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Coulomb Force, Charge, and Electric Properties under Collision Space-Time

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Abstract

We have recently published a series of papers on a theory we call collision space-time, that seems to unify gravity and quantum mechanics. In this theory, mass and energy are redefined. We have not so far demonstrated how to make it compatible with electric properties such as charge and the Coulomb force. The aim of this paper is to show how electric properties can be reformulated to make it consistent with collision space-time. It is shown that we need to incorporate the Planck scale into the electric constants to do so. This is also fully possible from a practical point of view, as it has recently been shown how to measure the Planck length independent of other constants and without the need for dimensional analysis.

Keywords

Coulomb's Law, Elementary Charge, Planck Charge, Electric Units, Collision Space-Time

1. Short Background on Deeper Aspects of Gravity and Collision Space-Time

The Newton gravity force formula, as known today, is given by:

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

where G is the gravitational constant. Actually, the original Newton gravity force formula, which he presented in words in *Principia* [1] had no gravitational constant. It was simply $F = M_n m_n / R^2$, but then Newton had a very different opinion about what matter ultimately was, compared to the view of it in modern physics, and this is why we use notation M_n and m_n, rather than M and m. Newton assumed that matter ultimately consisted of indivisible particles with spatial dimension, an idea he got from the ancient Greek atomists, Democritus and Leuppicus; see, for example, [2] [3] [4]. Modern physics assumes particles are ultimately point particles with no spatial dimensions and that all we need to know about the mass in the Newton formula is the kilogram amount of the mass, and that the kilogram mass is identical to so-called gravitational mass, something we will soon get back to.

The gravitational constant was actually first introduced in 1873 by Cornu and Baille [5] with the formula $F = fMm/R^2$. They had introduced a gravity constant where they used the symbol f for it. Boys [6] in 1894 was likely the first to use the symbol G for the gravitational constant. However, it took time before the notation G became the standard. Einstein [7] used the symbol k for the gravity constant in his 1916 general relativity papers, while Max Planck [8] used the notion f as late as 1928. Which symbol one uses for the gravity constant is naturally not important, but what is important is that the Newton gravity theory was used successfully for several hundred years without any gravitational constant.

We think it is no coincidence that the gravity constant was introduced at about the same time as the kilogram definition of mass became the standard in European scientific circles. The kilogram became widely accepted in scientific circles after the meter convention meeting in 1870. Also, Cavendish [9] never introduced or measured the gravitational constant, as has been incorrectly claimed by several researchers in the field-even by Feynman; see Clotfelter [10] and Sean [11].

The gravitational force has never been measured directly, but only indirectly through its many observable effects. When deriving from the Newton force formula other well-known formulas that can predict something that can be checked with observations, then the small mass m always cancels out in the derivations. That is, all gravitational phenomena that can be observed contain GM and never GMm. In real two-body problems, when the small mass also has a significant gravitational field relative to M, the gravitational parameter is $\mu = G(M+m) = GM + Gm$. In other words, we always use G multiplied by the kilogram mass to make predictions about gravity, and this is more important to pay attention to than one might first think.

In our view, G is needed to fix the incomplete kilogram mass M. Newton's gravitational constant has output units $m^2 \cdot kg^{-1} \cdot s^{-2}$, so when G is multiplied by M, the kilogram always cancels out. If the kilogram is the only information about the mass that enters the Newton formula, why would the kilogram unit then always cancel out for predictions of something we can actually observe and check the predictions with? We have, in a several papers, shown that all gravity predictions that can be observed and therefore checked, which can be done with no knowledge of G and M, see [12] [13]. This does not mean one doesn't need information about the mass to make gravity predictions, but simply that standard theory has limited insight into mass in relation to gravity.

Max Planck [14] [15] in 1899 assumed there were three important universal constants: the gravity constant G, the Planck constant h, and the speed of light c.

Based on these and dimensional analysis, he found a unique length: $l_p=\sqrt{\frac{G\hbar}{c^3}}$, time: $t_p=\sqrt{\frac{G\hbar}{c^5}}$, mass: $m_p=\sqrt{\frac{\hbar c}{G}}$ and temperature $T_p=\sqrt{\frac{\hbar c^5}{Gk_b}}$; today known as the Planck units.

Instead of calculating Planck units from also *G*, we can solve, for example, the Planck length formula for *G*, and this gives:

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

Actually, Cahill [16] [17] in 1984 already suggested that the gravity constant could be expressed in the form of the Planck mass on the form $G=\frac{\hbar c}{m_p^2}$, thus expressing the idea that the Planck units represented something more fundamental than *G*. In 1987, Cohen [18] suggested the same formula for *G*, but came to the correct conclusion that, as long as no one had shown it possible to find the Planck units independent of *G*, then this would just lead to a circular problem, as one had to know *G* to find the Planck units. This has been the view held until recent years.

However, in 2017, we [19] demonstrated for the first time that it was possible to extract the Planck length from gravity observations using a Cavendish apparatus without any knowledge of *G*. Later, we showed that one can find the Planck length independent of knowledge of *G*, $\hbar$, and even *c*; see [13] [20]. This means that the gravity constant can be seen as a composite constant of the form $G=\frac{l_p^2c^3}{\hbar}$. For an in-depth review of the composite view of the gravitational constant, see Haug [21].

