Proof That Newton Gravity Moves at the Speed of Light and Not Instantaneous (Infinite Speed) as Thought!

Espen Gaarder Haug*

Norwegian University of Life Sciences

November 10, 2020

Abstract

In this paper, we will prove based on reasoning as well as mathematical evidence and experimental observations why Newtonian gravity moves at the speed of light and is not instantaneous as previously thought. The misunderstanding that Newton gravity is instantaneous has constrained our progress in understanding gravity to its full extent.

All of Newton's gravitational phenomena contain the Planck length and the speed of gravity; this speed of gravity is identical to the speed of light. A series of gravitational phenomena that are considered non-Newtonian and most often explained by theory of general relativity actually contain no information about the speed of gravity. However, all observable gravity phenomena can be predicted from the Planck length and the speed of gravity alone, and we can easily extract both of them from gravitational phenomena with no knowledge of any physics constants. We can also measure the speed of light from electromagnetic phenomena and then extract the Planck length from any of Newton's gravity phenomena with no knowledge of G or $\hbar$.

Key words: Speed of gravity, Planck length, Newton's gravity, general relativity.

1 Background

Newton's formula for gravitational force is well-known today as

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

where G is Newton's gravitational constant, M and m are two masses, and R is the distance center to center between the two masses. This is likely the second best known physics formula after Einstein's $E = mc^2$, so one might think there is nothing new to discover about it; however, such a view will be strongly challenged in this paper. It seems clear from the formula that gravity is a function of the masses and the distance between them. The speed of light (or any other speed) do not appear anywhere in the formula and one quickly gets the impression that Newton's gravitational force formula 1) says nothing about the speed of gravity, and 2) that it would even be inconsistent with a finite speed of gravity. This was pointed out by Good in 1975 [1], for example:

> "*We may fairly conclude that a finite rate of propagation of gravitation is inconsistent with Newton's inverse square law or any other force that is function of distance only.*"

This reflects the view held by modern physics to this day. At first glance, the argument look fully valid and sound, but as we will later see it is, in fact, flawed due to a failure to understand the Newton gravity formula in depth. Another argument often used to claim that Newton's gravitational force is instantaneous, and therefore that the speed of gravity is infinite, is from the so-called Newtonian field equation, which is derived from the Gaussian law. This is given by

$$\oiint_{\partial V} \boldsymbol{g} \cdot d\boldsymbol{A} = -4\pi G M_i \tag{2}$$

where M_i is the mass inside the Gauss surface, and $\boldsymbol{g}$ is the gravitational acceleration vector. This can also be written in differential form (the Poisson equation) as

$$\nabla^2 \phi = 4\pi G \rho \tag{3}$$

*

Here ϕ is the gravitational potential, a scalar field, and ρ is the mass density. It seems that if one changes the mass density, then the gravitational field will change instantaneously. It has, therefore, been concluded that Newtonian gravity is instantaneous, and that it implicitly assumes that the speed of gravity moves at an infinite speed; see [2], for example, who states: *"In Newton's theory of gravity, perturbations of the gravitational field propagate at infinite speed.". This view reflects the consensus in gravity among researchers in the field..* The same idea is conveyed in popular media platforms such as Wikipedia: "*In modern terms, Newtonian gravitation is described by the Poisson equation, according to which, when the mass distribution of a system changes, its gravitational field instantaneously adjusts. Therefore, the theory assumes the speed of gravity to be infinite.* ", Wikipedia 7 -Nov. We are not quoting Wikipedia for its reliability in science information, but simply to show this assumption that the speed of gravity in Newton is infinite is widespread across scientific journals and also among "popular-science" distributors.

Laplace [3] may have been the first to indicate that Newton gravity might be infinite in velocity (in 1805). In 1890, Maurice Lévy [4] was likely the first to suggest that the speed of gravity is equal to the speed of light. In addition, in 1904, Poincare [5] argued that, based on relativity theory, the speed of gravity could not be faster than the speed of light in a vacuum.

The speed of light in Einstein's [6] theory of general relativity is assumed to be the same as the speed of light in a vacuum, see also [7, 8]. For many years, there has been debate over whether the speed of gravity is the same as the speed of light, or if it is significantly different. Experimental research in recent years [9] has been able to discern the difference between the speed of gravity and the speed of light to being between -3×10^{-15} and $+7 \times 10^{-16}$ times the speed of light. Therefore, the speed of gravity is very likely to be equal to the speed of light, as predicted by general relativity. If that is the case, however, then one may ask, ?How can a theory that assumes the infinite speed of gravity still be so accurate for many gravity phenomena, particularly since Newton infinity is much higher than the speed of light. Does this mean that Newtonian gravity phenomena such as the orbital velocity of the Moon is independent, or close to independent on the velocity of gravity?? We will answer this and many other questions related to the speed of gravity in this paper.

Returning to Newton's formula for gravitational force, equation 1 is actually not the formula Newton presented. The formula he showed [10] in Principia was simply

$$F = \frac{\bar{M}\bar{m}}{R^2} \tag{4}$$

where $\bar{M}$ and $\bar{m}$ are the two masses. Here we are using a slightly different notation for mass than in equation 1 because Newton's definition of mass was not the same as the modern definition of mass. Newton actually only stated this formula through words (and not equations) in the Principia [10], which is to say, Newton never invented, nor did he use a gravitational constant. Even so, he was still able to predict such things as the relative mass between planets, see Principia and also [11]. It is often claimed that Cavendish [12] in 1798 was the first to measure Newton's gravitational constant, but in fact Cavendish did not mention, measure, or use a gravitational constant either. What is true, however, is that a Cavendish apparatus can indeed be used to find the value of the so-called Newton's gravitational constant, which was actually first introduced in 1873 by Cornu and Baille [13] in the formula $F = f\frac{Mm}{R^2}$, where f was the gravitational constant. This is basically identical to Newton's gravitational force formula as we know it today. The current notation for the gravitational constant of G was possibly first introduced by Boys in 1894 [14]. Many scientists used the notation f for the gravity constant long into the early 19th century; Max Planck, for example, employed it as late as 1928, [15]. Naturally, whether one uses the notation f or G for the gravitational constant is merely cosmetic. What is important here is that the gravitational constant first came into existence in 1873, almost two hundred years after Newton introduced his formula for gravitational force, and ?Newton's? gravitational constant is partly related to the fact that in the 1870s, a definition of mass incorporating the kg came into use internationally (in parts of the world).

Yet, it is important to understand that in 1873, there was no clear understanding of what mass was at a deeper level. Newton himself had introduced the term mass in the Principia and defined it as a quantity of matter ("quantities material"). Less known among most researchers today is that Newton held on to the view that matter ultimately consisted of indivisible particles with spatial dimension, something he claim in the third part of Principia, which is about gravity, and this was the principle behind all of his philosophy. So, mass in Newton's view had to be linked to the quantity of these particles in a given object (or clump of matter) somehow. However, these indivisible particles were extremely small, so there was no way to observe them directly. In the Principia, Newton also mentions indivisible time, or indivisible moments. All in all, it is not completely clear what mass is in Newton's theory, but he points out several times in Principa that weight is proportional to the quantity of matter; in his own words,"*I have always found that the quantity of matter to be proportional to their weight.*". So, if we know the weight of two bodies (measured at the same distance from a gravity object for example Earth) , we know their relative mass. We can easily find the relative mass of planets and the Sun, for example, using Newton's principles without any knowledge of the misnamed gravitational constant that was introduced in 1873. The mass of the Earth relative to the Sun is given by

$$\frac{M_2}{M_1} = \frac{R_1^3 T_2^2}{R_2^3 T_1^2} \tag{5}$$

where T_2 and T_1 are the orbital velocities of the Moon around the Earth, and the Earth around the Sun, for example, and R_2 is the distance from the center of the Earth to the Moon, and R_1 is the distance from the center of the Sun to the Earth. We can find the distances with parallax, which was part of the method Newton used when he found the relative mass of the planets as shown in the Principia. The orbital time of the Moon around the Earth is approximately 27 days, and the orbital time of the Earth around the Sun is 365 days; the distance of the Earth to the Moon is approximately 384 400 km, and the distance of the Earth to the Sun is approximately 149597870 km. This gives us $\frac{149597870^3\times 27^2}{384400^3\times 365^2} \approx 322,528$, which is basically the same as the well-known mass of the Sun relative to the Earth. Even in Newton's time, one could gauge the approximate diameter of the Earth and the Sun and Newton also calculated the relative density between the Earth and the Sun. In the Principia, he gives the number four, which is very close to today's measurement of 3.91. The point here is simply that we can complete many gravitational predictions using Newton's original theory, even without the gravitational constant.

