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PAPER

Finding the Planck length multiplied by the speed of light without any knowledge of G, c, or $\hbar$, using a Newton force spring

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Abstract

In this paper, we show how one can find the Planck length multiplied by the speed of light, $l_p c$, from a Newton force spring with no knowledge of the Newton gravitational constant G, the speed of light c, or the Planck constant h. This is remarkable, as for more than a hundred years, modern physics has assumed that one needs to know G, c, and the Planck constant in order to find any of the Planck units. We also show how to find other Planck units using the same method. To find the Planck time and the Planck length, one also needs to know the speed of light. To find the Planck mass and the Planck energy in their normal units, we need to know the Planck constant, something we will discuss in this paper. For these measurements, we do not need any knowledge of the Newton gravitational constant. It can be shown that the Planck length times the speed of light requires less information than any other Planck unit; in fact, it needs no knowledge of any fundamental constant to be measured. This is a revolutionary concept and strengthens the case for recent discoveries in quantum gravity theory completed by (Haug 2020 *Phys. Essays* **33** 46–78).

1. Background on Planck units

In 1899, Max Planck [1, 2] first published his hypothesis on the Planck units. He assumed there were three essential universal and fundamental constants, namely the speed of light c, the Newton gravitational constant G, and the Planck constant h, which is equal to the reduced Planck constant multiplied by 2π. Based on dimensional analysis, he then derived what he thought could be fundamental units for mass, energy, length, and time; known as the Planck units, they were given by $m_p = \sqrt{\frac{\hbar c}{G}}$, $E_p = \sqrt{\frac{\hbar c^5}{G}}$, $l_p = \sqrt{\frac{G\hbar}{c^3}}$, and $t_p = \sqrt{\frac{G\hbar}{c^5}}$. What is important here is that we see all of these Planck units require the three universal constants, a view held to this day.

In this paper, we will challenge this view, and basically prove that in order to find the Planck length times the speed of light, we need no knowledge of these constants at all. Based on Planck's original analysis, if we take the Planck length times the speed of light, this would be $l_p c = \sqrt{\frac{G\hbar}{c}}$, so this is still dependent on the three universal constants.

Our finding, which we will show in the next sections, takes a divergent approach, in particular since the Planck scale is assumed to be essential for several theories of quantum gravity. However, most physicists have argued that the Planck scale cannot actually be detected, or is so difficult to detect that we do not have any experiments showing evidence of the Planck scale, at least according to the standard view. Recently, Haug [3] has introduced a new quantum gravity theory, which predicts that gravity itself is Lorentz symmetry breakdown at the Planck scale, and shows that the Planck scale can be detected by almost any gravity observation. This also seems to offer a way to unify with quantum mechanics.

This paper will give strong support to that theory by demonstrating that the Planck length multiplied by the speed of light can be extracted from a simple Newton force spring without any knowledge of G, $\hbar$, or even c. We will claim this is revolutionary, as it strongly points to a quantized quantum gravity theory that can be detected in basically any gravity phenomena. Naturally the reader is encouraged to be critical and check our arguments and derivations carefully. However, we also note that on unresolved questions and paradoxes in physics, in particular, it is important to consider new approaches and fresh thinking with an open mind. Rigid thinking and prejudice against alternative viewpoints can slow the progress of physics down, while robust and thoughtful criticism can, of course, be quite useful. We hope the physics community will find this topic to be of interest for closer study; the findings can be tested experimentally and can also be evaluated from a theoretical standpoint.

2. Background on the Compton wavelength

Since the Compton wavelength will be an essential input, it is important to understand some background on it and its relation to mass. Here we will cover the Compton wavelength in depth, based on investigations over many years. We will demonstrate how one can, in theory, find the Compton wavelength for any mass without knowledge of the Planck constant, or of the mass of the object in kg.

First of all, any rest-mass in kg can be described as

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

where h is the Planck constant, $\hbar$ is the reduced Planck constant, and λ and $\bar{\lambda}$ are the Compton wavelength and the reduced Compton wavelength, respectively. The Compton wavelength of an electron can be found by Compton scattering without any knowledge of the electron mass, see [4]. This is simply used to solve the Compton wavelength formula $\lambda = \frac{h}{mc}$ with respect to m. All masses are built of atoms that again consist of more elementary particles, so a composite mass will consist of many elementary particles that each have a Compton wavelength. These Compton wavelengths can be aggregated by the following formula

$$\lambda = \frac{1}{\sum_i^n \frac{1}{\lambda_i}} \tag{2}$$

and the same rule applies for the reduced Compton wavelengths

$$\bar{\lambda} = \frac{1}{\sum_i^n \frac{1}{\bar{\lambda}_i}} \tag{3}$$

where n is the number of fundamental particles in the composite mass. This addition rule is not in conflict with standard addition of mass; rather, it actually gives, or we can say is fully consistent with the standard addition of mass. So, the aggregated composite mass M consists of smaller masses m_i (particles) in the following standard way $M = \sum_i^n m_i$. This means if we know the Planck constant and the speed of light, we only need to know the Compton wavelength of that mass to know its mass in kg. Even if the Compton wavelength of a composite mass does not exist, it is a number that contains information about the aggregated Compton wavelengths of all particles in the mass.