In addition, we can take the Compton [22] wavelength formula $\lambda=\frac{h}{mc}$ and solve it for *m*. This gives:

$$m=\frac{h}{\lambda}\frac{1}{c}=\frac{\hbar}{\bar{\lambda}}\frac{1}{c} \tag{3}$$

where λ is the Compton wavelength, and $\bar{\lambda}$ is the reduced Compton wavelength of the mass in question. Further, *h* is the Planck constant and $\hbar$ is the reduced Planck constant; the latter is also known as the Dirac constant. It is easy to think this can only be valid for an electron, as the Compton wavelength was originally derived by Compton in relation to electrons. However, we [20] [23] have shown in recent papers that this formula can be used to express any kilogram mass; that is, even for planets, stars, galaxies, and the whole observable universe. Since we have *GM* in any gravity predictions, we can now replace *G* with $G=\frac{l_p^2c^3}{\hbar}$ and *M* with $M=\frac{\hbar}{\bar{\lambda}}\frac{1}{c}$. This gives:

$$GM=\frac{l_p^2c^3}{\hbar}\frac{\hbar}{\bar{\lambda}_M}\frac{1}{c}=c^3\frac{l_p}{c}\frac{l_p}{\bar{\lambda}_M} \tag{4}$$

where $\bar{\lambda}_M$ is simply the reduced Compton wavelength of the mass *M*. By multiplying *G* with *M*, the Planck constant cancels out. To multiply *G* with *M* is basically done to get the Planck constant out of the mass and the Planck length into the mass. That the Planck constant cancels out is directly related to the kilogram output unit cancelling out when multiplying *G* with *M*.

In collision space-time, we have defined a new mass as collision-time, and it is given by:

$$\bar{m} = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}} = t_p\frac{l_p}{\bar{\lambda}} \tag{5}$$

This is simply the Planck time multiplied by $\frac{l_p}{\bar{\lambda}}$. This last part gives the number of Planck events inside the mass $\bar{m}$ in the Planck time. The Planck events is, according to collision space-time, the number of collisions between the building blocks of photons, that again are assumed to be indivisible particles, as also Newton suggested. This means *GM* is identical to c^3 times the collision-time mass.

This means any collision-time mass is equal to the kilogram mass multiplied by $\frac{G}{c^3}$, which again is identical to multiplying the kilogram mass with $\frac{l_p^2}{\hbar}$, so we have:

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

and naturally we also have

$$c^3\bar{M} = GM \tag{7}$$

For an in-depth discussion on this view of mass, see [24] [25]. In collision space-time, the energy is given as a collision-length and we have:

$$\bar{E} = \bar{m}c = l_p\frac{l_p}{\bar{\lambda}} \tag{8}$$

At first this seems inconsistent as we are so used to $E = mc^2$, but it is fully consistent with this formula and even Einstein's relativistic energy momentum relation $E^2 = p^2c^2 + m^2c^4$. See the appendix for how these two relations are connected and consistent with each other.

Even in standard theory, there is nothing mathematically wrong about saying we redefine energy as $E_2 = E/c$. Standard energy *E* is joule, and joule has output units kg·m^2·s^{-2}. Now the new energy definition would be kg·m·s^{-1}. At a deeper level, pure energy in the form of joule can simply be described as the Planck constant multiplied by a frequency $E = h\frac{c}{\lambda}$; something that is naturally well known. If we now divide this by *c*, as I suggested above, we clearly get a less intuitive form of energy, namely $E_2 = \frac{h}{\lambda}$, so there is naturally no reason to do this as it would just make it even harder to understand what energy is, and it is already far from clear in standard theory what energy really is, or as Feynman once told: "*It is important to realize that in physics today, we have no knowledge what energy is.*"

On the other hand, when we use the collision-time mass and multiply it by c rather than c^2, we get that energy is a length, and not only that, but also that energy is quantized. We get that pure energy is $\bar{E} = l_p \frac{l_p}{\bar{\lambda}}$ where the last part $\frac{l_p}{\bar{\lambda}}$ gives the number of collisions between light particles (indivisibles) per Planck time. This is internal energy and thereby collisions inside matter. Matter in this model consists of indivisible particles moving back and forth over the reduced Compton wavelength and colliding at the reduced Compton frequency, but each collision itself only has a duration of the Planck time. We will not go into too much detail about this here, as it was already discussed in detail in our other papers: [24] [25] [26].

In our model, we end up with the gravity force giving the same predictions in numbers and outputs as Newton's theory, given by:

$$\bar{F}_N = c^3 \frac{\bar{M}\bar{m}}{R^2} \tag{9}$$

This gives different output units than does the 1873 modified Newton formula $F = G\frac{Mm}{R^2}$. The output units of this formula is m·s^{-1}; in other words, velocity. However, the Newton gravity force is never observed directly so even if the two formulas, our new and the 1873 modified Newton force formula, have different output units for the gravity force, they remarkably give the exact same output units and numbers for any gravity phenomena that can be observed. This is demonstrated in **Table 1**. This is because all gravity observable phenomena depend on GM and not on GMm. Further, $c^3\bar{M} = GM$, so for anything just involving GM, the formulas are, at a deeper level, the same and give the same output. This is illustrated in **Table 1**.