However, there was still one significant challenge that Newton was not able to solve in his time: to find the density of the Earth relative to a known uniform substance, such as water, lead, or gold. It would take another hundred years or so to accomplish this, which Cavendish was able to do in 1798 by using what is known today as a Cavendish apparatus. By means of this apparatus, Cavendish could measure the gravitational effect from a clump of a known uniform material (the large balls in the apparatus), such as iron, mercury, lead or gold . Then he could find the density of the Earth relative to this clump (sphere) of uniform known substance, but again this was accomplished with no knowledge of any gravitational constant. The gravitational constant G is needed when one defines mass as kg, something we will return to soon.

As noted previously, the adjusted Newton formula with a gravitational constant was first published in 1873. Sixteen years later Max Planck [16, 17] assumed there were three universal constants, the gravity constant G, the Planck constant $\hbar$, and the speed of light c. Based on dimensional analysis, he then found a unique length $l_p = \sqrt{\frac{G\hbar}{c^3}}$, time: $t_p = \sqrt{\frac{G\hbar}{c^5}}$, and mass: $m_p = \sqrt{\frac{\hbar c}{G}}$. These are known as the Planck units today. It is worth mentioning that in 1883, Stoney [18] had already used G, and c, as well as the elementary charge and the Coulomb constant to come up with similar natural units. However, the consensus among physicists today is that the Planck units seem to be more essential than the Stoney units, a view we also hold.

After publishing his theory of general relativity theory, Einstein claimed in 1916 that a quantum gravity theory was the next natural step, or in his own words:

> *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.*

In 1922, Eddington [19] suggested that the Planck length had to play a central role in a quantum gravity theory, stating:

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

Other prominent physicists like Bridgman [20] (who received the 1946 Nobel Prize in physics) ridiculed this idea and claimed the Planck units were merely mathematical artifacts coming out of dimensional analyses, see also [21]. Today most physicists think the Planck length is the smallest possible length, see for example [22–24]. However, a minority of physicists, for example Unzicker [25] claim that the Planck units are not useful. Unzicker bases his claim on the view that "*there is not the remotest chance of testing the validity of the Planck units*". His point is reminiscent of Einstein's claim relative to the ether. If the ether cannot be detected or lead to observable predictions, then why not simply abandon it?

Still, many physicists think that the Planck units probably play an important role and have attempted to build theories incorporating them. One strain of super string theory, for example, assumes that there are only two universal fundamental constants, namely the Planck length and the speed of light [26], although such theories have not yet shown any breakthroughs in observable predictions and the jury is still out. Several quantum gravity theories predict that Lorentz symmetry will be broken at the Planck scale, see [27]. However, despite extensive experimental research, there has been no evidence of this yet. At the moment, little has changed since the introduction of the Planck units and although a series of physicists have claimed they likely play an important role, there has been no proof of this based on experimental research. It is consensus among physicists today that so far, the Planck units have only been found through dimensional analysis. However, this view has recently been challenged by Haug, who has claimed that one can easily find the Planck length from gravity observations with no prior knowledge of G or $\hbar$, see [28, 29]. If this is truly the case, then it is a breakthrough in understanding the Planck scale. As we soon will see, this is also important for understanding Newton's theory of gravity from a deeper perspective.

2 Newton's Theory of Gravity Is Only Understood from the Surface, Not in Depth

Returning to the modern version of Newton's gravitational formula, $F = G\frac{Mm}{R^2}$, before we can use this formula to predict any observable gravity phenomena we have to calibrate it to a gravity observation to find G. We can say G is the missing information in the formula that is found from calibration in order to make the formula work. When the formula is first calibrated to one gravity observation using a Cavendish apparatus, for example, then it can be used to predict a series of other observable gravity phenomena, such as orbital velocity and gravitational acceleration. We also know what units G must be in for it to be consistent with the outputs such as orbital velocity. If the mass is in kg, then G must have the following units $m^3 \cdot kg^{-1} \cdot s^{-2}$ for $v_o = \sqrt{\frac{GM}{R}}$ to come out as a velocity (length divided by time). Still, the modern Newton gravity theory does not tell us anything about what this gravity constant really represents. We know with very high probability it is a constant, and if it is calibrated to one gravity observation, it can be used to predict a series of other gravity observations very accurately. Further, it does not seem to change over time, so we can be highly confident that it is a constant. However, the universe itself does not invent constants and it is unlikely that anything in the universe consists of $m^3 \cdot kg^{-1} \cdot s^{-2}$. Is there anything directly observable that is, in fact, meters cubed times kg divided by seconds squared? Even if we not could see it, can you imagine anything in the universe with such properties? I cannot. However, I can imagine something with a length, for example my shoes. I can imagine something with weight, like my shoes. I can imagine a speed, as this is simply how far something have moved during a selected upon duration. But I cannot imagine anything that is $m^3 \cdot kg^{-1} \cdot s^{-2}$. Our point is simply that there could be something more fundamental behind G, that G is simply what is missing in the gravity formula when we have decided to define mass as kg. Further, although this is missing, whatever it may be, it can be found indirectly by calibrating the model to gravitational observations. We could also point to the kg masses M and m in the modern Newton formula, and ask, ?What exactly do they represent?? We could also ask, ?What is a kg?? But even though the kg definition did not exist in Newton's time, Newton was clear on the idea that weight is proportional to mass, and mass is a quantity of matter. We could even delve deeper and ask, ?What is matter?? Today, we have a partial understanding that matter has particle-wave duality properties. So, when we write GMm/R^2, we can say this is just a formula that we partly understand, and that fits observations. An important question is: Whether or not we can understand the formula from a deeper perspective and thereby get new insight into the formula and gravity itself. As we will see, we believe we can do so!

Looking at the predictions from Newton's gravity formula, Table 1 show a series of observable and several non-observable gravity phenomena.

Gravity force	$F = G\frac{Mm}{R^2}$
Field equation	$\nabla^2\phi == 4\pi G\rho$
Observable Predictions:	**Formula:**
Gravity acceleration	$g = \frac{GM}{R^2}$
Orbital velocity	$v_o = \sqrt{\frac{GM}{R}}$
Orbital time	$T = \frac{2\pi R}{\sqrt{\frac{GM}{R}}}$
Velocity ball Newton cradle	$v_{out} = \sqrt{2\frac{GM}{r^2}H}$
Frequency Newton spring	$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi R}\sqrt{\frac{GM}{x}}$
Periodicity pendulum (clock)[a]	$T = 2\pi\sqrt{\frac{L}{g}} = T = 2\pi R\sqrt{\frac{L}{GM}}$
Non-Observable Predictions:	**Formula:**
Escape velocity	$v_e = \sqrt{\frac{2GM}{R}}$

Table 1: The table shows a series of gravity effects that can be predicted from Newton's formula. As expected, the speed of light (gravity) does not appear in any of the formulas.

[a]This was actually derived by Huygens [30] some years before Newton.

Also, in none of these formulas can we see the speed of light. This is not surprising, as all of these formulas can be derived from Newton's force formula. But again, what does G truly represent? And what is a mass from a deeper perspective? As stated by Prof. Jammer [31] in his work on mass "mass is a mess," his point is that we still do not really understand what mass is.

3 Extracting the speed of light(gravity) times half the Schwarzschild radius from Newton type gravity observations with no prior knowledge of any gravity phenomena

In Table 2, we can see that all of Newton's gravity phenomena only are a function of the speed of light c (gravity?) and the Schwarzschild radius, as well as such variables as the distance to the center of the gravity object, R, or the length of a pendulum, and L, or the height we are dropping a ball in a Newton cradle from.

