Using a Grandfather Pendulum Clock to Measure the World's Shortest Time Interval, the Planck Time (with Zero Knowledge of G).

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Abstract

Haug [1] has recently introduced a new theory of unified quantum gravity coined "collision space-time." From this new and deeper understanding of mass we can also understand how a grandfather pendulum clock can be used to measure the world shortest time interval, namely the Planck time [2, 3], indirectly. Such a clock can, therefore, also be used to measure the diameter of an indivisible particle indirectly. Further, such a clock can easily measure the Schwarzschild radius of the gravity object and what we will call "Schwarzschild time." This basically proves that the Newton gravitational constant is not needed to find the Planck length or the Planck time; it is also not needed to find the Schwarzschild radius. Unfortunately, there is significant inertia in the current physics establishment towards new ideas that could significantly alter our perspective on the fundamentals, but this is not new in the history of science. Still, the idea that the Planck time can be measured totally independent of any knowledge of Newton's gravitational constant could be very important for moving forward in physics.

Key Words: Pendulum clock, Planck time, Planck length, Schwarzschild radius, Schwarzschild time, collision time, Newton's gravitational constant, Huygens.

1 Important Elements in the History of Gravity

Before we show how to measure the Planck time with a grandfather clock, we will briefly summarize the key points in the history of gravity that are relevant for this paper.

- 1656 – Pendulum clock invented by Christiaan Huygens.
- 1673 – Christiaan Huygens [4] publishes theory on how to calculate the pendulum periodicity from gravity acceleration: $T = 2\pi\sqrt{\frac{L}{g}}$.
- 1687, 1713, and 1726 – Three versions of the Principia. Newton's [5] gravitational formula $F = \frac{Mm}{r^2}$. Newton only states this in words. Newton never introduced a gravitational constant per se, nor did he have any use for one; at best we might claim that he hinted at one. Newton stated that mass is proportional to weight. Further, he showed how to extract the relative mass of astronomical objects easily and, based on the size of the planets, he could find their relative densities. Newton was focusing on relative masses, as also pointed out by Cohen [6]; "*That is, since Newton is concerned with relative masses and relative densities, the test mass can take any unity, so that weight-force may be considered the gravity or gravitational force per unit mass...*".
- 1796 – The introduction of the kilogram (kg).
- 1798 – Cavendish [7] calculates the density of the Earth relative to known elements such as water using a torsion balance. This torsion balance was invented by Cavendish's friend John Michell sometime before 1783, but Michell was not able to perform the experiment before he died. However, Cavendish never mentions a gravitational constant.
- 1873 – The idea that one needed a constant, now known as Newton's gravitational constant to obtain the gravity force, $F = f\frac{Mm}{r^2}$ was mentioned explicitly by Cornu and Baille [8], with notation f for the gravity constant (although the formula was only mentioned in a footnote). It was needed due to the practice of

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defining mass in terms of the kg. The gravitational constant was then used to remove an element from an arbitrary mass that had nothing to do with gravity, and to include what had been missing in the kg definition of mass, namely the Planck length. This appears to have occurred in a subtle way, without physicists actually examining or challenging this evolution in the conception of mass, see [1].

- 1894 – The gravitational constant was first called G by Boys in August 1884, see [9]. Here he stated the following formula: $Force = G\frac{\text{Mass}\times\text{Mass}}{\text{Distance}^2}$, although this latest step going from f to G is merely cosmetic. Many physicists still used f, even in the early 1900s, see Isaachsen [10], for example, who had studied under Helmholtz. Max Planck also uses the notation f for the gravity constant in 1899, 1906, and even as late as 1928 [2, 3, 11]. Einstein [12] uses k for the gravitational constant in 1911. However, by the 1920s, today's standard notation of G had taken hold more completely.
- 1916 – Einstein [13] produces his theory of general relativity, where he "naturally" is heavily dependent on G in his formulas.
- 2019/2020 – For more than 100 years, physicists have tried to unify theories of gravity and quantum mechanics with minimal success. The recently published theory of collision space-time [1] offers a fresh, new perspective that seems to unify a modified special relativity with gravity and quantum mechanics in a fully consistent way. This should not be taken for granted, and further careful study of the theory is warranted. In the end discussions and investigations by many researchers over time will be the best way to evaluate its merits.