Our gravity force formula can also be written in terms of gravity energy (collision-length), and it is then given by:

$$\bar{F}_N = c\frac{\bar{E}\bar{E}}{R^2} \tag{10}$$

Also, this gives the same output and predictions as the 1873 Newton gravity formula. For more on this, see [27]. An advantage with the collision space-time gravity force formulas is that they are actually more precise than the modern 1873 Newtonian modified formula used by modern physics. The reason is it relies on an exact constant, c, while G has large uncertainty. The 1873 formula can be used just as precisely, but only if one finds the gravity parameter GM (often described as $\mu = GM$) directly without finding G separately. However, this is outside the main topic of this article and is discussed in detail in Haug [28].

Table 1. The table shows the predictions from the 1873 modified Newton formula that is used by modern physics today, and the collision space-time force formula that also predicts the same in terms of output units for any effect from gravity that is actually observable.

	1873 modified Newton:	Collision space-time:
Mass	$M=\frac{\hbar}{\bar{\lambda}_M}\frac{1}{c}(\mathrm{kg})$	$\bar{M}=\frac{l_p}{c}\frac{l_p}{\bar{\lambda}_M}$ (collision-time)
Energy	$E=\hbar\frac{c}{\bar{\lambda}_M}(\mathrm{kg})$	$\bar{E}=l_p\frac{l_p}{\bar{\lambda}_M}$ (collision-length)
Non observable (contains *GMm*)		
Gravitational constant	$G,\left(G=\frac{l_p^2c^3}{\hbar}\right)$	c^3
Gravity force	$F_N=G\frac{Mm}{R^2}\left(\mathrm{kg}\cdot\mathrm{m}\cdot\mathrm{s}^{-2}\right)$	$\bar{F}_N=c^3\frac{\bar{M}\bar{m}}{R^2}\left(\mathrm{m}\cdot\mathrm{s}^{-1}\right)$
Observable predictions, identical for the two methods: (contains only *GM*)		
Gravity acceleration	$g=\frac{GM}{R^2}=\frac{c^2}{R^2}\frac{l_p^2}{\bar{\lambda}_M}$	$g=\frac{c^3\bar{M}}{R^2}=\frac{c^2}{R^2}\frac{l_p^2}{\bar{\lambda}_M}$
Orbital velocity	$v_o=\sqrt{\frac{GM}{R}}=c\sqrt{\frac{l_p^2}{R\bar{\lambda}_M}}$	$v_o=\sqrt{\frac{c^3\bar{M}}{R}}=c\sqrt{\frac{l_p^2}{R\bar{\lambda}_M}}$
Time dilation	$T_R=T_f\sqrt{1-\sqrt{\frac{2GM}{R}}^2\Big/c^2}=T_f\sqrt{1-\frac{2l_p^2}{R\bar{\lambda}_M}}$	$T_R=T_f\sqrt{1-\sqrt{\frac{2c^3\bar{M}}{R}}^2\Big/c^2}=T_f\sqrt{1-\frac{2l_p^2}{R\bar{\lambda}_M}}$
Gravitational redshift	$z=\frac{\sqrt{1-\frac{2GM}{R_1c^2}}}{\sqrt{1-\frac{2GM}{R_2c^2}}}-1=\frac{\sqrt{1-\frac{2l_p^2}{R_1\bar{\lambda}_M}}}{\sqrt{1-\frac{2l_p^2}{R_2\bar{\lambda}_M}}}-1$	$z=\frac{\sqrt{1-\frac{2c^3\bar{M}}{R_1c^2}}}{\sqrt{1-\frac{2c^3\bar{M}}{R_2c^2}}}-1=\frac{\sqrt{1-\frac{2l_p^2}{R_1\bar{\lambda}_M}}}{\sqrt{1-\frac{2l_p^2}{R_2\bar{\lambda}_M}}}-1$
Gravitational redshift	$z_\infty(r)\approx\frac{GM}{c^2R}=\frac{l_p^2}{R\bar{\lambda}_M}$	$z_\infty(r)\approx\frac{c^3\bar{M}}{c^2R}=\frac{l_p^2}{R\bar{\lambda}_M}$
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	$v_e=\sqrt{\frac{2GM}{R}}=c\sqrt{2\frac{l_p^2}{R\bar{\lambda}_M}}$	$v_e=\sqrt{\frac{2c^3\bar{M}}{R}}=c\sqrt{2\frac{l_p^2}{R\bar{\lambda}_M}}$
Schwarzschild radius	$r_s=\frac{2GM}{c^2}=2\frac{l_p^2}{\bar{\lambda}_M}$	$r_s=\frac{2c^3\bar{M}}{c^2}=2\frac{l_p^2}{\bar{\lambda}_M}$

Continued

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	$\mu = G(M_1 + M_2) = c^2 \frac{l_p^2}{\bar{\lambda}_1} + c^2 \frac{l_p^2}{\bar{\lambda}_1}$	$c^3(\bar{M}_1 + \bar{M}_2) = c^2 \frac{l_p^2}{\bar{\lambda}_1} + c^2 \frac{l_p^2}{\bar{\lambda}_2}$

The main point to understand here is that gravity, when understood at a deeper level, is dependent on the Planck length, the reduced Compton wavelength, and the speed of light, which is identical to the speed of gravity; see [13] [29]. In other words, to try to unify such things as charge and the Coulomb force with gravity, we need to somehow also incorporate the Planck length. This will be the aim in Section 3, but first we will quickly look at the Coulomb force and charge in standard theory.