Compton scattering consists of shooting a photon at an electron, and is based on measuring the wavelength of the photon before and after the impact on the electron. The original Compton scattering formula, as given by Compton, was

$$\lambda_1 - \lambda_2 = \frac{h}{mc}(1 - \cos\theta). \tag{4}$$

where λ_1 is the wavelength of the photon sent out, that is, before it hits the electron, λ_2 is the wavelength of the photon after it has hit the electron, and θ is the angle between the incoming and outgoing beams of light. Further, m_e is the electron mass, and h is the Planck constant. However, since $\lambda = \frac{h}{mc}$, and also because any mass can be written as $m = \frac{h}{\lambda}\frac{1}{c}$, we can rewrite this as

$$\begin{aligned} \lambda_1 - \lambda_2 &= \frac{h}{mc}(1 - \cos\theta) \\ \lambda_1 - \lambda_2 &= \frac{h}{\frac{h}{\lambda_e}\frac{1}{c}c}(1 - \cos\theta) \\ \lambda_1 - \lambda_2 &= \lambda_e(1 - \cos\theta) \\ \lambda_e &= \frac{\lambda_1 - \lambda_2}{1 - \cos\theta} \end{aligned} \tag{5}$$

where λ_e is the Compton length of the electron that is found by shooting a photon at an electron. If we know the Planck constant h and the speed of light, then all we need to do to find the mass of an electron is a Compton scattering experiment, as shown by Prasannakumar *et al* [5], for example. Yet, to find the Compton wavelength of the electron, we do not need knowledge of the Planck constant, or the speed of light, as shown in formula 5.

Extending on this analysis, the cyclotron frequencies in masses are directly inversely proportional to their Compton wavelengths. A mass (a particle, for example) with twice the cyclotron frequency has half the Compton wavelength of the other particle. We have that

$$\frac{\bar{\lambda}_1}{\bar{\lambda}_2} = \frac{f_2}{f_1} = \frac{m_2}{m_1} \tag{6}$$

where f_1 and f_2 are the cyclotron frequencies of mass one and mass two. Thus, if one knows the cyclotron frequency ratio of different particles, such as protons and electrons, then one also knows their relative Compton wavelength ratio. For example, [6, 7] used cyclotron resonance experiments to find that the proton to electron mass ratio, m_P/m_e, was about 1836.152 47. The angular cyclotron velocity is given by

$$\omega = \frac{v}{r} = \frac{qB}{m} \tag{7}$$

and since electrons and protons have the same charge, the cyclotron ratio is given by

$$\frac{\omega_P}{\omega_e} = \frac{\frac{qB}{m_P}}{\frac{qB}{m_e}} = \frac{m_e}{m_P} = \frac{\lambda_P}{\lambda_e} \tag{8}$$

This means we can find the Compton wavelength of the proton without any knowledge of the mass of the proton, or even knowledge of the Planck constant. Next, in order to find the Compton wavelength of a larger mass, one kg, for example, we can count the number of protons in one kg. Naturally, this is far from easy in practice, but it is not impossible. If we know the Planck constant, we can do do this more easily by using the Compton wavelength formula for any mass, even composite masses. So, as an example, for one kg we have

$$\lambda_{1\ kg} = \frac{h}{1\ kg \times c} = \frac{h}{c} \approx 2.21 \times 10^{-42}\text{m} \tag{9}$$

Again, this is a Compton wavelength that does not exist in practice; it is the sum of the Compton wavelengths for all the subatomic particles that make up one kg.

3. Finding the Planck length times the speed of light from a Newton spring

In 1678, Robert Hooke [8] published the following relation for a spring

$$F = kx \tag{10}$$

where k is the spring constant and x is the amount by which the end of the spring was displaced from its 'relaxed' position (when it is not being stretched). Further, the harmonic oscillator function of a spring is given by (the spring frequency)

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} \tag{11}$$

where m is the mass attached to the end of a spring. Based on Haug's [3] recent insight in quantum gravity, we can easily show that we must have

$$l_p c = R\sqrt{\frac{kx\lambda}{2\pi m}} = R\sqrt{\frac{g\lambda}{2\pi}} \tag{12}$$

that is. to find the Planck length multiplied by the speed of light, we only need to know the spring constant k, the spring displacement x, and the mass m; $\bar{\lambda}$ is the reduced Compton wavelength of the gravity object. Further, R is the radius of the gravity object, that is, from the center of the gravity object to where the measurement is performed. If it is done on the surface of the Earth, this is simply the Earth's radius. We have claimed that the Planck length times the speed of light can be found independent of knowledge of the value of G, $\hbar$, and c, so we need to demonstrate that the inputs can be found without any knowledge of them as well.