What is important to understand here is that Newton never invented a gravitational constant, nor did he use one himself. Still, from his theory and insight he was able to calculate the relative masses of heavenly objects, such as the Earth, the Sun, Jupiter, and Saturn; see the Principia and [6], for example. He was also able to calculate their approximate relative densities. Newton claimed and showed that weight was proportional to mass. Mass for Newton was a quantity of matter and he thought matter consisted of indivisible particles. Weight was not linked to kg in those days, as the kilogram definition of mass was first was put forward in 1796, long after Newton's death.

The kg at a deeper level is a collision frequency ratio, as shown by Haug, and the rest mass of one kg can be described as

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

where $\hbar$ is the Planck constant, $\bar{\lambda}$ is the reduced Compton wavelength [14], and c is the speed of light. Some will likely question why we not are using the de Broglie [15, 16] matter wave, as it is normally the wavelength linked to matter. We think one of the greatest mistakes in physics has been to build quantum theory and matter theory around the de Broglie wavelength rather than the Compton wavelength. For example, the de Broglie wavelength is infinite for a rest mass particle – something that is absurd, but has been accepted and not even questioned much anymore, as it has been in use for almost 100 years.

One does obtain the correct predictions when building a theory using the de Broglie wavelength, but at the cost of unnecessarily complexity. In our view, the de Broglie wavelength is simply a mathematical derivative of the true matter wave, which we claim is the Compton wavelength; this is discussed in more detail in [1]. The relationship between the Compton wavelength and the de Broglie wavelength is simply that the de Broglie wavelength is the Compton wavelength multiplied by $\frac{c}{v}$.

However, the standard mass definition (even if we write it as a function of the de Broglie instead) does not contain any information about how long each collision lasts. For this detail, one needs the unknown length of the indivisible particle x, which we have already shown in our previous work is the Planck length. Here we will show that it can be extracted from a simple pendulum with no knowledge of the so-called Newton's gravitational constant if one combines it with an understanding of collision space-time. Gravity is directly linked to collision space-time and modern physics has indirectly incorporated this by combining the kg mass measure with the gravitational constant. This is covered quite thoroughly in [1]. Here we will concentrate on how our new understanding of mass makes it possible to measure the Planck time with a pendulum clock.

2 Using a Pendulum Clock to Find the Planck Time

Haug [1, 17] has shown how to find the Planck length independent of both G and $\hbar$ using a Cavendish apparatus. Here we extend on this work to show how a grandfather pendulum clock can be used to find the Planck time (and thereby naturally the Planck length as well). Huygens was the first to derive the formula for the period of an ideal mathematical pendulum

$$T = 2\pi\sqrt{\frac{L}{g}} \tag{2}$$

where L is the length of the pendulum and g is the gravitational acceleration. The gravitational acceleration at the surface of the Earth is experimentally known to be about $g \approx .9.81\ m/s^2$. From modern Newtonian gravity, including the gravitational constant G, we also know that the gravitational acceleration is given by

$$g = \frac{GM}{R^2} \tag{3}$$

However, based on our new collision space-time quantum gravity theory, any rest-mass can be viewed as collision-time, which is given by

$$\bar{m} = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}} \tag{4}$$

where l_p is the diameter of an indivisible particle and $\bar{\lambda}$ is the reduced Compton wavelength of the mass in question. Be aware that this formula holds for any mass, even large astronomical bodies like the Earth and the Sun. The Earth does not have a physical reduced Compton wavelength, but we predict that each elementary particle making up the Earth has one, and these are adapted in the following formula

$$\bar{\lambda} = \sum_{i=1}^{n} \frac{1}{\frac{1}{\bar{\lambda}_1} + \frac{1}{\bar{\lambda}_2} + \cdots + \frac{1}{\bar{\lambda}_n}} \tag{5}$$

Be aware that masses in terms of collision-time is just a function of the Compton wavelength. The standard addition rule of masses, for example, is still the same as before. Actually the addition rule for Compton wavelength in composite masses is the same no matter if one uses the kg mass definition or the collision-time mass definition.