2. Background on Coulomb's Law

Coulomb's [30] force, in modern physics, (see, for example, [31]) is given as:

$$|F| = k_e \frac{|q_1||q_2|}{r^2} \tag{11}$$

where k_e is the so-called Coulomb's constant. Coulomb never invented such a constant himself, but it was introduced when the definition and units of charge were later changed. The Coulomb constant today is normally expressed as:

$$k_e = \frac{1}{4\pi\varepsilon_0} \tag{12}$$

where ε_0 is the so-called vacuum permittivity given by $\varepsilon_0 = \frac{1}{\mu_0 c^2}$. Further μ_0 is the vacuum permeability: $\mu_0 = 4\pi \times 10^{-7}$. If one replaces these into the Coulomb constant formula above, one gets:

$$k_e = \frac{1}{4\pi\varepsilon_0} = c^2 \times 10^{-7} \tag{13}$$

Thus the Coulomb constant is not, in reality, a new constant but is simply the speed of light multiplied by 10^{-7}. After the Coulomb constant and charge were again redefined in 2019, this changed slightly, and we would say for the worse. This is outside the scope of this paper, but is discussed in Haug [32].

The elementary charge can be written as:

$$e = \sqrt{\frac{\hbar}{c}\alpha \times 10^7} \approx 1.60217 \times 10^{-19} \text{ Coulomb} \tag{14}$$

where α is the fine structure constant and $\hbar$ is the reduced Planck constant. Now we can insert this in the Coulomb force formula and we get:

$$F = k_e \frac{e^2}{r^2} = c^2 \times 10^{-7} \times \frac{\sqrt{\frac{\hbar}{c}\alpha \times 10^7}\sqrt{\frac{\hbar}{c}\alpha \times 10^7}}{r^2} = \frac{\hbar c \alpha}{r^2} \tag{15}$$

It is important to pay attention to how 10^7 cancels out with 10^{-7}. We suspect the charge is never directly observed[1]. This means one always has the charge squared and also that the 10^7 embedded in the Coulomb constant always cancels with the embedded 10^{-7} in the elementary charge. We think it would therefore make sense to redefine the Coulomb constant to simply $k_e = c^2$ (in a redefined SI system) and the elementary charge to simply $e = \sqrt{\frac{\hbar}{c}\alpha}$, as is the topic of our other article [32]. This would still give the same Coulomb force between two elementary charges:

$$F = k_e \frac{e^2}{r^2} = c^2 \frac{\sqrt{\frac{\hbar}{c}\alpha}\sqrt{\frac{\hbar}{c}\alpha}}{r^2} = \frac{\hbar c\alpha}{r^2} \quad (16)$$

When it comes to the Planck charge, this can be described as:

$$q_p = \sqrt{\frac{\hbar}{c}\times 10^7} \approx 1.876\times 10^{-18} \text{ Coulombs} \quad (17)$$

and this gives a Coulomb force of:

$$F = k_e \frac{q_p^2}{r^2} = c^2 \times 10^{-7} \frac{\sqrt{\frac{\hbar}{c}10^7}\sqrt{\frac{\hbar}{c}10^7}}{r^2} = \frac{\hbar c}{r^2} \quad (18)$$

Again, we see the 10^7 and 10^{-7} cancel each other out. So, we have, in a previous paper [32], suggested reformulating the Planck charge inside standard theory to simply:

$$q_p = \sqrt{\frac{\hbar}{c}} \quad (19)$$

and again the Coulomb constant is then suggested to be only c^2. This modification alone, of simply dispensing with 10^7 and 10^{-7}, is not enough to make the Coulomb force and electric units unify with gravity. To accomplish that, we have to somehow incorporate the Planck length. This is the topic of the next sections.

3. Coulomb Force and Charge in Collision Space-Time

In collision space-time we will claim the elementary charge could be described as:

$$\bar{e} = \sqrt{\frac{l_p^2}{c}\alpha} = \sqrt{t_p l_p \alpha} \approx 7.98\times 10^{-41}\left(\text{s}^{1/2}\cdot\text{m}^{1/2}\right) \quad (20)$$

As we will later see, this seems to lead to consistency. The output dimension is square root of the Planck time, times the Planck length, that again is multiplied by the fine structure constant; that is, the dimensions are ($\sqrt{TL}$). Be aware that $\bar{e}$ is not used to illustrate the charge as a vector, but just to distinguish it from the standard charge definition symbol of *e*. Coulomb's law for two elementary charges can then be described as:

[1]Or at least, not directly in the form it is expressed mathematically.

