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# Potential Simplification of Charge and the Coulomb Force without Affecting Predictions

**Espen Gaarder Haug**

Norwegian University of Life Sciences, Ås, Norway
Email: espenhaug@mac.com

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## Abstract

We are taking a deeper look at charge and the Coulomb force and other electric properties. There is an embedded $10^{-7}$ in the Coulomb constant that we will claim is "only" needed to cancel out an embedded $10^{7}$ in the charge squared. We suggest three alternatives to redefine the charge and the Coulomb constant that give considerable simplification. The Coulomb constant is not needed as a separate constant as, in the new suggested framework, it can be replaced with simply the speed of light without affecting predicted output values. We also point out potential issues with the 2019 redefinition of the Coulomb constant and elementary charge. This is not meant conclusive but to open up for further discussion on how one potential can simplify parts of physics.

## Keywords

Coulomb Law, Coulomb Constant, Elementary Charge, Planck Charge, Planck Voltage, Electric Units

## 1. Discussion of the Coulomb's Law and Charge

The Coulomb's [1] force is, in modern physics papers and university text books, [2] given as:

$$F = k_e \frac{|q_1||q_2|}{r^2} \tag{1}$$

where $k_e$ is the so-called Coulomb's constant that Coulomb himself actually never invented or used, but that was introduced later when a new definition of the charge was given. For simplicity, we will skip the absolute value signs for the charges going forward as it will not affect any conclusions from our analysis. The Coulomb's constant is normally written as:

$$k_e = \frac{1}{4\pi\varepsilon_0} \tag{2}$$

This way of writing the Coulomb constant is, we will claim, confusing as it conceals what the Coulomb constant actually represents. It looks like the Coulomb constant is a separate constant needed, which is not the case in our view. In the Coulomb constant, the $\varepsilon_0$ is the so-called vacuum permittivity given by $\varepsilon_0 = \frac{1}{\mu_0 c^2}$, and $\mu_0$ is the vacuum permeability: $\mu_0 = 4\pi \times 10^{-7}$. If one replaces this into $k_e$ and simplifies, one simply gets:

$$k_e = \frac{1}{4\pi\varepsilon_0} = c^2 \times 10^{-7} \tag{3}$$

That is, the Coulomb constant is nothing more than the speed of light squared multiplied by $10^{-7}$. This was also exact before 2019. This is different than the 2019 SI definition of the Coulomb constant, where its value is uncertain and given by: $k_e = \frac{1}{4\pi\varepsilon_0} = c^2 \times 1.00000000054(15) \times 10^{-7}$ something we soon get back to. What is important here is that the Coulomb constant is simply the well-known speed of light squared multiplied by a number. Further, the elementary charge can be described as:

$$e = \sqrt{\frac{\hbar}{c}\alpha \times 10^7} \approx 1.60217 \times 10^{-19} \text{ Coulomb} \tag{4}$$

Here, there will be an uncertainty in the elementary charge that comes from the uncertainty in the measurements of the fine structure constant $\alpha$. Since 2019, the elementary charge has been exactly defined as 1.602176634 × $10^{-19}$ Coulomb (C) (see [3]), something we will soon get back to.

Based on the definition of elementary charge given by Equation (4) we then have:

$$F = k_e \frac{e^2}{r^2} = c^2 \times 10^{-7} \times \frac{\sqrt{\frac{\hbar}{c}\alpha \times 10^7}\sqrt{\frac{\hbar}{c}\alpha \times 10^7}}{r^2} = \frac{\hbar c \alpha}{r^2} \tag{5}$$

Pay attention to the fact that the $10^{-7}$ in the Coulomb's constant is basically needed to cancel with the $10^7$ we get from the elementary charged squared. In our view, the units of the charge could have been chosen differently, and one could have decided to define the elementary charge as:

$$e = \sqrt{\frac{\hbar}{c}\alpha} \approx 5.067 \times 10^{-23} \tag{6}$$

That is, simply take the $\sqrt{10^7}$ out of it. And in that case, the Coulomb's constant has to be redefined as $c^2$ and the rewritten Coulomb force formula would still give the same output as before. In practice, does one ever directly observe the elementary charge? Or is it only observed indirectly as a mathematical function of something else one observes? We think the latter, but are open to discussions and suggestions on this point. We suggest that one is simply observing the

Coulomb force, which always consists of the charged squared multiplied by the Coulomb's constant.