We can find the kg weight of the mass m simply by weighing it on a calibrated scale. We could also take the old *kg* in Paris and put both of them on an old fashioned scale, and thereby find the weight in kg of the mass attached to the end of the spring. Next we can measure the spring displacement x by hanging the mass m on the spring. We then will measure how much the spring extends. Next, the spring constant is given by

$$k = \frac{F}{x} = \frac{G\frac{Mm}{R^2}}{x} = \frac{gm}{x} \tag{13}$$

where g is the gravitational acceleration, which is about $9.81 m/s^2$. This can be found from the Newton force spring by

$$g = 4\pi^2 x f^2 \quad (14)$$

where x is the spring displacement and f is the spring frequency; both are easily measured without any knowledge of G, $\hbar$, or c. Here we have already found m and x, so now we also have the spring constant. The last thing we need to find is the reduced Compton wavelength of the Earth. This we can do independent of any knowledge of the mass of the Earth by using the methodology described in the first section of this paper. First, we will measure the Compton wavelength of an electron, simply by measuring the wavelength of a photon before and after it hits the electron and taking the angle between the ingoing and outgoing photon. Second, since the cyclotron frequency is proportional to the Compton wavelength, we can find the ratio of the Compton wavelength of the proton relative to that of the electron by a cyclotron experiment. This also requires no knowledge of the mass, or the Planck constant, or the speed of light, as demonstrated in section one. We now have the Compton wavelength of a proton. Next, we could count the number of protons in the Earth, though obviously this would be a very costly, if not impossible task in practice. Luckily, there is a much more practical way to accomplish this task. Since the Compton wavelength of two masses is inversely proportional to the gravitational acceleration field ratio of the masses, we must have

$$\frac{\lambda_1}{\lambda_2} = \frac{g_2 R_2^2}{g_1 R_1^2} \quad (15)$$

where λ_1 and λ_2 are the Compton wavelengths of mass one and two, and g_1 and g_2 are the gravitational acceleration fields of the two masses, and R_1 and R_2 are the distances from the centers of the two masses used in the gravity observations). We have already found the gravitational acceleration field of the Earth using the Newton force spring, and to find the gravitational acceleration from a small gravitational object, we can use a Cavendish apparatus (see figure 1); the derivation gives

$$g_c = \frac{4\pi^2 L}{T^2}\theta \quad (16)$$

where L is the length between the two small balls in the Cavendish apparatus, T is the oscillation periodicity of the movable arm in the Cavendish apparatus, and θ is the measured displacement angle from the rest position to the position to which the arm moves, . As $T = \frac{1}{f_2}$ where f_2 is the oscillation frequency in the Cavendish apparatus, we see that the main difference between formula 14 and formula 16 is the angle θ, and naturally that L is the length of the bar in the Cavendish apparatus, and x is the displacement of the spring. Still, we see that the two formulas are very similar structurally: in the Newton force spring, we do not need to know any angle. In the small object, we can technically count the number of atoms; this is of particular relevance with the recent progress in silicon spheres being used count the number of atoms, see Becker [9] and Bartl *et al* [10]. We then know the number of protons (and for simplicity we assume that neutrons have the same Compton wavelength), and we can find the Compton wavelength of the proton with no knowledge of $\hbar$ or c using the cyclotron frequency relative to the electron. All inputs to the Planck time formula (formula 12) can be found without knowledge of G, $\hbar$, or the speed of light.

4. Other Planck units from the Newton spring

The Planck length is given by

$$l_p = \frac{R}{c}\sqrt{\frac{kx\lambda}{2\pi m}} \quad (17)$$

which is trivial mathematically, but we see that in order to find the Planck length, we need to know one more constant compared to what we needed when finding the Planck length multiplied by the speed of light. We can naturally (and luckily) measure the speed of light independent of any gravity experiment. So, this means we can find the Planck length independent of G and $\hbar$. In keeping with the discussion above, Haug has shown how the Planck length can be found independent of G using a Cavendish apparatus, see in particular the appendix in [11]; this paper extends that work further.

The Planck time is given by

$$t_p = \frac{R}{c^2}\sqrt{\frac{kx\lambda}{2\pi m}} \quad (18)$$

As we can measure the speed of light independent of gravity, this means we can find the Planck length with no knowledge of any fundamental constant except for the speed of light.