$$\left|F\right| = \bar{k}_e \frac{\bar{e}^2}{r^2} = c^2 \frac{\sqrt{\frac{l_p^2}{c}\alpha}^{\,2}}{r^2} = \frac{l_p^2}{r^2}\alpha c \tag{21}$$

where $\bar{k}_e = c^2$ by definition. Further, the Planck mass charge is now given by:

$$\bar{q}_p = \sqrt{\frac{l_p^2}{c}} = \sqrt{t_p l_p} \tag{22}$$

This means that the Planck charge squared is the Planck time multiplied by the Planck length[2]. In physics, there is a lesser-known term called *absement*, which is defined as time multiplied by length or, in SI units, as meters times seconds, so the Planck charge squared would be the Planck analogy of absement. The interesting thing is that absement has been pointed out to be the mechanical analog of integrated charge; see Jeltsema [34]. In other words, our redefined elementary and Planck charge are potentially not that far off from what others have also thought about electrical properties. Be aware that our collision space-time theory is, at the deepest level, purely mechanical, so it is indeed a mechanical analog to charge.

This means the Coulomb force for Planck mass charges is now given by:

$$\bar{F} = \bar{k}_e \frac{\bar{q}_p^2}{r^2} = c^2 \frac{\sqrt{\frac{l_p^2}{c}}^{\,2}}{r^2} = c\frac{l_p^2}{r^2} \tag{23}$$

The output dimension of the Coulomb force is now a speed (or velocity). In the special case of $r = l_p$, we get that for the Planck charge:

$$\bar{F} = \bar{k}_e \frac{\bar{q}_p^2}{l_p^2} = c \tag{24}$$

The gravity force in collision space-time is given by:

$$\bar{F}_N = c^3 \frac{\bar{M}\bar{m}}{r^2} = c\frac{l_p^2}{R^2}\frac{l_p}{\bar{\lambda}_M}\frac{l_p}{\bar{\lambda}_M} \tag{25}$$

where $\bar{M} = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}_M}$ and $\bar{m} = \frac{l_p}{c}\frac{l_p}{\bar{\lambda}}$; that is, we are using the collision-time definition for mass and, in the case of two Planck masses and also $r = l_p$, we get:

$$\bar{F}_N = c^3 \frac{\bar{m}_p\bar{m}_p}{l_p^2} = c\frac{l_p^2}{l_p^2} = c \tag{26}$$

The gravity force and the electromagnetic force have the same speed at the Planck scale, namely the speed of light. That is, gravity and electromagnetism both have the same speed limit. However, we should be very careful with interpretation here as *GMm* is a non-observable, while only *GM* is used to predict observable gravity phenomena. Secondly, the mass *m* should be much smaller than *M*, so if one has two identical Planck masses in the formula, it can likely not

[2]Already in 2018 we worked on incorporating the Planck length into the elementary charge and the Planck charge, but then under a still non optimal mass definition, see [33].

be written as done here. Then we are dealing with a real two-body problem where the gravity parameter is $\mu = G(M+m) = GM + Gm$. Several suggestions have been made in relation to unifying gravity and the Coulomb force, see, for example, Davidson and Owen [35], Caillon [36], Zegarra *et al.* [37], Pilot [38] and Sharafiddinov [39]. This paper also tries to look at the connection between gravity and the Coulomb force. It is not in our view necessarily true that the Coulomb force is directly linked to gravity, but our methodology seems to make it at least easier to compare it with gravity.

4. Electric Properties Related to the Planck Scale

Electric properties linked to the Planck scale have been discussed in the standard literature. For example, Planck voltage has been described by Lundgren [40] and Buczyna *et al.* [41] as:

$$V_p = \sqrt{\frac{c^4}{4\pi\varepsilon_0 G}} = \frac{c}{l_p}\sqrt{c\hbar}\sqrt{10^{-7}} \tag{27}$$

Further, voltage times charge should be energy. The Planck voltage times Planck charge should therefore be Planck energy, as it is:

$$E_p = V_p q_p = \hbar\frac{c}{l_p} \tag{28}$$

This gives the standard Planck energy in joule. However, in collision space-time, Planck energy is simply given as a collision-length equal to the Planck length:

$$\bar{E}_p = \bar{m}_p c = t_p \frac{l_p}{\bar{\lambda}} c = l_p \frac{l_p}{\bar{\lambda}} = l_p \tag{29}$$

Since the reduced Compton wavelength of the Planck mass particle is the Planck length, so $\bar{\lambda} = l_p$, we end up with a collision-length energy equal to the Planck length.

Since we have already defined the Planck charge as $\bar{q}_p = \sqrt{t_p l_p}$, in the last section, this means the Planck voltage must be defined as $\bar{V}_p = \sqrt{c}$, for the Planck voltage times Planck charge to be consistent with this. **Table 2** shows a series of standard electrodynamic properties related to the Planck mass particle and how we think these must be reformulated to be consistent with collision space-time.

Most (except two) of the collision space-time electromagnetic properties in **Table 2** one gets from simply replacing $\hbar$ with l_p^2 and also getting rid of 10^7 and 10^{-7} in the standard units. So, we can easily go back and forth between the two systems. When it comes to energy, one in addition needs to divide by c to go from Joule energy to collision-length energy.