We suggest the Coulomb formula can be rewritten as:

$$F = c^2 \frac{qq}{r^2} \tag{7}$$

but now with the $\sqrt{10^7}$ taken out of the charge. For elementary charges this would now give:

$$F = c^2 \frac{ee}{r^2} = c^2 \frac{\sqrt{\frac{\hbar}{c}\alpha}\sqrt{\frac{\hbar}{c}\alpha}}{r^2} = \hbar \frac{c\alpha}{r^2} \tag{8}$$

in other words, the same end result as before from Equation (5). Perhaps even simpler would be to re-define the elementary charge as:

$$e = \sqrt{\hbar\alpha} \tag{9}$$

and then the Coulomb constant as *c*, which would give:

$$F = c\frac{ee}{r^2} = c\frac{\sqrt{\hbar\alpha}\sqrt{\hbar\alpha}}{r^2} = \hbar\frac{c\alpha}{r^2} \tag{10}$$

In other words, this is the same as before, but with a strong simplification of the formulation. This would naturally lead to one also needing to redefine other electric properties accordingly.

The Planck charge is given by:

$$q_p = \sqrt{\frac{\hbar}{c}\times 10^7} \approx 1.876\times 10^{-18} \text{ Coulombs} \tag{11}$$

which gives a Coulomb's force of:

$$F = k_e \frac{e^2}{r^2} = c^2 \times 10^{-7} \frac{\sqrt{\frac{\hbar}{c}\times 10^7}\sqrt{\frac{\hbar}{c}\times 10^7}}{r^2} = \frac{\hbar c}{r^2} \tag{12}$$

The Planck charge would be based on our new suggestion, where $k_e$ is redefined as $c^2$ and the charge have to be re-defined from $q_p = \sqrt{\frac{\hbar}{c}\times 10^7}$ to

$$q_p = \sqrt{\frac{\hbar}{c}} \tag{13}$$

or in the case in which we set $k_e = c$, we have to re-define the Planck charge as simply $\sqrt{\hbar}$. This would still give the same result as before, as we would have:

$$F = c\frac{q^2}{r^2} = c\frac{q_p q_p}{r^2} = c\frac{\sqrt{\hbar}\sqrt{\hbar}}{r^2} = \hbar\frac{c}{r^2} \tag{14}$$

which is the same end result what one gets in the standard theory.

Column one in Table 1 shows the standard way (the way before 2019) to express some electric properties as well as the Coulomb force. Normally, the Coulomb constant is written as $k_e = \frac{1}{4\pi\varepsilon_0}$, something we will claim is confusing as it is

**Table 1.** The table shows different electric properties as can be described by standard definitions as well as three suggested simplifications.

| | Standard (pre-2019): | Alternative 1: | Alternative 2: | Alternative 3: |
|---|---|---|---|---|
| The Coulomb constant | $k_e=\frac{1}{4\pi\varepsilon_0}=c^2\times 10^{-7}$ | $k_e=c^2$ | $k_e=c$ | |
| Elementary charge | $e=\sqrt{\frac{\hbar}{c}\alpha\times 10^7}$ | $e=\sqrt{\frac{\hbar}{c}\alpha}$ | $e=\sqrt{\hbar\alpha}$ | $e=\sqrt{\hbar\alpha c}$ |
| Planck charge | $q_p=\sqrt{\frac{\hbar}{c}\times 10^7}$ | $q_p=\sqrt{\frac{\hbar}{c}}$ | $q_p=\sqrt{\hbar}$ | $q_p=\sqrt{\hbar c}$ |
| The Coulomb force | $F=k_e\frac{qq}{r^2}$ | $F=c^2\frac{qq}{r^2}$ | $F=c\frac{qq}{r^2}$ | $F=\frac{qq}{r^2}$ |
| The Coulomb force elementary charges | $F=k_e\frac{ee}{r^2}=\hbar\frac{c\alpha}{r^2}$ | $F=c^2\frac{ee}{r^2}=\hbar\frac{c\alpha}{r^2}$ | $F=c\frac{ee}{r^2}=\hbar\frac{c\alpha}{r^2}$ | $F=\frac{ee}{r^2}=\hbar\frac{c\alpha}{r^2}$ |
| Coulomb force Planck charges | $F=k_e\frac{q_pq_p}{r^2}=\hbar\frac{c}{r^2}$ | $F=c^2\frac{q_pq_p}{r^2}=\hbar\frac{c}{r^2}$ | $F=c\frac{q_pq_p}{r^2}=\hbar\frac{c}{r^2}$ | $F=\frac{q_pq_p}{r^2}=\hbar\frac{c}{r^2}$ |