Gravity force	$F = G\frac{Mm}{R^2}$
Field equation	$\nabla^2\phi == 4\pi G\rho$
Observable Predictions:	**Formula:**
Gravity acceleration	$g = \frac{GM}{R^2} = \frac{1}{2}r_s\frac{c^2}{R^2}$
Orbital time	$T = \frac{2\pi R}{\sqrt{\frac{GM}{R}}} = \frac{2\pi}{c_g\sqrt{\frac{1}{2}\frac{r_s}{R}}}$
Orbital velocity	$v_o = \sqrt{\frac{GM}{R}} = c_g\sqrt{\frac{1}{2}\frac{r_s}{R}}$
Velocity ball Newton cradle	$v_{out} = \sqrt{2\frac{GM}{r^2}H} = c_g\sqrt{\frac{r_s}{R^2}}$
Frequency Newton spring	$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi R}\sqrt{\frac{GM}{x}} = \frac{c_g}{2\pi R}\sqrt{\frac{r_s}{x}}$
Periodicity pendulum (clock)[a]	$T = 2\pi\sqrt{\frac{L}{g}} = T = 2\pi R\sqrt{\frac{L}{GM}} = \frac{2\pi R}{c_g}\sqrt{\frac{L}{\frac{1}{2}r_s}}$
Non-Observable Predictions:	**Formula:**
Escape velocity	$v_e = \sqrt{\frac{2GM}{R}} = c_g\sqrt{\frac{r_s}{R}}$

Table 2: The table shows a series of gravity effects that can be predicted from Newton's formula. However, we have rewritten this and shown that they can be written as a function of the speed of gravity c_g and half of the Schwarzschild radius.

[a]This was actually derived by Huygens [30] some years before Newton.

The Schwarzschild radius is, by general relativity theory, given by $r_s = \frac{2GM}{c^2}$. That is, if we need to predict it from other gravity phenomena where we already have calibrated and found G, we need to know the kg mass of the gravity object and the speed of light as well. However, one can also find the Schwarzschild radius directly from gravitational observations with no knowledge of G, c, or M. If we observe the light bending from the Sun, for example, we will find that light is bent by 1.75 arcseconds, as first observed by Eddington [32]. Then from this observation with no knowledge of G, c, or even M, we can find the Schwarzschild radius to be $r_s = \frac{\delta R}{2}$. This means the Schwarzschild radius of the Sun is

$$r_s = \frac{1.75 \times \pi/648000 \times 696340000}{2} \approx 2,954\ m$$

, extracted directly from an observation, and not predicted based on prior knowledge of G, c, and M.

We can now just observe the orbital velocity of the Earth around the Sun $v_0 = \frac{2\pi R}{T}$, where T is the orbital time of the Earth, 365 days, and $R = 149600000000\ m$ is the distance from the Earth to the Sun.

$$c_g = \frac{2\pi R}{T\sqrt{\frac{1}{2}\frac{r_s}{R}}} = \frac{2\pi \times 149600000000}{365 \times 24 \times 60 \times 60 \times \sqrt{1/2 \times \frac{2,954}{149600000000}}} \approx 299,973,934 \approx c \tag{6}$$

That is, we have found the speed of gravity from a Newtonian observation, namely the orbital velocity of the Earth, combined with a length we found from the gravity deflection of the Sun. The small difference between this estimated speed and the speed of light is due to measurement errors. The same we can do from all Newton gravity phenomena, but we do need to combine this with observations that supposedly only have been predicted by GR; we have extracted the speed of gravity from observing gravity phenomena only. As we will demonstrate, all of Newton's gravity phenomena (at least the ones in the table above) contain both the speed of gravity and the Schwarzschild radius, and the Schwarzschild radius, as we will later see, is directly linked to the Planck length.

That all Newton gravity phenomena contains the speed of light (gravity) embedded, should be an eye opener. Some will possibly claim we are using just a mathematical trick here, since we are relying on the Schwarzschild radius which theoretically is given by $r_s = \frac{2GM}{c^2}$. So, are we not simply taking something that is related to GR, where the speed of gravity is indeed assumed to be $c_g = c$ and therefore able to get c_g from GR? We will demonstrate that such a view is wrong. First of all, we are not using any GR predictions, we are just using an observation from the Sun's deflection of light. Second, the c^2 in the GR formula to predict deflection, or the

Gravity force Field equation	$F = G\frac{Mm}{R^2}$ $\nabla^2\phi = 4\pi G\rho$
Observable Predictions:	**Formula:**
Gravity acceleration	$c_g = R\sqrt{\frac{g}{1/2r_s}}$
Orbital time	$c_g = \frac{2\pi}{T\sqrt{\frac{1}{2}\frac{r_s}{R^3}}}$
Orbital velocity	$c_g = v_o\sqrt{\frac{2R}{r_s}}$
Velocity ball Newton cradle	$c_g = v_{out}\sqrt{\frac{R^2}{r_s^2}}$
Frequency Newton spring	$c_g = \frac{2\pi f}{\sqrt{\frac{r_s}{x}}}$
Periodicity pendulum (clock)	$c_g = \frac{2\pi R}{T}\sqrt{\frac{L}{\frac{1}{2}r_s}}$
Combined with deflection:	**Formula:**
Gravity acceleration	$c_g = R\sqrt{\frac{g}{\delta R}}$
Orbital time	$c_g = \frac{2\pi}{T\sqrt{\frac{1}{2}\frac{\delta}{R^2}}}$
Orbital velocity	$c_g = v_o\sqrt{\frac{2}{\delta}}$
Velocity ball Newton cradle	$c_g = v_{out}\sqrt{\frac{1}{\delta^2}}$
Frequency Newton spring	$c_g = \frac{2\pi f}{\sqrt{\frac{\delta R}{x}}}$
Periodicity pendulum (clock)	$c_g = \frac{2\pi R}{T}\sqrt{\frac{L}{\delta R}}$
Combined with red-shift:	**Formula:**
Gravity acceleration	$c_g \approx R\sqrt{\frac{g}{\frac{R_1 R_2 Z}{R_1 - R_2 + R_1 Z}}}$
Orbital velocity	$c_g \approx v_o\sqrt{\frac{R_1 - R_2 + R_1 Z}{R_2 Z}}$
Velocity ball Newton cradle	$c_g \approx v_{out}\sqrt{\frac{R^2}{\left(\frac{2R_1 R_2 Z}{R_1 - R_2 + R_1 Z}\right)^2}}$
Frequency Newton spring	$c_g \approx \frac{2\pi f}{\sqrt{\frac{r_s}{x}}}$
Periodicity pendulum (clock)	$c_g \approx \frac{2\pi R}{T}\sqrt{\frac{L}{\frac{R_1 R_2 Z}{R_1 - R_2 + R_1 Z}}}$

Table 3: The table shows how we can extract the speed of gravity from a series of gravity phenomena by combining two gravity observations without any knowledge of any physical constants..

Schwarzschild radius is used to get the speed of light out of the formula, not into the formula; this is because both G and M contains the speed of light (gravity) embedded, something we soon will discuss. One can already get a good intuition about this because all of the Newtonian observational phenomena are directly or indirectly linked to velocity. The orbital velocity, the escape velocity, the periodicity of a pendulum, and the orbital time are all linked to velocity, so it would not be surprising if these velocities were linked to a more fundamental velocity, namely the speed of light (gravity). On the other hand, light deflection is an angle, and the Schwarzschild radius is a length only, so why should these contain the speed of light (gravity)? We will quickly go through a few more ways to find the Schwarzschild radius without knowledge of any physical constants.

The gravitational red-shift is given by

$$z = \frac{\sqrt{1 - \frac{r_s}{R_1}}}{\sqrt{1 - \frac{r_s}{R_2}}} - 1 \tag{7}$$

Solved with respect to the Schwarzschild radius, this gives

$$r_s = \frac{R_1 R_2 Z(2 + Z))}{R_1 - R_2 + 2R_1 Z + R_1 Z^2} \tag{8}$$

in a weak gravitational field, we have the very good approximation

$$r_s \approx \frac{2R_1 R_2 Z}{R_1 - R_2 + R_1 Z} \tag{9}$$

And since "all" we need to find the speed of gravity from a Newton observable gravity phenomenon is to get the Schwarzschild radius out of the observational values. In the last section of Table 3, we have combined observations of standard Newton gravity phenomena with observations of red-shift. This will give us the speed of gravity. Again, the reason we have to combine two gravitational phenomena to find c_g is that we need a gravity phenomenon that depends on and therefore contains information about the speed of gravity in addition to another gravity phenomena that does not depend on the speed of gravity, like gravitational deflection and gravitational red-shift. As stated before, we can indeed extract the speed of gravity from all these phenomena with no prior knowledge of G, c, or $\hbar$ or the kg mass of the object in question. This alone is very important, and again this strongly points towards the idea that Newtonian phenomena contain the speed of gravity. Further, the speed of gravity we can extract this way is very close to the speed of light, only measurement errors likely make it inexact.