In standard physics one has, for example, the SI units, the Gauss unit system, and the Heaviside-Lorentz unit system for electrodynamic properties; see [42] [43]. Also, inside collision space-time one can similarly choose between different unit systems, where some have certain advantages over the other units. For

Table 2. The table shows different electric properties as can be described by standard definitions, as well as efforts to make them compatible with collision space-time theory.

	Standard:	Linked to collision space-time:
Coulomb constant	$k_e = \frac{1}{4\pi\varepsilon_0} = c^2 \times 10^{-7}$	$\bar{k}_e = c^2$
Planck charge	$q_p = \sqrt{\frac{\hbar}{c} \times 10^7}$	$\bar{q}_p = \sqrt{t_p l_p}$
Planck voltage	$V_p = \frac{c}{l_p}\sqrt{\hbar c}\sqrt{10^{-7}}$	$\bar{V}_p = \sqrt{c}$
Planck energy	$E_p = V_p q_p = \hbar \frac{c}{l_p}$	$\bar{E}_p = \bar{V}_p \bar{q}_p = l_p$
Planck impedance	$I_p = \frac{\sqrt{\hbar c \times 10^7}}{l_p}$	$\bar{I}_p = \frac{\sqrt{\hbar c}}{l_p}$
Planck resistance	$R_\Omega = \frac{V_p}{I_p} = c \times 10^{-7}$	$\bar{R}_\Omega = \frac{V_p}{I_p} = c$
Magnetic field	$\sqrt{k_e \frac{c^5}{\hbar G^2}} = \frac{\sqrt{\hbar c \times 10^{-7}}}{l_p^2}$	$\frac{\sqrt{c}}{l_p}$
Electric field	$\sqrt{k_e \frac{c^7}{\hbar G^2}} = \frac{c\sqrt{\hbar c \times 10^{-7}}}{l_p^2}$	$\frac{c\sqrt{c}}{l_p}$
Coulomb force Planck charges	$F = k_e \frac{q_p q_p}{r^2} = \hbar \frac{c}{r^2}$	$\bar{F} = c^2 \frac{\bar{q}_p \bar{q}_p}{r^2} = \frac{l_p^2}{r^2} c$
Charged squared	$q^2 = \frac{\hbar}{c} \times 10^7$	$\bar{q}_p^2 = t_p l_p$ (absement)

example, the standard Heaviside-Lorentz unit system is often used in quantum field theory instead of the SI or Gauss unit system as it simplifies many calculations there. Only further analysis over time can therefore likely tell what the optimal unit system for electrical properties under collision space-time is. However, it is quite clear that the Planck units must be incorporated and that the Planck constant $\hbar$ must be thrown out even of such things as charge. In Planck charge, under the SI unit system, there are no embedded Planck units as it is $q_p = \sqrt{\frac{\hbar}{c} \times 10^7}$. The Planck constant is not part of the Planck units, even if the Planck constant is one of three constants Max Planck used to derive the Planck units.

Table 3 shows a Gauss unit-inspired system modified to fit collision space-time. Here the Coulomb constant is one. This gives a Coulomb force formula like the one Coulomb himself introduced, which had no Coulomb constant. The Coulomb constant was introduced later when the units for charge were reformulated.

Table 4 shows a Heaviside-Lorentz-inspired unit system. Interesting in this unit system is that charge square under collision space-time is simply the surface

Table 3. The table shows different electric properties as can be described by Gauss unit-inspired system under kilogram definition of mass and Joule as energy. This is under the column "standard". A similar unit system under collision space-time is shown in the last column.

	Standard:	Linked to collision space-time:
Coulomb constant	$k_e = 1$ (none)	$k_e = 1$ (none)
Planck charge	$q_p = \sqrt{\hbar c}$	$\bar{q}_p = l_p \sqrt{c}$
Planck voltage	$V_p = \frac{\sqrt{\hbar c}}{l_p}$	$\bar{V}_p = \frac{1}{\sqrt{c}}$
Planck energy	$E_p = V_p q_p = \hbar \frac{c}{l_p}$	$\bar{E}_p = \bar{V}_p \bar{q}_p = l_p$
Planck impedance	$I_p = \frac{\sqrt{\hbar}}{l_p \sqrt{c}}$	$\bar{I}_p = \frac{1}{\sqrt{c}}$
Planck resistance	$R_\Omega = \frac{V_p}{I_p} = c$	$\bar{R}_\Omega = \frac{V_p}{I_p} = c$
Magnetic field	$\sqrt{\frac{c^7}{\hbar G^2}} = \frac{\sqrt{\hbar c}}{l_p^2}$	$\frac{\sqrt{c}}{l_p}$
Electric field	$\sqrt{\frac{c^9}{\hbar G^2}} = \frac{c\sqrt{\hbar c}}{l_p^2}$	$\frac{c\sqrt{c}}{l_p}$
Coulomb force Planck charges	$F = \frac{q_p q_p}{r^2} = \hbar \frac{c}{r^2}$	$\bar{F} = \frac{\bar{q}_p \bar{q}_p}{r^2} = \frac{l_p^2}{r^2} c$
Charge squared	$q_p^2 = c\hbar$	$\bar{q}_p^2 = c l_p^2$

Table 4. The table shows different electric properties as can be described by standard definitions under a Heaviside-Lorentz-inspired unit system for kilogram mass and joule (standard) as well as under collision space-time (collision-time mass and collision-length energy).