not easy for a non-trained person to see the Coulomb constant embedded contains the speed of light. If $k_e=\frac{1}{4\pi\varepsilon_0}=c^2\times 10^{-7}$, then some curious researchers will start to wonder why the $10^{-7}$ is there, and why not only $c^2$. We think we possibly have the answer to this; namely, that the embedded $10^7$ and $10^{-7}$ are only due to human convention and that the $10^{-7}$ is only there indirectly to cancel out the $10^7$ that is embedded in the elementary charge as well as the Planck charge. And the reason for this is likely an arbitrary choice of units before the theory had attained much depth. We therefore suggest re-formulating both the charge and the Coulomb constant and thereby the Coulomb force. The first alternative is shown in Table 1, where we just got rid of the $10^7$ and $10^{-7}$, while alternatives two and three simplify this further.

The Coulomb force in alternative 3 is similar to the Gauss unit system, which was frequently used in older papers and is still used today. In the Gauss unit system, for example, the Coulomb force is given by $F=\frac{qq}{r^2}$; that is, with no Coulomb force constant. See, for example [4].

## 2. Short Discussion of the Coulomb Constant and Elementary Charge Using the 2019 Definition

In the 2019 redefinition of the SI base units, the value of the vacuum permeability $\mu_0$ is defined as $4\pi\times 1.00000000054(15)\times 10^{-7}$ rather than as its exact value $4\pi\times 10^{-7}$ as it had before the 2019 new SI standard, see [5]. The 2019 SI standard introduced uncertainty in the vacuum permeability means the Coulomb constant is now given by:

$$k_e=c^2\times 1.00000000054(15)\times 10^{-7} \tag{15}$$

Further, the elementary charge was redefined to be an exact value. We doubt this was optimal or even a very Logical consistent redefinition of SI units. In our view, the $10^{-7}$ is simply needed to cancel the $10^{7}$ embedded in the elementary charged squared as described in the section above. Making the Coulomb constant a non-exact constant seems to be far from the optimal way to move around the uncertainty in the measured Coulomb force. The uncertainty in the Coulomb force should, in our view, come from the uncertainty in the charge that again comes from the uncertainty in the fine structure constant. The elementary charge can be, as described in the previous section, expressed as:

$$e=\sqrt{\frac{\hbar}{c}\alpha\times 10^{7}} \tag{16}$$

but this is not compatible with the new 2019 SI definition.

We think it would have been more consistent with fixing the Planck charge and instead let the elementary charge have uncertainty related to the uncertainty in the fine structure constant as also discussed by [6]. The Planck charge should be fixed to $q_p=\sqrt{4\pi\varepsilon_0\hbar c}=\sqrt{\frac{\hbar}{c}\times 10^{7}}$. This requires that one keep the vacuum permeability $\mu_0=4\pi\times 10^{-7}$. The elementary charge can then not be fixed as the difference between the Planck charge and the elementary charge is the $\sqrt{\alpha}$, that is $e=q_p\sqrt{\alpha}$, and there is uncertainty in the fine structure constant.