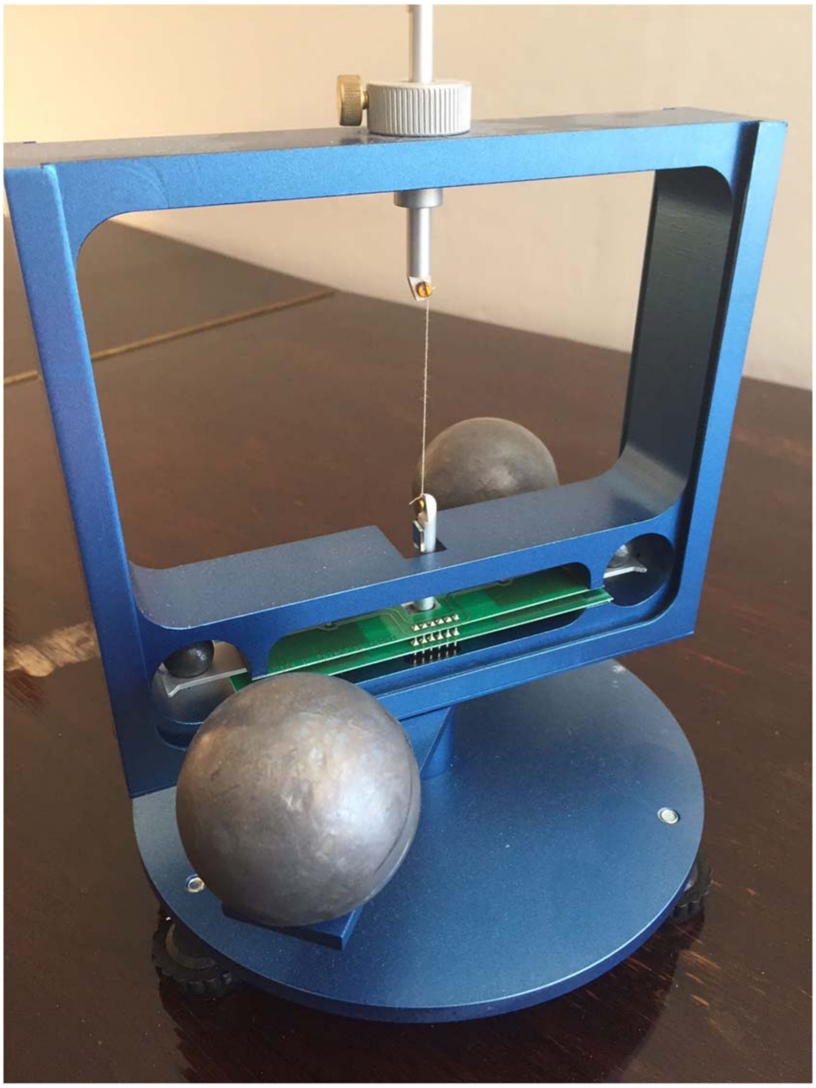

Figure 1. A low-budget modern Cavendish apparatus combining old mechanics with modern electronics that feeds directly to your computer through a USB cable.

The Planck mass is given by

$$m_p = \frac{\hbar}{R}\sqrt{\frac{2\pi m}{kx\lambda}} \tag{19}$$

Interestingly, we see that to find the Planck mass, we need to know one more constant than to know the Planck length multiplied by the speed of light; we need to know the Planck constant as well. This is, in our view, simply because the mass definition is linked to an arbitrary clump of matter known as the kg. As explained by Haug in [3] a more fundamental mass measure can be used, but we will leave that discussion to the other paper.

The Planck energy is given by

$$E_p = \frac{\hbar c^2}{R}\sqrt{\frac{2\pi m}{kx\lambda}} \tag{20}$$

Here we can see that to find the Planck energy, we need to know two more constants than we did to determine the Planck length times the speed of light; here we need to know the Planck constant and the speed of light.

The speed of light is given by

$$c = \frac{R}{l_p}\sqrt{\frac{kx\lambda}{2\pi m}} \tag{21}$$

and to find the speed of light (gravity), we need to know one more constant than we did to know the Planck length times the speed of light; here we need to know the Planck length as well.

It is worth mentioning that the Planck length times the speed of light, $l_p c = R\sqrt{\frac{kx\lambda}{2\pi m}} = R\sqrt{\frac{g\lambda}{2\pi}}$ is the 'unit' that requires the minimum amount of information. It needs no information about any other physical constants. It does need the spring constant, but the spring constant itself needs no constants to be found, as it is given by $\frac{gm}{x}$, and we have shown how g can easily be measured by the same Newton spring force with no knowledge about any constants. The Planck length times the speed of light, we will claim, contains the two most important fundamental constants for gravity, namely the Planck length and the speed of gravity (light), c. We think this is highly significant for quantum gravity theories. This means that even in a weak gravitational field, we can measure the Planck length times the speed of gravity (light) with no knowledge of constants that are assumed to be important for knowledge of gravity, namely G and the speed of gravity $c_g = c$.

As shown previously in this paper, we do not even need knowledge of the small mass m, as the formulas above can be simplified further. We have that the Planck length times the speed of light is given by

$$l_p c = R\sqrt{\frac{kx\lambda}{2\pi m}} = R\sqrt{\frac{g\lambda}{2\pi}} = Rf\sqrt{2\pi x\lambda} \tag{22}$$

whereas before f is the spring frequency and x is the spring displacement.

The Planck length is given by

$$l_p = \frac{R}{c}\sqrt{\frac{kx\lambda}{2\pi m}} = \frac{R}{c}\sqrt{\frac{g\lambda}{2\pi}} = \frac{Rf}{c}\sqrt{2\pi x\lambda} \tag{23}$$

The Planck time is given by

$$t_p = \frac{R}{c^2}\sqrt{\frac{kx\lambda}{2\pi m}} = \frac{R}{c^2}\sqrt{\frac{g\lambda}{2\pi}} = \frac{Rf}{c^2}\sqrt{2\pi x\lambda} \tag{24}$$

The Planck mass is given by

$$m_p = \frac{\hbar}{R}\sqrt{\frac{2\pi m}{kx\lambda}} = \frac{\hbar}{R}\sqrt{\frac{2\pi}{g\lambda}} = \frac{\hbar}{Rf}\sqrt{\frac{1}{2\pi x\lambda}} \tag{25}$$

The Planck energy is given by

$$E_p = \frac{\hbar c^2}{R}\sqrt{\frac{2\pi m}{kx\lambda}} = \frac{\hbar c^2}{Rf}\sqrt{\frac{1}{2\pi x\lambda}} \tag{26}$$

The speed of light is given by

$$c = \frac{R}{l_p}\sqrt{\frac{kx\lambda}{2\pi m}} = \frac{R}{l_p}\sqrt{\frac{g\lambda}{2\pi}} = \frac{Rf}{l_p}\sqrt{2\pi x\lambda} \tag{27}$$

We think it is a significant point that to find the speed of light, we need to know the Planck length, if measured using a Newton force spring, and to find the Planck length, we only need to know the speed of light. This strongly supports Haug's quantum gravity theory that shows the speed of light is related to how far an indivisible particle can travel while two indivisible particles collide. The diameter of these indivisible particles are the Planck length, and they travel at the speed of light. Gravity contains both of them (but not separately). To find both, we only need to find one of them.