	Standard:	Linked to collision space-time:
Coulomb constant	$k_e = \frac{1}{4\pi}$	$k_e = \frac{1}{4\pi}$
Planck charge	$q_p = \sqrt{4\pi\hbar c}$	$\bar{q}_p = l_p \sqrt{4\pi c}$
Planck voltage	$V_p = \frac{\sqrt{\hbar c}}{l_p \sqrt{4\pi}}$	$\bar{V}_p = \frac{1}{\sqrt{4\pi c}}$
Planck energy	$E_p = V_p q_p = \hbar \frac{c}{l_p}$	$\bar{E}_p = \bar{V}_p \bar{q}_p = l_p$
Planck impedance	$I_p = \frac{\sqrt{4\pi\hbar c}}{l_p}$	$\bar{I}_p = \frac{\sqrt{4\pi}}{\sqrt{c}}$
Planck resistance	$R_\Omega = \frac{V_p}{I_p} = c$	$\bar{R}_\Omega = \frac{V_p}{I_p} = c$

Continued

Magnetic field	$\sqrt{\frac{1}{4\pi}\frac{c^5}{\hbar G^2}} = \frac{\sqrt{\hbar c \times 10^{-7}}}{\sqrt{4\pi} l_p^2}$	$\frac{\sqrt{c}}{\sqrt{4\pi} l_p}$
Electric field	$\sqrt{\frac{1}{4\pi}\frac{c^7}{\hbar G^2}} = \frac{c\sqrt{\hbar c}}{\sqrt{4\pi} l_p^2}$	$\frac{c\sqrt{c}}{\sqrt{4\pi} l_p}$
Coulomb force Planck charges	$F = \frac{1}{4\pi}\frac{q_p q_p}{r^2} = \hbar\frac{c}{r^2}$	$\bar{F} = \frac{1}{4\pi}\frac{\bar{q}_p \bar{q}_p}{r^2} = c\frac{4\pi l_p^2}{4\pi r^2} = \frac{l_p^2}{r^2}c$
Charged square	$q_p^2 = 4\pi c\hbar$	$\bar{q}_p^2 = c4\pi l_p^2$

area of a sphere with radius equal to the Planck length, $4\pi l_p^2$, multiplied by the speed of light. The speed of light can then likely simply be seen as a scaling factor linking the length and time through the speed of light. When time and distance are linked through the speed of light, then the speed of light is set equal to one ($c = 1$) and then we see the charge square is simply the surface area of the Planck sphere. The Coulomb force is now simply the surface area of a Planck sphere divided by the surface area relative to the surface area of the distance we make the measurement from.

The Planck charge squared in **Table 3** is given by: $\bar{q}_p^2 = cl_p^2$ and in the unit system in **Table 4** it is $\bar{q}_p^2 = c4\pi l_p^2$. The term cl_p^2 can be easily extracted from a series of gravity phenomena with zero knowledge of G, $\hbar$ or c as demonstrated in [20]. So, this perhaps indicates that gravity could indeed also be related to electrodynamics at the Planck scale. At least, further investigation is warranted.

Table 5 gives a unit system that we [32] have previously introduced when dealing with kilogram and joule-related unit systems. Here, it is extended to also working in collision-time theory in the last column. In this unit system, the electric field is now just one divided by the Planck mass when the mass is defined as collision-time. This is the Planck frequency. Further, the magnetic field is simply one divided by the collision-length energy of a Planck mass particle. That is, the electric field is linked to time, as frequency is linked to time, and the magnetic field is linked to space. In collision space-time theory, these are two different sides of the same coin so to say; see [25] for an in-depth discussion on the relation between collision-time and collision-length.

In all these unit systems, charge and Coulomb force can likely be measured as before. It is just that we give the charge a different value and unit system. For this system to work, we must first have found the Planck length and Planck time from a gravitational phenomenon, as can easily be done, and as described in detail by [13] [44]. This will lead to larger uncertainty in, for example, the charge than before, but then it now also contains some information about quantum gravity theory. The old system can still be used in collision space-time, but we then strip it first of all information about quantum gravity. So, in collision space-time we can decide if we want to use the old standard system or the new unit system when dealing with non-directly linked gravity phenomena. The

Table 5. The table shows different electric properties as can be described by a unit system as suggested in [32] when dealing with kilogram and joule. The last column shows how this system would be under collision space-time.