Based on this, the gravitational acceleration of any object must be

$$g = \frac{c^3\bar{m}}{R^2} \tag{6}$$

Thus, we have simply replaced the standard mass measure with our mass measure, and we have replaced the gravitational constant with c^3, which is the much simpler "gravity" constant in our reformulated quantum gravity theory. It is the speed of light cubed. In other words, we are getting rid of a constant, namely G. Now we can rewrite the Huygens formula and solved with respect to the mass, this gives

$$\begin{aligned} T &= 2\pi\sqrt{\frac{L}{\frac{c^3\bar{m}}{R^2}}} \\ \frac{T^2}{4\pi^2} &= \frac{L}{\frac{c^3\bar{m}}{R^2}} \\ \bar{m} &= \frac{4\pi^2R^2L}{c^3T^2} \end{aligned} \tag{7}$$

Next keep in mind that we claim $\bar{m} = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}}$; this means we can solve with respect to l_p and this gives

$$\begin{aligned} \frac{l_p^2}{c\bar{\lambda}} &= \frac{4\pi^2R^2L}{c^3T^2} \\ l_p &= \frac{2\pi R\sqrt{L\bar{\lambda}}}{cT} \end{aligned} \tag{8}$$

we can divide this by c and get the Planck time

$$t_p = \frac{2\pi R\sqrt{L\bar{\lambda}}}{c^2T} \tag{9}$$

However, some may claim that we cannot know the Compton wavelength of the Earth $\bar{\lambda}$ without knowing G. This is actually not the case. We can measure the Compton wavelength of an electron from Compton [14] scattering, or alternatively we could use the hydrogen spectrum lines to extract the Compton length of the electron; see the Appendix. The cyclotron frequency is linearly proportional to the reduced Compton frequency. Conducting a cyclotron experiment, one can find the reduced Compton frequency ratio between the proton and the electron. For example, [18] measured it to be about (see also [19])

$$\frac{\frac{c}{\bar{\lambda}_P}}{\frac{c}{\bar{\lambda}_e}} = \frac{f_P}{f_e} = 1836.152470(76) \tag{10}$$

.

They actually measured the proton-electron mass ratio this way and not the mass in kg. To measure the relative mass between particles rather than their mass in kg is very similar (in spirit) to Newton measuring the relative mass between planets, again without having a kg or a similar mass measure involved.

This means the Compton frequency of a proton is approximately 1,836 times higher than it is in an electron. We now have to count the number of protons in the Earth. This is theoretically possible, even if not practically possible (without going an indirect route). Assume we have counted the number of protons (we assume neutrons are the same for simplicity) in the Earth and found that there are approximately 3.57×10^{51} protons in the Earth. The Compton frequency (internal collision frequency) in the Earth must then be $3.57\times10^{51}\times\frac{c}{\bar{\lambda}_e}\times1,836\approx5.089\times10^{75}$ times per second. This means the Compton wavelength of the Earth is $\bar{\lambda}\approx\frac{c}{5.089\times10^{75}}\approx5.89\times10^{-68}\quad m$. Take note that we found this without relying on the Planck constant, and therefore we have totally avoided the kg definition of mass. The speed of light is known. The pendulum time on a 25 cm pendulum we measure to be about 1 second. We can now input this in our formula, and if the formula is based on sound logic, it should give an accurate value of the Planck time

$$t_p \quad = \quad \frac{2\pi\times6371000\sqrt{0.25\times\bar{\lambda}}}{c^2\times1}\approx5.4\times10^{-44}\ s \tag{11}$$

which is the well-known Planck time. In other words, we have mathematically proven that a pendulum clock can be used to find the smallest time unit without any knowledge of G or the Planck constant. Of course, we never could have counted the number of protons in the Earth in practice. However, there exist simple indirect ways to do so. We could use a Cavendish apparatus to measure the Schwarzschild radius of a lead ball. To do this also requires no knowledge of G or the Planck constant. The formula is given by

$$r_s=\frac{L4\pi^2R^2\theta}{c^2T^2} \tag{12}$$

This is the Schwarzschild radius from the large lead ball in a Cavendish apparatus. Again G or $\hbar$ not needed. Now we can count the number of protons in the large lead ball. This is also, a practical challenge, but theoretically possible. Alternatively, we can use the Planck constant. Assume our large lead ball is half a kg; the Compton frequency in half a kg is given by $f=\frac{c}{\frac{\hbar}{mc}}=\frac{mc^2}{\hbar}$. And the Schwarzschild radius of the Earth can be found by the following formula

$$r_{s,E}=2g\frac{R^2}{c^2} \tag{13}$$

The Compton frequency in the Earth is now the Compton frequency we found in the lead ball multiplied by the Schwarzschild radius of the Earth divided by the Schwarzschild radius of the ball. So, we can easily find the Planck time and Planck length without relying on G, or even $\hbar$ if we count the number of protons with a method that does not rely on the Planck constant.