We maintain that the Planck constant is not a true fundamental constant. It is linked to an arbitrary amount of mass, as discussed in [3]. If we instead use the more fundamental collision-time as mass and collision length as energy, then we do not need to know the Planck constant. The Planck constant is, however, essential if we want to operate with kg. The Planck constant is indeed linked to quantization of energy (and mass), but only when we want to compare this to one kg.

We could alternatively have completed the same process by using a pendulum 'clock' instead of a spring. We then have

$$l_p c = Rf_p\sqrt{2\pi L\lambda} \tag{28}$$

whereas before f_p is the pendulum clock frequency and L is the length of the pendulum, R is the radius of the Earth as we complete the measurements from the radius of the Earth.

The Planck length is given by

$$l_p = \frac{Rf_p}{c}\sqrt{2\pi L\lambda} \tag{29}$$

The Planck time is given by

$$t_p = \frac{Rf_p}{c^2}\sqrt{2\pi L\lambda} \tag{30}$$

The Planck mass is given by

$$m_p = \frac{\hbar}{Rf_p}\sqrt{\frac{1}{2\pi L\lambda}} \tag{31}$$

The Planck energy is given by

$$E_p = \frac{\hbar c^2}{Rf_p}\sqrt{\frac{1}{2\pi L\lambda}} \tag{32}$$

The speed of light is given by

$$c = \frac{Rf_p}{l_p}\sqrt{2\pi L\lambda} \tag{33}$$

From the equations, one can see that a Newton force spring and a pendulum clock have much in common; the difference is that in one method, we use the spring displacement and in the other method, we use the length of the pendulum. Both have a frequency and there is basically a form of gravity clock in both methods.

5. Is this not just a 'clever' way of getting the Planck units from G and $\hbar$ concealed?

One could ask if claiming that $l_p c = f(g, R, \bar{\lambda})$ can be obtained without any knowledge of G, c, or $\hbar$ is misleading because the set $(g, R, \bar{\lambda})$ contains information for the set (G, c, h). However, we will demonstrate why this is not the case even though it may be tempting to think so initially since we have $g = \frac{GM}{R^2}$, and therefore it seems that g must contain G. First of all, the gravitational acceleration g, can, as we have shown, easily be measured without any direct knowledge of G, $\hbar$, or c. The same holds true for the radius of the Earth, and we have also shown that the Compton wave for a proton can be found from Compton scattering of electrons plus a cyclotron. Next it is 'just' about counting the atoms in the gravitational objects. The latter is naturally a formidable task and one could question the practically of it, but it is possible, at least in theory. Our claim is that $l_p c$can be found without any knowledge of G and h, and we will demonstrate that this is more than just a transformation of units.

In order to understand why we do not need G and $\hbar$ to find the Planck length, there are a few interesting things we would like to point out. We will claim that G and $\hbar$ are, in fact, not needed in any gravitational predictions, but that the Planck length is always needed, either directly or indirectly. However, we need to study mass and gravity in more detail. First, let us look at the Compton wavelength formula again; it is given by $\lambda = \frac{h}{mc}$, and solved with respect to the rest-mass we get equation (1): $m = \frac{h}{\lambda}\frac{1}{c}$. That is, the rest-mass is now given by two constants, namely the Planck constant and the speed of light, and, in addition, one mass dependent variable, namely the Compton wavelength. Normally, it is the Broglie [12, 13] wavelength that is considered the matter wave. However, the de Broglie matter wave is mathematically undefined for a rest-mass particle, or we can claim it approaches infinity as the particles come to rest, see for example [14]. Actually, the de Broglie wave is always equal to the Compton wave[1] multiplied by $\frac{c}{v}$, but the Compton wave has the advantage that it is also well-defined for rest-mass particles, see [3]. Our point is simply that we can describe any mass in kg using the Compton wave through equation (1). So, to predict G times M from this perspective we need to know

$$GM = G\frac{h}{\lambda}\frac{1}{c} \tag{34}$$

This formula can be seen as GM broken down into constants that cannot be reduced further. It indicates that gravity is dependent on a gravitational constant and that the mass is related to quantization through the Planck constant, but that it always has a wave component expressed here through the Compton wave and the speed of light. That is, we need to know what Planck claimed to be the three most important universal constants: G, h, and c in addition to the mass dependent variable, which is the Compton wave: λ to describe GM with something closer to the quantum scale than simply GM. In this view, we assume G cannot be broken down further, but that the mass can be represented by two fundamental constants and a variable.

[1] The relativistic form of the Compton wave is $\lambda = \frac{h}{mc\gamma}$ and the relativistic form of the de Broglie wave is $\lambda_b = \frac{h}{mv\gamma}$, so we must have $\lambda_b = \lambda\frac{c}{v}$.