	Standard:	**Linked to collision space-time:**
Coulomb constant	$k_e = c$	$k_e = c$
Planck charge	$q_p = \sqrt{\hbar}$	$\bar{q}_p = l_p$
Planck voltage	$V_p = c\frac{\sqrt{\hbar}}{l_p}$	$\bar{V}_p = c$
Planck energy	$E_p = V_p q_p = \hbar\frac{c}{l_p}$	$\bar{E}_p = \frac{\bar{V}_p \bar{q}_p}{c} = l_p$
Planck impedance	$I_p = \frac{\sqrt{\hbar}}{l_p}$	$\bar{I}_p = 1$
Planck resistance	$R_\Omega = \frac{V_p}{I_p} = c$	$\bar{R}_\Omega = \frac{V_p}{I_p} = c$
Magnetic field	$\frac{\sqrt{\hbar}}{l_p^2}$	$\frac{1}{l_p}$
Electric field	$\frac{c\sqrt{\hbar}}{l_p^2}$	$\frac{c}{l_p}$
Coulomb force Planck charges	$F = c\frac{q_p q_p}{r^2} = \hbar\frac{c}{r^2}$	$\bar{F} = c\frac{\bar{q}_p \bar{q}_p}{r^2} = \frac{l_p^2}{r^2}c$
Charge squared	$q_p^2 = \hbar$	$\bar{q}_p^2 = l_p^2$

point is, we have built a bridge between the two systems, or at least attempted to do so.

To go from one system using kilogram and joule to the system in any of the tables to the last column in each table when dealing with mass as collision-time, all we need to do is replace the Planck constant by l_p^2. So, it is easy to go between the two systems in any table. When we deal with energy (and voltage) we need to also divide by c to get the collision-length energy from joule; see also [24] [26] and also the appendix in this paper.

In our theory, there are naturally also still unsolved challenges. For example, why does the fine structure constant, that is part of the elementary charge, have the value it has? This is not answered in our theory yet either. Ideally, we should be able to derive its value, or at least have a deeper understanding of why it has the value it has. Another topic to look closer at is exactly what is measured and what is derived from experiments related to charge and the Coulomb force, and then look more closely at what properties are just derived units and which one correspond closer to observed units. One can also look further into derivations here; for example, by following the interesting outlines looked at in recent literature, see [43] [45]. An important outstanding issue is how this can potentially be incorporated in Maxwell's equations. We know from standard theory that Maxwell's equations look a little different for each unit system. Would Maxwell's equations even be compatible with our new unit system? This needs further investigation.

5. Conclusions

In this paper, we have looked at how to potentially reformulate charge and the Coulomb force to be consistent with a new quantum gravity theory that seems able to unify quantum mechanics with gravity.

The new electric unit system contains the Planck length and Planck time. These can be found first from gravity phenomena. Such things as charge will be found as before but, for example, one elementary charge will then be defined with value as given in this paper. In this way, electric properties are linked to gravity.

Just like in standard physics, we have also suggested several different unit systems that are consistent with collision space-time theory. One is, for example, Heaviside-Lorentz inspired while another is Gaussian unit-inspired. Further research can likely find out which is the optimal system to use, and which again could be purpose dependent, just as in standard theory. A major step forward would be to show how this new view can potentially be linked to Maxwell's equations. It is well known it is possible to derive the Coulomb force from Maxwell's equations. Here, we have a new formulation of the Coulomb force linked to collision space-time; an interesting question is whether it could be reverse engineered to modify Maxwell's equation. This paper is mainly meant as inspiration for further discussions rather than to claim this is how it must be. Progress in physics has often started out as speculative ideas; then a more solid framework has evolved over time step by step, or the idea has been rejected. This is how science progresses.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendix

In our model, we have $\bar{E} = \bar{m}c$ but this is fully consistent with $E = mc^2$ and also the relativistic energy momentum principle. This we can see by the following derivations:

$$\bar{E} = \bar{m}\gamma c_g$$

$$\bar{E}^2 = \bar{m}^2 c_g^2 \gamma^2$$

$$\bar{E}^2 = \bar{m}^2 c^2 \gamma^2 - \bar{m}^2 c^2 + \bar{m}^2 c^2$$

$$\bar{E}^2 = \frac{\bar{m}^2 c^2}{1 - v^2/c^2} - \bar{m}^2 c^2 + \bar{m}^2 c^2$$

$$\bar{E}^2 = \frac{\bar{m}^2 c^2}{1 - v^2/c^2} - \frac{\bar{m}^2 c^2 \left(1 - v^2/c^2\right)}{1 - v^2/c^2} + \bar{m}^2 c^2$$

$$\bar{E}^2 = \frac{\bar{m}^2 c^2}{1 - v^2/c^2} - \frac{\bar{m}^2 c^2 - \bar{m}^2 v^2}{1 - v^2/c^2} + \bar{m}^2 c^2$$

$$\bar{E}^2 = \frac{\bar{m}^2 v^2}{1 - v^2/c^2} + \bar{m}^2 c^2$$

$$\bar{E}^2 = \bar{p}^2 + \bar{m}^2 c^2$$

$$\bar{E} = \sqrt{\bar{p}^2 + \bar{m}^2 c^2} \tag{30}$$

where γ is the Lorentz factor $\gamma = 1\big/\sqrt{1 - v^2/c^2}$. Next our energy $\bar{E}$ must be multiplied by $\frac{\hbar}{l_p^2}c$ to go from collision-length to joule, so we have:

$$\bar{E}\frac{\hbar}{l_p^2}c = \frac{\hbar}{l_p^2}c\sqrt{\bar{p}^2 + \bar{m}^2 c^2}$$

$$E = \sqrt{p^2 c^2 + m^2 c^4} \tag{31}$$

Which is the standard relativistic energy momentum relation with joule energy and kilogram mass. See [25] for more details.