It is quite impressive that we can use a grandfather pendulum clock to indirectly measure the smallest time-interval there is. How can this be? The pendulum clock is a type of gravity clock; the pendulum periodicity is depending on gravitational acceleration. What we have extracted is the shortest possible collision time, and shortest possible length. If we want to know the aggregated collision time, we do not need to know the Compton frequency of the Earth, as this only is used to divide the total collision time into its building blocks, which are the Planck time length collisions. In other words, we evaluate the collision time of the entire Earth per shortest possible time interval, which is given by

$$r_{s,t}=\frac{8\pi^4R^2L}{c^3T^2} \tag{14}$$

where R is the radius of the Earth, T is the measured pendulum oscillation time, L is the length of the pendulum, and c is the speed of light. This is simply half the Schwarzschild radius divided by the speed of light.

But why can we measure the Schwarzschild radius of the Earth only using a grandfather pendulum clock? Is the Schwarzschild radius not related to black holes, where all the mass is pulled inside a black hole within the Schwarzschild radius that only is 8mm for the Earth? We actually question the view that the Schwarzschild radius is related to black holes. We think the Schwarzschild radius is the collision length of indivisible particles making up the gravity object. This indivisible particle is incredibly small, but it is the most important of all elements, as the essential building block of energy and mass.

3 Conclusion

We have shown how a simple grandfather clock (a pendulum clock) can be used to measure the shortest time interval there is, namely the Planck time. This can be done with no knowledge of G or the Planck constant. Without the Planck constant, it is difficult at a practical level, but fully possible in principle, albeit it would be a very expensive experiment. If we take advantage of the Planck constant, we can easily do it in practice. This shows that the so-called Newton gravitational constant is not essential for finding the Planck units and the Planck constant is not needed for gravity if one redefines mass in a model that takes into account what likely to be the most fundamental form of mass, namely an indivisible particle.

It is also worth mentioning that Newton never invented or used a gravitational constant. We claim that Newton's original theory is, in many ways, superior to today's modified version of his formula. The ancient formula made one wonder what mass truly was, and we now simply assume we know what mass is. The mass should be relative to the Planck mass that, in reality, likely is a collision between two indivisible particles. To relate the mass to an arbitrary quantity like the kg and, in addition, failing to truly grasp mass at a deeper level has caused much confusion and constrained progress and understanding in physics. Mass is, as suggested by Newton himself, directly linked to an indivisible particle, which we claim has a diameter equal to the Planck length. This is one of a series of papers strongly supporting this view.

In conclusion, we assert that in principle, we can measure the smallest possible time not with a i-Phone, an atomic clock, or even the most advanced optical clock, but rather with an old fashioned grandfather pendulum clock and. The key difference is that the grandfather clock is a gravity clock and the shortest time interval is directly linked to the building blocks of mass, which are in turn linked to gravity.

Appendix: Finding the Compton Wavelength of the Electron

There are several ways to find the Compton wavelength of the electron, one way is to use Compton scattering. The Compton scattering method has the advantage that it needs no knowledge of the Planck constant to find the Compton wave. Another method to find the Compton wavelength of the electron is to watch the hydrogen spectral lines. The Compton wavelength of the electron is linked to the spectral lines with the following formula

$$\lambda_e = \lambda\left(\frac{1}{\sqrt{1-\alpha^2/n_1^2}}-\frac{1}{\sqrt{1-\alpha^2/n_2^2}}\right) \tag{15}$$

This method also requires that we know the fine structure constant, which likely means that we also need to know the Planck constant. For hydrogen-like atoms with elements above $z > 1$, the following formula can be used to find the Compton wavelength

$$\lambda_e = \lambda\left(\frac{1}{\sqrt{1-(z\alpha/n_1)^2}}-\frac{1}{\sqrt{1-(z\alpha/n_2)^2}}\right) \tag{16}$$

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