4 The Newton Gravity Constant Must be a Universal Composite Constant

The Planck length is given by the Planck formula to be $l_p = \sqrt{\frac{G}{c^3\hbar}}$. There is nothing mathematically wrong by solving this with respect to G, which gives

$$G = \frac{l_p^2 c^3}{\hbar} \tag{10}$$

Many will here likely protest, as they will claim the only way to find the Planck length is from first knowing G, and then to make G a function of l_p, will just lead to a circular problem. However, if one can find the Planck length totally independent of any knowledge of G, then there is no such circular problem. We will demonstrate here that we can find the Planck length independent of any knowledge of G, and even without any knowledge of G, $\hbar$, or c. Still, it would not be totally absurd to claim that G is a composite constant, as one clearly did not know anything about the Planck constant or the Planck length when G was introduced in 1873. However, even if the Newton formula when used to gather with kg mass definition of mass missed the value of several constants, there is nothing wrong in claiming all these constants where found as a composite value from calibration without knowing so. That is, if they could be extracted from gravity. That is, assume we in reality have

$$F = \frac{l_p c^3}{\hbar}\frac{Mm}{R^2} \tag{11}$$

then we could set $x = \frac{l_p c^3}{\hbar}$ and then have $F = x\frac{Mm}{R^2}$, basically the exact Newton formula and then simply see if we could calibrate the unknown x to a gravity phenomenon with a Cavendish apparatus. Then see if we then could use the formula now with a calibrated value of x to predict other gravitational phenomena. If it works, it possibly indicates that we found the value of l_p, c, and $\hbar$ in the calibration, but not their separate values, rather their values as a composite. This would mean one does not need to know c and l_p separately for any Newton phenomena. Newton did not know or suggest that gravity moves at the speed of light, nor did the researchers suggesting the gravitational constant.[1]. The fact that the gravitational constant came before the Planck length does not mean that it is more fundamental than the Planck length. On the contrary, we live in a world where what we tend to observe is far away from the subatomic world. It is therefore natural that we scratch and understand the surface of reality before we understand what is going on at a deeper level.

Continuing the analysis, the mass can be expressed from a deeper level, in our view, by taking advantage of the Compton [33] wavelength formula $\bar{\lambda} = \frac{\hbar}{mc}$. Solving this with respect to m we get

$$m = \frac{\hbar}{\bar{\lambda}}\frac{1}{c} \tag{12}$$

This formula is valid for rest-masses. Be aware that the de Broglie [34, 35] wavelength formula $\lambda_b = \frac{h}{mv}$ not is valid for rest-mass particles, as one cannot divide by zero. We can now express the Newton formula as

$$F = G\frac{Mm}{R^2} = \frac{l_p^2 c^3}{\hbar}\frac{\frac{\hbar}{\bar{\lambda}_M}\frac{1}{c}\frac{\hbar}{\bar{\lambda}}\frac{1}{c}}{R^2} \tag{13}$$

This is, in our view, what the modern Newton formula truly represents as understood from a deeper perspective. We can now see it contains the speed of light. However, the Newton gravitational force itself is never directly observable or measurable. Directly observable gravity phenomena that also can be predicted from Newtons formula are in Table 1. Notice that we then always have GM and not GMm in any directly observable gravity phenomena. The small mass always cancels out in derivations to obtain formulas to predict something observable. In real two body problems, when both masses significantly large act on each other, the gravity parameter is $\mu = G(M_1 + M + 2) = GM_1 + GM_2$, that is in all directly observable gravity phenomena (or at least all we have looked at) we have GM and not GMm. Further, $GM = \frac{l_p^2 c^3}{\hbar}\frac{\hbar}{\bar{\lambda}_M} = c^2\frac{l_p^2}{\bar{\lambda}}$, and $\frac{l_p^2}{\bar{\lambda}} = \frac{1}{2}r_s$. As

[1] Actually he knew the approximate speed of light, as he stated in Principia it would take approximate seven to eight minutes for the light from the Sun to reach the Earth.

all observable Newtonian phenomena (at least all we have looked at) contain $GM = c^2 \frac{l_p^2}{\bar{\lambda}_M}$, this means they contain two constants: the speed of light and the Planck length; they also contain the speed of light and the Schwarzschild radius.

Table 5 shows that all Newton gravitational observations need the Planck length and the speed of gravity (light) to be predicted. This also means these observations contain both the Planck length and the speed of gravity. To extract only the speed of gravity, we need a way to find the Planck length alone, so we can separate out the speed of gravity (light). We see from the table that gravitational deflection, time dilation, and red-shift only contain the Planck length and not the speed of gravity (light). All of them contain GM/c^2 in their traditional formulation, but here we see the real reason for this, namely to get c^2 out of $GM = c^2 \frac{l_p^2}{\bar{\lambda}_M}$.

Since the gravitational deflection, time dilation, and red-shift are only dependent on the Planck length (plus some variables), we can from observing any of these phenomena extract the Planck length with no knowledge of any other physical constants. For example, if we have observed the deflection of light from the Sun, then we can from this observation find the Planck length, if we solve the formula in the table with respect to l_p, we get

$$l_p = \sqrt{\frac{\delta \bar{\lambda}_M R}{4}} \tag{14}$$

where δ is the observed deflection, R is the distance from the center of the gravitational object to where the light beam passes by the Sun, and $\bar{\lambda}_M$ is the Compton wavelength of the Sun. The radius of the Sun we can measure with parallax and other methods; the deflection of the Sun we can observe. The question is how we can find the Compton wavelength of the Sun that is also in this formula. Some will now likely protest and think the Sun cannot have a Compton wavelength. It is true that the Sun cannot have one physical Compton wavelength, but the Sun consists of atoms that again consist of elementary particle that have a Compton wavelength. There is a way to aggregate the Compton wavelengths of these particle to get the aggregated Compton wavelength of the Sun or any other mass. The Compton wavelength of a composite mass can be found from the Compton wavelengths making up the composite mass through the following formula

$$\bar{\lambda} = \sum_{i=1}^{n} = \frac{1}{\frac{1}{\bar{\lambda}_1} + \frac{1}{\bar{\lambda}_2} + \frac{1}{\bar{\lambda}_3} + \cdots + \frac{1}{\bar{\lambda}_n}} \tag{15}$$

This formula is fully consistent with standard mass addition because we have

$$\begin{aligned} m &= m_1 + m_2 + m_3 \\ \frac{\hbar}{\bar{\lambda}} \frac{1}{c} &= \frac{\hbar}{\bar{\lambda}_1} \frac{1}{c} + \frac{\hbar}{\bar{\lambda}_1} \frac{1}{c} + \frac{\hbar}{\bar{\lambda}_1} \frac{1}{c} \\ \frac{\hbar}{\frac{1}{\frac{1}{\bar{\lambda}_1} + \frac{1}{\bar{\lambda}_2} + \frac{1}{\bar{\lambda}_3}}} \frac{1}{c} &= \frac{\hbar}{\bar{\lambda}_1} \frac{1}{c} + \frac{\hbar}{\bar{\lambda}_1} \frac{1}{c} + \frac{\hbar}{\bar{\lambda}_1} \frac{1}{c} \end{aligned} \tag{16}$$

If we know the mass of the Sun in kg and the Planck constant, we can simply find the reduced Compton wavelength of the Sun by $\bar{\lambda} = \frac{\hbar}{mc}$. There is also a way to find the Compton wavelength of the Sun with no knowledge of any physical constants or any knowledge of the kg mass of the Sun. From the Compton 1923 paper, we have that the Compton wavelength of the electron is given by

$$\begin{aligned} \lambda_1 - \lambda_2 &= \frac{h}{mc}(1 - \cos\theta) \\ \lambda_1 - \lambda_2 &= \frac{h}{\frac{h}{\lambda_e} \frac{1}{c} c}(1 - \cos\theta) \\ \lambda_1 - \lambda_2 &= \lambda_e(1 - \cos\theta) \\ \lambda_e &= \frac{\lambda_1 - \lambda_2}{1 - \cos\theta} \end{aligned} \tag{17}$$

That is, we need to shoot photons at an electron and measure the wavelength (frequency) of the photon before and after the impact with the electron. In addition, we need to measure the angle θ, that is the angle between the incoming and outgoing photon we shoot at the electron.