Since the discovery of charge, there have naturally been many papers discussing how to measure it most accurately; see, for example, [7] [8]. However, since 2019, the elementary charge has been defined as exact [9]. We know $c$ has already been defined as exact and this makes sense as the round-trip speed has been well tested to be a constant, and isotropic, and the same in any reference frame. Further, the one-way speed of light is the same as the round-trip speed of light when using Einstein's synchronized clock (per definition). In rotating systems, it could be more complicated; see [10] [11]. Further, the Planck constant is a constant. The fine structure constant is not exact, so to get this formula now to be exact based on the 2019 assumptions, then $10^{7}$ cannot be exactly $10^{7}$, but must be slightly different, and not only that, the uncertainty in $10^{7}$ must exactly offset the uncertainty in $\alpha$. That is, the errors in the two must cancel exactly. This makes no sense in our view, in particular, since $10^{7}$ will always cancel with $10^{-7}$ embedded in the Coulomb constant. We think it has been a mistake to define the elementary charge exactly in 2019, as this likely leads to more problems than it solves, in particular in terms of lack of logic. The decision to not have the Planck charge constant and to make the elementary charge constant was partly favored by arguments from super string theory:

"*The advantage of the second choice is the possibility of accommodating a space-time varying fine structure constant, which appears then as a property of the vacuum and, in this case, easier implementation of gauge invariance. Advanced string theory points in this direction for the future* [12]." From [6] page 585.

Superstring theory has had very limited success as is very well illustrated by the book by Conlon [13] titled: *Why String Theory*? This book has a chapter with the title: "*Experimental evidence of string theory*" and then this chapter has only one sentence: "There is no direct experimental evidence for string theory". Even if a bit humoristic, this is a book written by a string theorist and this chapter of one sentence very well illustrates the lacking success of this theory. That string theories basically non-testable predictions therefore have been used indirectly to decide on or at least influence the choice of having the elementary charge constant rather than the Planck charge as a constant makes in our view little sense. To fix the Planck charge only means one has to fix the speed of light and the Planck constant as was already been done in 2019. To fix $e$ again means the uncertainty in the fine structure constant somehow must exactly offset the uncertainty in the now (2019 SI standard) uncertainty in the vacuum permeability.

We suggest to re-considering fixing the Planck charge and having the elementary charge a function of the fine structure constant as in formula 16. However, we suggest further change that is to remove the $10^7$ embedded both in the Planck charge and in the elementary charge, and also then to remove $10^{-7}$ embedded in the Coulomb constant. All the alternatives in **Table 1** seem to simplify physics compared to the 2019 standard, where the columns marked alternative 1 to 3 again seem to be preferable. One then has the elementary charge as a function of the fine structure constant, and thereby uncertain.

## 3. The Composite View of the Gravity Constant Simplifies Many Formulas Related to Planckian Electricity

Max Planck [14] [15] in 1899 introduced the Planck length: $l_p = \sqrt{\frac{G\hbar}{c^3}}$, the Planck time: $t_p = \sqrt{\frac{G\hbar}{c^5}}$, the Planck mass: $m_p = \sqrt{\frac{\hbar c}{G}}$, and the Planck temperature: $T_p = \sqrt{\frac{\hbar c^5}{G k_b}}$. These he derived based on dimensional analysis, assuming there were three important universal constants: $G$, $c$ and $\hbar$. In 1984, Cahill [16] already suggested that one could express the Newton gravitational constant as a function of the Planck mass: $G = \frac{\hbar c}{m_p^2}$. This is simply the Planck mass formula solved with respect to $G$. However, Cohen [17] in 1987 pointed out that this way to express $G$ made little sense as it seemed impossible to find the Planck units without first knowing $G$, so it seemed to just lead to a circular problem, a view held by the physics community until at least 2016. In 2017, Haug [18] was able, for the first time, to demonstrate that the Planck length could actually be found without any knowledge of $G$, and later he showed how the Planck length could be found without any knowledge of $G$ and $\hbar$; see [19] [20] and even without any knowledge off $G$, $h$ and $c$; see [21] [22]. This means we can express the gravity constant as a function of the Planck length of the form $G = \frac{l_p^2 c^3}{\hbar}$, which is simply the Planck length formula solved with respect to $G$. That is the composite view of $G$ as recently discussed in detail by Haug [23]. However, now, as we can find $l_p$ independently of $G$, this no longer leads to a circular problem so we can replace $G$ in a series of Planck-related electric properties and see that this leads to simpler and more intuitive formulas; see also [24].

