{\lambda}}$	
Orbital time	$\frac{t_p}{\lambda} = n_p = \frac{2\pi\sqrt{R^3}}{Tc\sqrt{\lambda}}$	
Periodicity pendulum clock	$\frac{t_p}{\lambda} = n_p = \frac{2\pi R\sqrt{L}}{Tc\lambda}$	L is length pendulum.
Velocity ball Newton cradle	$\frac{t_p}{\lambda} = n_p = \frac{R\sqrt{v_{out}}}{c\sqrt{2H\lambda}}$	H height of ball drop.
Cavendish apparatus	$\frac{t_p}{\lambda} = n_p = \frac{L4\pi^2 R^2 \theta_c}{T^2 c \lambda}$	R distance from small to large ball. L distance between small balls, θ_c angle, T pendulum periodicity.

Table 2: The table shows various ways we can find the number of Planck mass events $\frac{t_p}{\lambda}$ without knowledge of G , \hbar , and c as well as without knowledge of G and \hbar .

The table above gives the number of Planck events per Planck time; that is, for the indivisible time interval. We can easily convert all the formulas above to the arbitrarily human chosen time interval of one second by multiplying all formulas in table 2 with $\frac{1}{t_p}$. One then ends up with $\frac{c}{\lambda} = f_c$, in other words, the reduced Compton frequency per second, which again is the number of Planck events per second in the gravitational mass.

7 Conclusion

We have looked at the history of the indivisible time interval. An indivisible time interval was mentioned in the New Testament, something that seems to have got lost in modern English translations. Isaac Newton clearly mentioned an indivisible time interval in his book *Principia*, though it is unclear if he got the idea for this from the New Testament and it is also not important. Today, the Planck time is considered by many physicists to be the smallest possible time interval and therefore somehow indivisible. However, very recently one has been able for the first time to measure the Planck time without calculating it from dimensional analysis. The Planck time can be found by combining two gravitational observations without any knowledge of G , \hbar , and c , or just from one gravitational observation if one only wants it independent of G and \hbar . This strongly supports the recent view that to observe simple effects from gravity itself, such as gravitational acceleration or orbital velocity, is remarkably a detection of the Planck scale. This is also in line with a recent quantum gravity theory that claims to unify gravity with quantum mechanics. If this attempt will be considered a useful one or not, only time will tell, when more researchers have carefully investigated it.

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Conflicts of Interest:

The author declares no conflict of interest.

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