Next, we have that the cyclotron frequency is given by

$$\omega = \frac{v}{r} = \frac{qB}{m} \tag{18}$$

An electron and a proton have the same charge, so the cyclotron ratio is equal to their mass ratio. Further, their mass ratio is equal to their Compton wavelength ratio

$$\frac{\omega_P}{\omega_e} = \frac{\frac{qB}{m_P}}{\frac{qB}{m_e}} = \frac{m_e}{m_P} = \frac{\lambda_P}{\lambda_e} \tag{19}$$

So, we now have the reduced Compton wavelength of a proton without any knowledge of any physical constants. If we now need to know the reduced Compton wavelength of the Earth, we could theoretically count all the protons in the Earth. There is nothing against the laws of physics to do this, even if it is technical impossible for us. One would then by formula 15 know the Compton wavelength of the Earth. However, there is a simpler way that likely could be done in practice. One could count the number of protons in a small mass the size of for example roughly half a kg. Next, use this mass as the gravity object (the large mass) in the Cavendish apparatus. There is naturally a challenge to counting the number of protons in a mass of even such a size, but it is not impossible. In recent years, silicon (^{28}Si) crystal balls have been turned into almost perfect spheres. As the material is very uniform and one knows the volume very accurately, one has been able to count the number of atoms [2], based on this, see [37, 38]. To count the number of atoms is therefore not pure theory. If we know the number of atoms in a piece of matter, we know its Compton wavelength (without having to rely on the Planck constant or the speed of light).

Next, we can find the gravitational acceleration of the sphere, in which we have counted the number of atoms, by using a Cavendish apparatus. The gravitational acceleration is given by

$$g = \frac{L4\pi^2\theta}{T^2} \tag{20}$$

where θ is the angle of the arm in the apparatus, and T is the time of the oscillation period, and L is the length between the two small balls in the apparatus. This is found totally without any knowledge of G or the Planck constant or c. This is the gravitational acceleration field from the large balls in the Cavendish apparatus at radius R_1, which is the distance from the large ball to the small ball in the Cavendish apparatus when the arm is in mid-position.

Next the Compton wavelength in masses are proportional to the gravitational acceleration:

$$\frac{g_1 R_1^2}{g_2 R^2} = \frac{\frac{GM_1}{R_1^2}R_1^2}{\frac{GM_2}{R_2^2}R_2^2} = \frac{M_1}{M_2} = \frac{\frac{\hbar}{\bar{\lambda}_1}\frac{1}{c}}{\frac{\hbar}{\bar{\lambda}_2}\frac{1}{c}} = \frac{\bar{\lambda}_2}{\bar{\lambda}_1} \tag{21}$$

We can therefore easily know the Compton wavelength of the Earth, or the Sun, for example, when we know the number of atoms in a clump of uniform matter on Earth. Since the Compton wavelength was the last needed input into formula 15, this means that we have a method to find the Planck length totally independent of any knowledge of G, $\hbar$, and c, from gravitational deflection.

We can also find the Planck length directly from measuring the gravitational frequency shift (red-shift) of a laser beam sent out from altitude R_2 and received at altitude R_1. In a weak gravitational field, we get

$$l_p \approx \frac{\sqrt{2\bar{\lambda}_M R_1 R_2 Z}}{\sqrt{R_1 - R_2 + R_1 Z}} \tag{22}$$

where Z is the observed red-shift, and $\bar{\lambda}$ is the reduced Compton wavelength of the mass causing the gravitational field we are doing the measurement in, for example the Earth.

So, from gravitational bending of light (deflection), from gravitational red-shift, and from gravitational time dilation, we can find the Planck length with no prior knowledge of any other physical constant. We can predict the same observations with only one constant, namely the Planck length. This strongly supports or basically proves that these gravity phenomena do not contain the speed of gravity. How can it be we can get out the Planck length without separating out any other constant, such as G, $\hbar$, or c? To understand why, let us for example look at the gravitational deflection. It requires according to general relativity two constants G and c (or actually three) to be predicted; this is because we have $\frac{GM}{c^2} = \frac{l_p c^3}{\hbar}\frac{\hbar}{\bar{\lambda}_M}\frac{1}{c} = \frac{l_p^2}{\bar{\lambda}_M}$, as we see the c^2 in the nominator is to cancel out the embedded c^2 in GM, and the embedded $\hbar$ in G cancels out with the Planck constant in the mass. Gravitational deflection evidently only depends on one constant and that is the Planck length. Also, based on our much deeper understanding than the consensus view we can guarantee that one cannot extract G from only observing deflection, because G is not in the deflection, only part of G, namely the Planck length. Nor can anyone extract the speed of gravity only from observing gravity deflection, red-shift, or time dilation without adding in other constants, or multiply with a known mass, as mass in kg contains $\hbar$ and c embedded. This is because these observations contain no information about the speed of light or the speed of gravity; all they contain in form of constants is the Planck length.

Classical Newton gravitational phenomena, on the other hand, we can see from Table 5 contain both the speed of gravity and the Planck length, and we need to know the Planck length to separate out the speed of gravity from these elements. We can also find the Planck length from Newton gravitational phenomena if we know the speed of light, for example, from simply measuring the speed of light.

[2] Also other methods exist to count the number of atoms, see [36], for example.

	Modern Newton:
Mass	$M = \frac{\hbar}{\bar{\lambda}_M}\frac{1}{c}$ (kg)
Non observable (contains GMm)	
Gravitational constant	$G, \left(G = \frac{l_p^2 c_g^3}{\hbar}\right)$
Gravity force	$F = G\frac{Mm}{R^2}$ $(kg \cdot m \cdot s^{-2})$
Field equation	Gauss "law": $\nabla^2\phi = 4\pi G\rho$
Observable predictions, identical for the two methods: (contains only GM)	
Gravity acceleration	$g = \frac{GM}{R^2} = \frac{c_g^2}{R^2}\frac{l_p^2}{\bar{\lambda}_M}$
Orbital velocity	$v_o = \sqrt{\frac{GM}{R}} = c_g l_p \sqrt{\frac{1}{R\bar{\lambda}_M}}$
Orbital time	$T = \frac{2\pi R}{\sqrt{\frac{GM}{R}}} = \frac{2\pi}{c_g l_p \sqrt{\frac{1}{2}\frac{1}{\bar{\lambda}_M R}}}$
Velocity ball Newton cradle	$v_{out} = \sqrt{2\frac{GM}{r^2}H} = \frac{c_g l_p}{R}\sqrt{\frac{1}{\bar{\lambda}_M}}$
Frequency Newton spring	$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi R}\sqrt{\frac{GM}{x}} = \frac{c_g l_p}{2\pi R}\sqrt{\frac{1}{\bar{\lambda}_M x}}$
Periodicity pendulum (clock)	$T = 2\pi\sqrt{\frac{L}{g}} = T = 2\pi R\sqrt{\frac{L}{GM}} = \frac{2\pi R}{c_g l_p}\sqrt{2L\bar{\lambda}_M}$
Observable predictions (from GR): (contains only GM)	
Gravitational red-shift	$z = \frac{\sqrt{1-\frac{2GM}{R_1 c^2}}}{\sqrt{1-\frac{2GM}{R_2 c^2}}} - 1 = \frac{\sqrt{1-\frac{2l_p^2}{R_1\bar{\lambda}_M}}}{\sqrt{1-\frac{2l_p^2}{R_2\bar{\lambda}_M}}} - 1$
Time dilation	$T_R = T_f\sqrt{1 - \sqrt{\frac{2GM}{R}}^2/c^2} = T_f\sqrt{1 - \frac{2l_p^2}{R\bar{\lambda}_M}}$
Gravitational deflection (GR)	$\delta = \frac{4GM}{c^2 R} = \frac{4}{R}\frac{l_p^2}{\bar{\lambda}_M}$
Advance of perihelion	$\sigma = \frac{6\pi GM}{a(1-e^2)c^2} = \frac{6\pi}{a(1-e^2)}\frac{l_p^2}{\bar{\lambda}_M}$

Table 4: The table shows that any gravity observations we can make contain GM and not GMm; GM contains and needs less information than is required to find G and M.

Table 5 shows how we can extract $c_g l_p$ as well as l_p and therefore also c_g and l_p separatly by observing only two gravity observations, and with no knowledge of G, c or $\hbar$. From these two constants we can then predict any other observable gravity phenomena.