The Planck length, as mentioned earlier in this paper, was given by Max Planck as $l_p = \sqrt{\frac{G\hbar}{c^3}}$. If we simply solve this formula with respect to G, we get $G = \frac{l_p^2 c^3}{\hbar}$. This must be a fully valid way to write G mathematically, and [15] has suggested the Newton gravitational constant actually is a universal composite constant exactly of this form. This means that G is fully valid and it is still a universal constant, but it is composed of more fundamental constants, namely of c, l_p, and $\hbar$. However, based on the standard view one might object here, as one would claim one need to know G to find l_p. At first sight it may seem that if one tries to introduce G as a composite constant rather than a more fundamental constant, then one simply introduces a circular problem. Based on this, one can argue that G therefore must be a fundamental constant and that the Planck length and related Planck units are simply derived entities that one gets from dimensional analysis. This view is, however, only valid if we cannot measure the Planck length without knowing G, something we have already demonstrated in this paper is possible. Still, why is this so? Let's go back to the gravitational acceleration g, which can obviously be measured without any knowledge of G and the Planck constant and that is known from before. In standard physics, g is given by $g = \frac{GM}{R^2}$. So, to predict g, one needs to know G, M, and R. Since $M = \frac{h}{\lambda}\frac{1}{c}$, one could argue that one needs to know G, $\hbar$, and c in addition to the Compton wavelength and R to predict g. Interestingly, if we replace G with its composite form $G = \frac{l_p^2 c^3}{\hbar}$ and the rest-mass M with $M = \frac{h}{\lambda}\frac{1}{c}$, then we see that to know G and M individually, we need to know the Planck constant. However, in their combined product GM, the Planck constants cancel each other out.

$$GM = \frac{l_p^2 c^3}{\hbar} \times \frac{h}{\lambda}\frac{1}{c} = c^2 \frac{l_p^2}{\bar{\lambda}} \tag{35}$$

This is an important point. To find GM, we need fewer physical constants than we need to find G and M. So, to reiterate, in order to describe G and M, we need knowledge of three physical constants, namely G, the Planck constant, and the speed of light, and if we accept that G is a composite constant, then we need to know $\hbar,\ c,\ l_p$ in addition to the Compton wave to know G and M. But to know GM when we know G is a composite, we only need to know two constants, namely c and l_p in addition the Compton wave.

One could try argue that we only need to know one constant G to know GM, as we can find M independent of knowing $\hbar$ and the Compton wave. However, this is not the case from a quantum perspective. The simplest way to describe a rest-mass using constants and quantities related to modern physics concept of mass is with the following formula $m = \frac{\hbar}{\bar{\lambda}}\frac{1}{c}$, and, as we have demonstrated in section 1, this can be used to describe any mass in terms of kg. This is what is needed as an input in gravity formulas, as all observable gravity phenomena involve GM to the best of our knowledge.

To conclude, in order to know G and M separately from a quantum perspective, we need to know $G,\ h,\ c,\ \bar{\lambda}$ or $l_p,\ h,\ c,\ \bar{\lambda}$. That is, to know G and M, we need to know three constants and one variable. However, when we understand G is a composite then we only need to know $l_p,\ c,\ \bar{\lambda}$ to know GM. And $GM = c^2\frac{l_p^2}{\bar{\lambda}}$ is the essence of predicting every gravity observation as can be seen in table 1. Table 1 shows that for all observable gravity phenomena we need to know GM. Only in the gravity force itself we have $GMm = \frac{l_p^2 c^3}{\hbar}\frac{\hbar}{\bar{\lambda}_M}\frac{1}{c}\frac{\hbar}{\bar{\lambda}_m}\frac{1}{c} = c\frac{l_p^2}{\bar{\lambda}_M}\frac{\hbar}{\bar{\lambda}_m}$, and here the Planck constant does not cancel out, but the gravity force is not observable. The gravity force formula, when used to predict something observable, is always first used in derivations where always one of the two masses cancel out. For any observable gravity phenomena, we are then, as shown in the table, always left with GM. What we need to predict for observable gravity phenomena is the product of G and M and this is $c^2\frac{l_p^2}{\bar{\lambda}}$.

We [3] have recently argued that the standard mass measure is lacking some information about the mass that is essential for gravity, namely the Planck length, and that the gravity constant actually is needed to get this essence into the mass and to remove the Planck constant from the mass. This is somewhat outside the scope of this article, but can be studied in our previous article.

But how can this be? Newton naturally did not invent a composite gravity constant as the Planck length and the Planck constant was invented/discovered several hundred years after his time. Actually, Newton [16] did not introduce or use a gravity constant, as his formula was $F = \frac{Mm}{R^2}$ (stated in words only by Newton), but he was still able to predict a series of gravity phenomena from this insight, such as relative mass sizes of planets [17]. Also, Cavendish [18], who is often referred to as the first to measure the Newton gravity constant did actually not introduce it himself. The gravity constant was actually first introduced in a footnote in 1873 by Cornu and Baille [19] not long after the kg become the mass standard (see also [20]). The gravitational constant is a calibrated constant that is needed to get make gravitational formulas to fit observations when one uses a kg definition of mass. The inventors of the gravitational constant had naturally no idea that it could be expressed as a composite constant of the form $G = \frac{l_p^2 c^3}{\hbar}$, since the Planck constant and the Planck length had not been discovered yet. That something came first does not mean it is more fundamental, we will claim it often is the other way around, that one is more likely to understand the 'surface' of some natural phenomena before one understands it in more

Table 1. The table shows that any gravity observations we can observe contain GM and not GMm; GM contains and needs less information than is required to find G and M.