Electric properties have been added in relation to the Planck scale since Max Planck introduced the Planck units. In 1961, de Beauregard [25] suggested that "*In terms of inter-actions* $\hbar c$ *plays the same role in the case of gravity as* $e^2$ *does in the case of electromagnetism*", and he links this to the Planck mass. This means that the Planck mass particle charge is $q_p = \sqrt{\hbar c}$. Today, the Planck charge has been re-defined as:

$$q_p = \sqrt{4\pi\varepsilon_0 \hbar c} = \frac{e}{\sqrt{\alpha}} \tag{17}$$

Further, this can be re-written as:

$$q_p = \sqrt{\frac{\hbar}{c}}\sqrt{10^7} \tag{18}$$

There are no Planck units embedded in the Planck charge; however, it is assumed this is the charge of a Planck mass particle. The difference is that there is no embedded fine structure constant in the Planck charge, in contrast to the elementary charge (of the proton and electron).

Planck current and Planck voltage, on the other hand, both contain $G$ and this means they indirectly contain Planck units. The Planck voltage is given by (see Lundgren [26] and also Buzcyna *et al.* [27]):

$$V_p = \sqrt{\frac{c^4}{4\pi\varepsilon_0 G}} \tag{19}$$

We can now replace $G$ with $G = \frac{l_p^2 c^3}{\hbar}$. This gives:

$$V_p = \frac{c}{l_p}\sqrt{c\hbar}\sqrt{10^{-7}} \tag{20}$$

In other words, the Planck charge is directly linked to the Planck length, or it even looks like it is linked to the Planck frequencies as we have $f_p = \frac{c}{l_p}$. Still, there is little intuition in having something that is Planck frequency times the square root of $c$ times $\hbar$ and again multiplied by the square root of $10^7$. We therefore highly suspect that the Planck voltage is something quite arbitrarily defined. It is clearly rooted in something very fundamental: $c$, $l_p$ and even $\hbar$, but we suspect it is a derivative of a deeper reality, something we plan to return to in another paper we hope to write.

Planck impendence is also linked to $G$ and thereby also indirectly to the Planck scale and is given by:

$$I_p = \sqrt{\frac{4\pi\varepsilon_0 c^6}{G}} \tag{21}$$

Again, if we replace $G$ with the composite form $G=\frac{l_p^2c^3}{\hbar}$, we get:

$$I_p=\sqrt{\frac{c^6}{k_eG}}=\frac{\sqrt{\hbar c\times 10^7}}{l_p} \tag{22}$$

Planck impendence is given by:

$$Z_p=\frac{1}{4\pi\varepsilon_0 c}=\frac{V_p}{I_p}=c\times 10^{-7} \tag{23}$$

In other words, the Planck impendence is nothing more than the speed of light times $10^{-7}$. Also, when it comes to so-called Planck electric properties, we think the $10^{-7}$ and $10^7$ always cancel out against each other in relation to direct observables. For example, energy can be observed. In general, Planck electric energy is considered much higher than we even can observe in LHC, but still it is at least theoretically something that can be observed, as it is simply a frequency multiplied by the minimum quantity of energy $\hbar$, and it is given by:

$$E_p=q_pV_p=\sqrt{\frac{\hbar}{c}}\sqrt{10^7}\times\frac{c}{l_p}\sqrt{c\hbar}\sqrt{10^{-7}}=\hbar\frac{c}{l_p} \tag{24}$$

Pay attention to the fact that $10^{-7}$ and $10^7$ just cancel each other out. We will suggest redefining the Planck charge as:

$$q_p=\sqrt{\frac{\hbar}{c}} \tag{25}$$

and the Planck voltage as:

$$V_p=\frac{c}{l_p}\sqrt{c\hbar} \tag{26}$$

and the Planck impedance as simply:

$$Z_p=c \tag{27}$$

The Coulomb force for the Planck charges, when using the standard way to express it, is given by:

$$F=k_e\frac{q_pq_p}{r^2}=\frac{\hbar c}{r^2} \tag{28}$$

Planck resistance is:

$$R_\Omega=\frac{V_p}{I_p}=\frac{\frac{c}{l_p}\sqrt{c\hbar}\sqrt{10^{-7}}}{\frac{\sqrt{\hbar c\times 10^7}}{l_p}}=c\frac{\sqrt{10^{-7}}}{\sqrt{10^7}}=c\times 10^{-7} \tag{29}$$

if we redefine the electric units so as to not contain $10^{-7}$ and $10^7$, then the Planck resistance is the speed of light $c$. How should this be interpreted? We see several possibilities here. One possibility is that since the resistance is $c$ and the maximum speed is $c$, then these cancel each other and the Planck mass particle must stand absolutely still, as we have already suggested before, based on a different angle of reasoning; see [21] [28].