We can also rewrite the Gaussian law based on the composite view of $G = \frac{l_p^2 c_g^3}{\hbar}$ and this gives

$$\nabla^2\phi = 4\pi G\rho = 4\pi\frac{l_p^2 c_g^3}{\hbar}\rho \tag{23}$$

In other words, the speed of light appears in the field equation. It is therefore likely wrong to conclude, as has been done in the past, that the Newtonian gravity is instantaneous and the implicit speed of gravity in the Newton formulation therefore infinite. That would mean we should put $c_g = \infty$, and that would lead to an infinite strong gravity potential, something that is absurd and not in line with Newtonian theory. Or if we set $c_g = 0$ then the gravitational field would be zero, which is also absurd and not in line with Newton predictions, nor observations. Only when we have $c_g \approx c$ can the equation be used for a series of predictions that is consistent with observations. In other words, Newtonian gravity hidden and embedded in $G = \frac{l_p^2 c_g^3}{\hbar}$ as well as in $M = \frac{\hbar}{\bar{\lambda}}\frac{1}{c}$ contains the speed of light, $c = c_g$. Newtonian gravity is consistent with that gravity moves at the speed of light. This is so revolutionary that I am tempted to say that Newton gravity is consistent with Godspeed!

General relativity, for example, leads to the same escape velocity as one can get from the Newton gravitational formula, see for example [39]. How can it be that GR and Newton gives the same escape velocity, if GR assume the speed of gravity $c_g = c$ and Newton assume the speed of gravity is infinite. This simply does not make logical sense. It is clear to us that Newton embedded contains the speed of gravity, not based on assumptions behind the foundation of the model, but by calibration of what is missing in the model that one gets into the composite constant G. This is, however, only fully understood when one both understand that G is a composite constant of the form $G = \frac{l_p^2 c^3}{\hbar}$ and that any kg mass can be described as $m = \frac{\hbar}{\bar{\lambda}}\frac{1}{c}$.

	Modern Newton:
Mass	$M = \frac{\hbar}{\bar{\lambda}_M}\frac{1}{c}$ (kg)
Non observable (contains GMm)	
Gravitational constant	$G, \left(G = \frac{l_p^2 c^3}{\hbar}\right)$
Gravity force	$F = G\frac{Mm}{R^2}$ $(kg \cdot m \cdot s^{-2})$
Field equation	Gauss "law": $\nabla^2\phi = 4\pi G\rho$
Planck length times speed of gravity from:	
Gravity acceleration	$c_g l_p = R\sqrt{g\bar{\lambda}_M}$
Orbital velocity	$c_g l_p = v_o\sqrt{R\bar{\lambda}_M}$
Orbital time	$c_g l_p = \frac{2\pi\sqrt{2\bar{\lambda}_M R}}{T}$
Velocity ball Newton cradle	$c_g l_p = v_{out}R\sqrt{\frac{\bar{\lambda}_M}{H}}$
Frequency Newton spring	$c_g l_p = f2\pi R\sqrt{\bar{\lambda}_M x}$
Periodicity Pendulum (clock)	$c_g l_p = \frac{2\pi R}{T}\sqrt{2L\bar{\lambda}_M}$
Planck length from:	
Gravitational red-shift	$l_p = \frac{\sqrt{\bar{\lambda}_M R_1 R_2 Z}\sqrt{Z+2}}{\sqrt{2R_1Z^2+4R_1Z+2R_1-2R_2}}$
Gravitational red-shift weak field approx:	$l_p \approx \frac{\sqrt{\bar{\lambda}_M R_1 R_2 Z}}{\sqrt{R_1-R_2+R_1Z}}$
Time dilation	$l_p = \frac{\sqrt{\bar{\lambda}_M R_1 R_2}\sqrt{T_1^2-T_2^2}}{\sqrt{2R_2T_1^2-2R_1T_2^2}}$
Time dilation weak field approx.:	$l_p \approx \frac{\sqrt{\bar{\lambda}_M R_1 R_2 T_2 - \bar{\lambda}_M R_1 R_2 T_1}}{\sqrt{R_1T_2-R_2T_1}}$
Gravitational deflection (GR)	$l_p = \sqrt{\frac{\delta\bar{\lambda}_M R}{4}}$
Advance of perihelion	$l_p = \sqrt{\frac{6\pi}{a(1-e^2)}\frac{\sigma}{\bar{\lambda}_M}}$

Table 5: The table shows how we can extract $c_g l_p$ from a series of gravitational observations, and further how we can extract the Planck length isolated from some other gravity observations. This means that we can also isolate c_g and l_p by performing two gravitational observations and without any knowledge of G, $\hbar$, c, or any other constant. Again, these can be used to predict any gravity phenomena. This means that Newton gravitational phenomena contain the speed of gravity and that the speed of Newtonian gravity is $c_g = c$.

5 Rethinking Newtonian Gravity and Returning to the Original Newton Formula

Haug [29] has suggested that the reason one must multiply G with M is to turn what we have reason to think is an incomplete kg mass definition $m = \frac{\hbar}{\bar{\lambda}}\frac{1}{c}$ into a complete mass definition. The gravity constant G is actually needed for removing the Planck constant from the kg mass and getting the Planck length into it. All gravity phenomena are linked to the Planck length, so without it one cannot do any gravity predictions. For the output numbers, one gets the same output if one has gotten the Planck length into the formula indirectly without knowing it, through a composite constant, or if one does it directly. The direct approach, as we soon will show, gives deeper insight in gravity. In the same paper, Haug has suggested that the mass actually used in all gravity calculations indirectly without researchers realizing it, therefore is what he has coined collision-time mass, $\bar{m} = \frac{G}{c^3}m = \frac{l_p^2}{\hbar}m = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}}$. Based on this this new mass definition that is actually embedded in the standard gravity theory, we get an alternative Newton-like gravity formula, namely

$$F = c^3\frac{\bar{M}\bar{m}}{R^2} \tag{24}$$

This formula has different output units and numerical output than the standard modern Newton gravity formula. Still, based on this formula, we get all the same predictions for any observable gravity phenomena as Newton. This can be seen in Table 6. We see that both the standard Newton formula as well as our alternative Newton formula all give outputs that only are dependent on the Planck length and the speed of gravity. The end result of all predictions is the same from the standard modern Newton formula and this new alternative.

This also means that all the Newton observed phenomena contains information about the speed of gravity equal to that of light and the Planck length. To extract only the speed of gravity from Newtonian observable gravity phenomena, we need to somehow independently find the Planck length; this we can do from light defection, red-shift, time dilation or precession of Mercury. These observations are only dependent on one physical constant, the Planck length, and therefore they also contain this constant and it can be extracted from them without any knowledge of any other constant, as can be seen in Table 7.

We can also derive a field equation using the Gaussian law from our new mass definition and this gives

$$\oiint_{\partial V} \boldsymbol{g} \cdot d\boldsymbol{A} = -4\pi c^4 \bar{M}_i \tag{25}$$

where $\bar{M}_i$ is the mass in terms of collision time inside the Gauss surface, $\boldsymbol{g}$ is the gravitational acceleration vector. This can also be written in differential form (the Poisson equation) as

$$\nabla^2 \phi = 4\pi c^3 \rho_c \tag{26}$$

where ρ_c is the mass density, but mass is defined as collision-time and not as kg. The collision-time mass has many implications for physics and seems to lead to a unified theory. This is not the topic of this paper, but more about this can be found in our recent paper [29].

In the case where one uses the same unit for length and time, that is, if the length unit is how long the light moved in the chosen upon time unit, then the speed of gravity (light) is $c_g = 1$ and then the formula above simplifies to Newton's original formula

$$F = \frac{\bar{M}\bar{m}}{R^2} \tag{27}$$

This formula can then still be used to predict all Newtonian gravity phenomena.

5.1 Example

Assume we now first measure the electron's Compton wavelength, it is $\bar{\lambda}_e \approx 3.86 \times 10^{-13}$ meter, Next we find the cyclotron frequency of electrons and protons and find that the ratio is about 1836.15. This means the Compton wavelength of a proton is $\bar{\lambda}_e/1836.15 \approx 2.1 \times 10^{-16}$ meters. Next, we count the number of atoms in a clump of uniform atoms. Assume for example a silicon sphere; if we count 3×10^26 protons (or neutrons that we assume have same mass as protons). The Compton wavelength of this mass will then be approximately $7.04. \times 10^{-43}$. Next, we find the gravitational acceleration from this mass by a Cavendish apparatus. It is given by

$$g = \frac{L 4\pi^2 \theta}{T^2} \tag{28}$$

Assume the distance between the small balls in the apparatus is 0.2 meter and also the distance between the large sphere and the small sphere when the arm with the small balls is in mid position is 0.2 meters. Time must here be measured in time units of 3.3 nano seconds, if we want to use same time unit as length units, as we have chosen meters as length unit. This led to a gravitational acceleration indirectly observed (from the measures in the Cavendish apparatus) of 9.3×10^{-27} meters per 3.3 nano seconds squared. Now we need to measure the gravitational acceleration on the surface of the Earth, this can be done with two time gates and a drop ball, it is $9.81 m/s^2$ which is equal to 1.06×10^{-16} meter per 3.3 nano seconds squared. The Earth's Compton wavelength is now

$$\frac{1.06 \times 10^{-16} \times 6371000^2}{9.3 \times 10^{-27} \times 0.2^2} \approx .5.9 \times 10^{-68} \text{ m}$$

Now if we take the gravitational acceleration on Earth, which was 1.06×10^{-16} meter per 3.3 nano seconds, we can find the Planck length simply from the formula

$$l_p = R\sqrt{g\bar{\lambda}_M} \tag{29}$$

which in case of the gravitational field of the Earth is

$$l_p = R\sqrt{g\bar{\lambda}_M} = 6371000\sqrt{1.06 \times 10^{-16} \times 5.9 \times 10^{-68}} \approx 1.62 \times 10^{-35}$$

From this constant alone we can predict all observable gravity phenomena. Be aware this only works if one uses for the speed of gravity the same unit for length and time, which mean $c_g = 1$.