Essential insight:	
Gravitational constant	$G = \frac{l_p^2 c^3}{\hbar}$ (contains Planck constant)
Mass	$M = \frac{\hbar}{\bar{\lambda}} \frac{1}{c}$ (contains Planck constant)
Gravitational constant times mass	$GM = c^2 \frac{l_p^2}{\bar{\lambda}}$ (no need for Planck constant)
Non 'observable' predictions: (contains GMm)	
Gravity force	$F = G\frac{Mm}{R^2} = \frac{\hbar c}{R^2} \frac{l_p}{\bar{\lambda}_M} \frac{l_p}{\bar{\lambda}_m}$ (needs Planck constant)
Observable predictions: (contains only GM)	
Frequency Newton spring	$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi R}\sqrt{\frac{GM}{x}} = \frac{c}{2\pi R}\sqrt{\frac{l_p^2}{x\bar{\lambda}}}$
Periodicity Pendulum (clock)	$T = 2\pi\sqrt{\frac{L}{g}} = 2\pi R\sqrt{\frac{L}{GM}} = \frac{2\pi R}{c}\sqrt{\frac{L\bar{\lambda}}{l_p^2}}$
Gravity acceleration	$g = \frac{GM}{R^2} = \frac{c^2}{R^2}\frac{l_p^2}{\bar{\lambda}}$
Orbital velocity	$v_o = \sqrt{\frac{GM}{R}} = c\sqrt{\frac{l_p^2}{R\bar{\lambda}}}$
Time dilation	$T_R = T_f\sqrt{1 - \sqrt{\frac{2GM}{R}}^2 \Big/ c^2} = T_f\sqrt{1 - \frac{2l_p^2}{R\bar{\lambda}}}$
Gravitational red-shift	$z = \frac{\sqrt{1 - \frac{2GM}{R_1 c^2}}}{\sqrt{1 - \frac{2GM}{R_2 c^2}}} - 1 = \frac{\sqrt{1 - \frac{2l_p^2}{R_1\bar{\lambda}}}}{\sqrt{1 - \frac{2l_p^2}{R_2\bar{\lambda}}}} - 1$
Gravitational red-shift	$z_\infty(r) \approx \frac{GM}{c^2 R} = \frac{l_p^2}{R\bar{\lambda}}$
Gravitational deflection	$\delta = \frac{4GM}{c^2 R} = \frac{4}{R}\frac{l_p^2}{\bar{\lambda}}$
Advance of perihelion	$\frac{6\pi GM}{a(1-e^2)c^2} = \frac{6\pi}{a(1-e^2)}\frac{l_p^2}{\bar{\lambda}}$
Indirectly/'hypothetical' observable predictions: (contains only GM)	
Escape velocity	$v_e = \sqrt{\frac{2GM}{R}} = c\sqrt{2\frac{l_p^2}{R\bar{\lambda}}}$
Schwarzschild radius	$r_s = \frac{2GM}{c^2} = 2\frac{l_p^2}{\bar{\lambda}}$

depth. Most physicists appear to agree on this, as shown in the long standing search for a unified quantum gravity theory.

If the Planck length and the speed of light are the essential constants for gravity, then we should be able to predict 'all' gravitational phenomena from these constants only, in addition to variables such as R and the Compton wave. This also means the Planck length can be extracted from any gravitational phenomena. This, in our view, also strongly points to that all gravitational phenomena are linked to the Planck scale and actually serve as a detection of that scale. The standard view on quantum gravity is that it is linked to the Planck scale and to Lorentz invariance breakdown at the Planck scale; this view is also our view. Still, in the standard view, even after extensive experimental research, there does not seem to be any evidence of the Planck scale. This is mostly due to the fact that effects predicted from the Planck scale only can be observed at extremely high energies very far above what can be achieved at the Large Hadron Collider, for example. However, there has also been an extensive search for effects researchers had hoped to detect at much lower energies, without any finding indicating detection of effects happening at the Planck scale, see for example the following review article [21]. This lies in sharp contrast with our new view that observing any gravity observation also means we are detecting the Planck scale. That is, gravity is an effect of the Planck scale and this is why we can extract the Planck length from gravity observations with no knowledge of G and $\hbar$. This view may also be used to unify quantum mechanics with gravity, as we have recently suggested.

In table 1, we see that all observable gravity phenomena (listed here) contain $\frac{l_p^2}{\bar{\lambda}}$; this is identical to half of the Schwarzschild radius, $\frac{1}{2}r_s = \frac{GM}{c^2} = \frac{l_p^2}{\bar{\lambda}}$. The Schwarzschild radius is normally linked to black holes, but we see that the Schwarzschild radius is in many ways the essence of every observable gravity phenomena. This is in many ways not a big surprise, as it can be found in the Schwarzschild solution of general relativity.