We naturally do not need nanosecond accurate measurements to find this, we must measure over a much longer period in a Cavendish apparatus, but then by mathematics turn our measurement over to units per nanoseconds. So, this part could even have been done at Cavendish time. Newton knew the approximate distance to the Sun and he also knew the approximate speed of the light from the Sun to the Earth (7 to 8 minutes). If Cavendish had followed up on this, he could simply have chosen any length unit, but then chosen a time unit that corresponded to how long it would take light to travel that length unit. So, Newton's formula used this way would actually indirectly mean we already know the speed of light and assume gravity move at the same speed, as well as using a time unit that is linked to the length unit through the speed of light.

Newton's original formula in this perspective is perfectly correct and I will say glorious and almost miraculous. If used as it originally was presented with the mass definition we have introduced, then it automatically assume gravity is the same as the speed of light. One must know the speed of light, but not the speed of gravity to operate the formula. One need to know the speed of light to use a time unit that is linked to the length unit through the speed of light.

Combined with modern knowledge of the Compton wavelength that can be found independent of G, $\hbar$, and c, the Newton formula gives us the most important of all constants namely the Planck length. From the Planck length alone, we can then predict all observable gravity phenomena.

	Modern Newton:	**Alternative:**
Mass	$M = \frac{\hbar}{\bar{\lambda}_M}\frac{1}{c}$ (kg)	$\bar{M} = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}_M}$ (collision-time, see [29])
Non observable (contains GMm)		
Gravitational constant	$G, \left(G = \frac{l_p^2 c^3}{\hbar}\right)$	c^3
Gravity force	$F = G\frac{Mm}{R^2}$ $(kg \cdot m \cdot s^{-2})$	$F = c^3\frac{\bar{M}\bar{m}}{R^2}$ $(m \cdot s^{-1})$
Observable predictions, identical for the two methods: (contains only GM)		
Gravity acceleration	$g = \frac{GM}{R^2} = \frac{c_g^2}{R^2}\frac{l_p^2}{\bar{\lambda}_M}$	$g = \frac{c_g^3\bar{M}}{R^2} = \frac{c^2}{R^2}\frac{l_p^2}{\bar{\lambda}_M}$
Orbital velocity	$v_o = \sqrt{\frac{GM}{R}} = c_g l_p\sqrt{\frac{1}{R\bar{\lambda}_M}}$	$v_o = \sqrt{\frac{c^3\bar{M}}{R}} = c_g l_p\sqrt{\frac{l_p^2}{R\bar{\lambda}_M}}$
Orbital time	$T = \frac{2\pi R}{\sqrt{\frac{GM}{R}}} = \frac{2\pi}{c_g l_p\sqrt{\frac{1}{2}\frac{1}{\bar{\lambda}R}}}$	$T = \frac{2\pi R}{\sqrt{\frac{c^3\bar{M}}{R}}} = \frac{2\pi}{c_g l_p\sqrt{\frac{1}{2}\frac{1}{\bar{\lambda}R}}}$
Velocity ball Newton cradle	$v_{out} = \sqrt{2\frac{GM}{r^2}H} = \frac{c_g l_p}{R}\sqrt{\frac{1}{\bar{\lambda}}}$	$v_{out} = \sqrt{2\frac{c^3\bar{M}}{r^2}H} = \frac{c_g l_p}{R}\sqrt{\frac{1}{\bar{\lambda}}}$
Frequency Newton spring	$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi R}\sqrt{\frac{GM}{x}} = \frac{c_g l_p}{2\pi R}\sqrt{\frac{1}{\bar{\lambda}x}}$	$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi R}\sqrt{\frac{c^3\bar{M}}{x}} = \frac{c_g l_p}{2\pi R}\sqrt{\frac{1}{\bar{\lambda}x}}$
Periodicity Pendulum (clock)[a]	$T = 2\pi\sqrt{\frac{L}{g}} = T = 2\pi R\sqrt{\frac{L}{GM}} = \frac{2\pi R}{c_g l_p}\sqrt{2L\bar{\lambda}}$	$T = 2\pi\sqrt{\frac{L}{g}} = T = 2\pi R\sqrt{\frac{L}{c^3\bar{M}}} = \frac{2\pi R}{c_g l_p}\sqrt{2L\bar{\lambda}}$
Observable predictions (from GR): (contains only GM)		
Gravitational red-shift	$z = \frac{\sqrt{1-\frac{2GM}{R_1c^2}}}{\sqrt{1-\frac{2GM}{R_2c^2}}} - 1 = \frac{\sqrt{1-\frac{2l_p^2}{R_1\bar{\lambda}_M}}}{\sqrt{1-\frac{2l_p^2}{R_2\bar{\lambda}_M}}} - 1$	$z = \frac{\sqrt{1-\frac{2c^3\bar{M}}{R_1c^2}}}{\sqrt{1-\frac{2c^3\bar{M}}{R_2c^2}}} - 1 = \frac{\sqrt{1-\frac{2l_p^2}{R_1\bar{\lambda}_M}}}{\sqrt{1-\frac{2l_p^2}{R_2\bar{\lambda}_M}}} - 1$
Time dilation	$T_R = T_f\sqrt{1-\sqrt{\frac{2GM}{R}}^2/c^2} = T_f\sqrt{1-\frac{2l_p^2}{R\bar{\lambda}_M}}$	$T_R = T_f\sqrt{1-\sqrt{\frac{2c^3\bar{M}}{R}}^2/c^2} = T_f\sqrt{1-\frac{2l_p^2}{R\bar{\lambda}_M}}$
Gravitational deflection (GR)	$\delta = \frac{4GM}{c^2R} = \frac{4}{R}\frac{l_p^2}{\bar{\lambda}_M}$	$\delta = \frac{4c^3\bar{M}}{c^2R} = \frac{4}{R}\frac{l_p^2}{\bar{\lambda}_M}$
Advance of perihelion	$\frac{6\pi GM}{a(1-e^2)c^2} = \frac{6\pi}{a(1-e^2)}\frac{l_p^2}{\bar{\lambda}_M}$	$\frac{6\pi c^3\bar{M}}{a(1-e^2)c^2} = \frac{6\pi}{a(1-e^2)}\frac{l_p^2}{\bar{\lambda}_M}$
Indirectly/"hypothetical" observable predictions: (contains only GM)		
Escape velocity	$v_e = \sqrt{\frac{2GM}{R}} = cl_p\sqrt{2\frac{1}{R\bar{\lambda}_M}}$	$v_e = \sqrt{\frac{2c^3\bar{M}}{R}} = cl_p\sqrt{2\frac{1}{R\bar{\lambda}_M}}$
Schwarzschild radius	$r_s = \frac{2GM}{c^2} = 2\frac{l_p^2}{\bar{\lambda}_M}$	$r_s = \frac{2c^3\bar{M}}{c^2} = 2\frac{l_p^2}{\bar{\lambda}_M}$
Gravitational parameter	$\mu = GM = c^2\frac{l_p^2}{\bar{\lambda}_M}$	$\mu = c^3\bar{M} = c^2\frac{l_p^2}{\bar{\lambda}_M}$
Two body problem	$\mu = G(M_1+M_2) = c^2\frac{l_p^2}{\bar{\lambda}_1} + c^2\frac{l_p^2}{\bar{\lambda}_1}$	$c^3(\bar{M}_1+\bar{M}_2) = c^2\frac{l_p^2}{\bar{\lambda}_1} + c^2\frac{l_p^2}{\bar{\lambda}_2}$
Quantum analysis:		
Constants needed	G, $\hbar$, and c or l_p, $\hbar$, and c	l_p and c
Variable needed	one for mass size	one for mass size

Table 6: The table shows that any observable gravity phenomena are linked to the Planck length and the speed of gravity that again is equal to the speed of light. For all observable gravity phenomena, we have GM and not GMm. This means the embedded Planck constant cancels out, and all observable gravity phenomena are linked to the Planck length and the speed of gravity that again are identical to the speed of light. When this is understood one can even rewrite Newton and GR gravity formulas to a simpler form that still give all the same results.

[a] This was actually derived by Huygens [30] some years before Newton.

6 Summary and Conclusion

We have demonstrated that the speed of gravity is embedded and hidden in Newton gravity together with the Planck length. All observable gravity phenomena, at least all we have looked at can be predicted only by two physical constants: l_p and $c_g = c$. This is the same as predicted by super string theory, but their approach does not seem to have led anywhere. Newton did not assume gravity move at the speed of light when deriving his formula. Still, the speed of gravity equal to the speed of light is embedded in the formula because what is missing in the formula one gets into the formula through a composite constant that is calibrated to a gravity observation, through a Cavendish experiment, for example. Both the Planck length and the speed of gravity are needed, and one gets both of these into the formula by calibrating to a Newtonian type gravity phenomenon to an observed gravity observation, for example, with a Cavendish apparatus.

For three hundred years, one has looked at the Newton formula without understanding what it represents at a deeper level. This paper should bring us much closer to what Newton gravity truly represents. The Newton formula after calibration is fully consistent with the idea that the speed of gravity moves at the speed of light. However, for planets and stars moving relative to the observer, one likely needs to take relativistic masses into account as well. This view has implications for how one will look at general relativity in the future, and also that G simply represents a composite universal constant.

References

[1] I. J. Good. Infinite speed of propagation of gravitation in newtonian physics. *American Journal of Physics*, 43(640), 1975. URL https://doi.org/10.1119/1.9766.

[2] A. Nielsen. Lecture notes on gravitational waves. *Journal of Physics, Conference Series*, 1263, 2019. URL https://doi.org/10.1088/1742-6596/1263/1/012008.

[3] P.S. Laplace. *A Treatise in Celestial Mechanics*. Volume IV, Book X, Chapter VII, translated by N. Bowditch (Chelsea, New York, 1966, 1805.

[4] M. Lévy. Sur l'application des lois électrodynamiques au mouvement des planétes. *Comptes Rendus*, 110, 1890.

[5] H. Poincaré. L'état actuel et l'avenir de la physique mathématique. *Bulletin des Sciences Mathématiques*, 28(2), 1904.

[6] Albert Einstein. Näherungsweise integration der feldgleichungen der gravitation. *Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften Berlin*, 1916.

[7] W. W. Salisbury. Velocity of gravitational waves. *Nature*, 224, 1969.

[8] S. Krasnikov. What is faster – light or gravity? *arXiv:1408.6813*, 2014.

[9] B. P. Abbott and et. al. Gravitational waves and gamma-rays from a binary Neutron star merger: Gw170817 and grb 170817a. *The Astrophysical Journal Letters, Volume 848*, 848(2):1?27, 2017. URL https://doi.org/0000-0002-7537-3210.

[10] I Newton. *Philosophiae Naturalis Principia Mathematica*. London, 1686.

[11] I. B. Cohen. Newton's determination of the masses and densities of the Sun, Jupiter, Saturn, and the Earth. *Archive for History of Exact Sciences*, 53(1):83, 1998. URL https://doi.org/10.1007/s004070050022.

[12] H. Cavendish. Experiments to determine the density of the Earth. *Philosophical Transactions of the Royal Society of London, (part II)*, 88, 1798.

[13] A. Cornu and J. B. Baille. Détermination nouvelle de la constante de l'attraction et de la densité moyenne de la terre. *C. R. Acad. Sci. Paris*, 76, 1873.

[14] C. V. Boys. The Newtonian constant of gravitation. *Nature*, 50:571, 1894. URL https://doi.org/10.1038/050571a0.

[15] M. Planck. *Einführung in die allgemeine Mechanik*. Verlag von Hirtzel, Leipzig, 1928.

[16] M. Planck. *Natuerliche Masseinheiten*. Der Königlich Preussischen Akademie Der Wissenschaften, 1899.

[17] M. Planck. *Vorlesungen über die Theorie der Wärmestrahlung*. Leipzig: J.A. Barth, p. 163, see also the English translation "The Theory of Radiation" (1959) Dover, 1906.

[18] J. G. Stoney. On the physical units of Nature. *The Scientific Proceedings of the Royal Dublin Society*, 3, 1883.

[19] A. S. Eddington. *A Mathematical Theory of Relativity*. Cambridge University Press, 1922.

[20] P. W. Bridgman. *Dimensional Analysis.* New Haven: Yale University Press, 1931.

[21] Gennady Gorelik. *First Steps of Quantum Gravity and the Planck Values.* Boston University, 1992.

[22] T. Padmanabhan. Planck length as the lower bound to all physical length scales. *General Relativity and Gravitation*, 17, 1985. URL https://doi.org/10.1007/BF00760244.

[23] R. J. Adler. Six easy roads to the Planck scale. *American Journal of Physics*, 78(9), 2010. URL https://doi.org/10.1119/1.3439650.

[24] S. Hossenfelder. Can we measure structures to a precision better than the Planck length? *Classical and Quantum Gravity*, 29, 2012. URL https://doi.org/10.12942/lrr-2013-2.

[25] A. Unzicker. *The Mathematical Reality: Why Space and Time Are an Illusion.* Independently published, 2020.

[26] M. J. Duff, L. B. Okun, and G. Veneziano. Trialogue on the number of fundamental constants. *Journal of High Energy Physics*, 2002, 2002. URL ttps://doi.org/10.1088/1126-6708/2002/03/023.

[27] A. Hees and et al. Tests of lorentz symmetry in the gravitational sector. *Universe*, 2(4), 2017. URL https://doi.org/10.3390/universe2040030.

[28] E. G. Haug. Finding the planck length multiplied by the speed of light without any knowledge of G, c, or h, using a Newton force spring. *Journal Physics Communication*, 33:46, 2020. URL https://doi.org/10.1088/2399-6528/ab9dd7.

[29] E. G. Haug. Collision space-time: Unified quantum gravity. *Physics Essays*, 33(1):46, 2020. URL https://doi.org/10.4006/0836-1398-33.1.46.

[30] C. Huygens. *Horologium oscillatorium sive de motu pendularium.* 1673.

[31] M. Jammer. *Concepts of Mas in Contemporary Physics and Philosophy.* Princeton University Press, 2000.

[32] A. S. Eddington. *Report On The Relativity Theory Of Gravitation.* The Physical Society Of London, Fleetway Press, London, 1918.

[33] A. H. Compton. A quantum theory of the scattering of x-rays by light elements. *Physical Review*, 21(5): 483, 1923. URL https://journals.aps.org/pr/abstract/10.1103/PhysRev.21.483.

[34] de. L. Broglie. Waves and quanta. *Nature*, 112:540, 1923. URL https://www.nature.com/articles/112540a0.

[35] de. L. Broglie. Recherches sur la thorie des quanta. *PhD Thesis (Paris)*, 1924.

[36] O. Wang, Z. W. and. Toikkanen, F. Yin, Z.Y. Li, B. M Quinn, and R. E. Palmer. Counting the atoms in supported, monolayer-protected gold clusters. *J. Am. Chem. Soc.*, 132:2854, 2010. URL https://pubs.acs.org/doi/pdf/10.1021/ja909598g.

[37] P. Becker. The new kilogram definition based on counting the atoms in a ^{28}si crystal. *Contemporary Physics*, 53:461, 2012. URL https://doi.org/10.1080/00107514.2012.746054.

[38] G. et. al. Bartl. A new ^{28} si single crystal: Counting the atoms for the new kilogram definition. *Metrologica*, 54:693, 2017. URL https://doi.org/10.1088/1681-7575/aa7820.

[39] A. T. Augousti and A. Radosz. An observation on the congruence of the escape velocity in classical mechanics and general relativity in a Schwarzschild metric. *European Journal of Physics*, 376:331–335, 2006.

References

Conflict of Interest

The author declares that there is no conflict of interest regarding the publication of this paper.