6. Historical perspective on the Planck units and quantum gravity

Einstein was likely the first to point out that understanding the quantum was important for making progress on understanding gravity. In 1916, he wrote '*Because of the intra-atomic movement of electrons, the atom must radiate not only electromagnetic but also gravitational energy, if only in minute amounts. Since, in reality, this cannot be the case in nature, then it appears that the quantum theory must modify not only Maxwell's electrodynamics but also the new theory of gravitation.*' However, he did not explicitly mention the Planck units here. In addition to Max Planck's work on the Planck units, Eddington [22], in 1918, was among the first to discuss the idea that the Planck length likely played a central role in gravity. In a discussion on the Planck length, he stated: '*But it is evident that this 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, both Planck's and Eddington's view on this were initially ignored, and they were even ridiculed by Bridgman in [23], for example. For more on the background on the historical background of quantum gravity, see [24].

While many physicists today think the Planck units must play a central role in physics and quantum gravity, (see for example [25–27]), there is still strong disagreement on whether or not the Planck length is the smallest possible measurable unit, even in a thought experiment inside a sound physical framework, see [28]. This disagreement is partly rooted in the view that even after extensive testing, there have been no clear signs of the Planck scale, see [29], for example, who dismisses the Planck units as not being helpful since he claims they cannot be detected (and therefore do not exist?). On the other hand, if the Planck length can be extracted easily from a series of observable gravity phenomena without knowledge of G or even $\hbar$, this could be an important development of our perspective on the quantum level. This strongly supports the initial view of Eddington.

From a certain point of view, the fact that the reduced Compton length $\left(\bar{\lambda}_c = \frac{\hbar}{mc}\right)$ is equal to half the Schwarzschild radius $\left(\frac{1}{2}r_s = \frac{Gm}{c^2}\right)$ i.e. $\bar{\lambda}_c = r_s/2$ when the mass (m) is equal to the Planck mass (m_p), may seem to corroborate a relationship between quantum gravity, black holes (general relativity) and quantum mechanics, where the Planck constant is fundamental. However, we claim that this view would not be fully correct. We have

$$r_{s,p} = \frac{2Gm_p}{c^2} = \frac{2\frac{l_p^2 c^3}{\hbar}\frac{\hbar}{l_p}\frac{1}{c}}{c^2} = 2l_p \tag{36}$$

Again, we see the Schwarzschild radius, even for a Planck mass, does not contain any information about the Planck constant because it cancels out in GM. However, the standard formula to find it, $r_s = \frac{2Gm_p}{c^2}$, does if we know m_p. In this special case of a Planck mass, the Compton wavelength of the Planck mass is equal to the Planck length. Further, from the Schwarzschild radius of the Planck mass, we can predict any hypothetical observable gravity phenomena caused by the Planck mass. The Schwarzschild radius and the Planck mass may also have interesting relations to entropy, as first pointed out by Bekenstein [30] and later discussed by Hawking [31], for example. Still, one can ask why the Planck length can be extracted from all gravity phenomena and why the Schwarzschild radius indirectly appears in any gravity phenomena, while the Planck constant that is linked to the new kg definition of mass does not appear in any observable gravity phenomena, but only in the gravity force formula. The Planck constant is directly linked to mass through the kg definition of mass.

We think the reason for this is that G indeed is a composite universal constant that is needed to get the Planck constant out of the definition of mass and to get the Planck length into the mass. The Planck length, which is related to the particle component of all masses (in a wave-particle duality) is missing in today's mass definition, as discussed by [3].

It is also still subject of debate whether the Planck mass is also linked to a particle or not. Motz was likely the first to suggest that a particle with mass equal to the Planck mass actually existed, which he called the uniton, see [32, 33]. In 1967, Markov [34] suggested a similar particle to Motz that he called a maximon. Motz naturally understood that a particle with a mass equal to the Planck mass would be much larger than any particles ever observed. He therefore suggested that Planck mass particles had existed just after the Big Bang and then had radiated/dissolved into today's observed particles. The Planck mass has also been linked to the concept of micro black holes [35] although they have not been observed yet. We do not think it is accident that we have observed neither super massive particles with mass similar to the Planck mass (10^{-8} kg), nor micro black holes, and at the same time we have also seen no sign of the Planck scale in effects for weaker energies. Based on our recent discoveries, it is possible that we have been searching for something that already has been found indirectly and can easily be measured now.

7. Conclusion

We have shown how the Planck length times the speed of light can be measured from a Newton force spring without any knowledge of G or $\hbar$. This is remarkable, as it is assumed that the Planck length (times the speed of light) can only be found from dimensional analysis of G, c, or $\hbar$. In order to find the Planck length times the speed of light, we need no knowledge of any fundamental constants; to find the Planck length and the Planck time, we need to know the speed of light; to find the Planck mass, we need to know the Planck constant; and to find the Planck energy, we need to know the speed of light and the Planck constant. Finally, to find the speed of light, we only need to know the Planck length, but to find the Planck length, we need to know the speed of light, so this last point basically confirms that the Planck length is closely related to the speed of light (gravity). Our findings strongly support Haug's recent published unified quantum gravity theory, which predicts that all gravity is Lorentz symmetry break down at the Planck scale, and that the Planck units therefore can be extracted from simple gravity experiments with no knowledge of G. This also supports Haug's analysis that the speed of light (gravity) and the Planck length are closely connected.

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