The Planck magnetic field is given by:

$$\sqrt{k_e \frac{c^5}{\hbar G^2}} = \frac{\sqrt{\hbar c \times 10^{-7}}}{l_p^2} \text{ Tesla} \tag{30}$$

The Planck electric field is given by:

$$\sqrt{k_e \frac{c^7}{\hbar G^2}} = \frac{\sqrt{c^3 \hbar \times 10^{-7}}}{l_p^2} = \frac{c\sqrt{\hbar c \times 10^{-7}}}{l_p^2} = \frac{V_p}{l_p}\left(\mathrm{V \cdot m^{-1}}\right) \tag{31}$$

We see that the ratio of the electric field divided by the magnetic field is simply the speed of light.

**Table 2** shows a series of electric properties related to the Planck scale, so called Planck electric properties.

**Table 2.** The table shows different electric properties as can be described when we use the composite form of $G = \frac{l_p^2 c^3}{\hbar}$, as well as three suggested simplifications of the Planck electric properites.

| | **Standard (pre-2019):** | **Alternative 1:** | **Alternative 2:** | **Alternative 3:** |
|---|---|---|---|---|
| The Coulomb constant | $k_e = \frac{1}{4\pi\varepsilon_0} = c^2 \times 10^{-7}$ | $k_e = c^2$ | $k_e = c$ | |
| Planck charge | $q_p = \sqrt{\frac{\hbar}{c} \times 10^7}$ | $q_p = \sqrt{\frac{\hbar}{c}}$ | $q_p = \sqrt{\hbar}$ | $q_p = \sqrt{\hbar c}$ |
| Planck voltage | $V_p = \frac{c}{l_p}\sqrt{\hbar c}\sqrt{10^{-7}}$ | $V_p = \frac{c}{l_p}\sqrt{\hbar c}$ | $V_p = \frac{c}{l_p}\sqrt{\hbar}$ | $V_p = \frac{\sqrt{\hbar c}}{l_p}$ |
| Planck current | $C_p = \frac{c^3}{\sqrt{k_e G}} = \sqrt{\frac{\hbar c \times 10^7}{l_p^2}}$ | $C_p = \sqrt{\frac{\hbar c}{l_p^2}}$ | $C_p = \sqrt{\frac{\hbar}{l_p^2}}$ | $C_p = \sqrt{\frac{\hbar}{l_p^2 c}}$ |
| Planck energy | $E_p = V_p q_p = \hbar \frac{c}{l_p}$ | $E_p = V_p q_p = \hbar \frac{c}{l_p}$ | $E_p = V_p q_p = \hbar \frac{c}{l_p}$ | $E_p = V_p q_p = \hbar \frac{c}{l_p}$ |
| Planck impedence | $I_p = \frac{\sqrt{\hbar c \times 10^7}}{l_p}$ | $I_p = \frac{\sqrt{\hbar c}}{l_p}$ | $I_p = \frac{\sqrt{\hbar}}{l_p}$ | $I_p = \frac{\sqrt{\frac{\hbar}{c}}}{l_p}$ |
| Planck resistance | $R_\Omega = \frac{V_p}{I_p} = c \times 10^{-7}$ | $R_\Omega = \frac{V_p}{I_p} = c$ | $R_\Omega = \frac{V_p}{I_p} = c$ | $R_\Omega = \frac{V_p}{I_p} = c$ |
| Magnetic field | $B = \sqrt{k_e \frac{c^5}{\hbar G^2}} = \frac{\sqrt{\hbar c \times 10^{-7}}}{l_p^2}$ | $B = \frac{\sqrt{\hbar c}}{l_p^2}$ | $B = \frac{\sqrt{\hbar}}{l_p^2}$ | $B = \frac{\sqrt{\frac{\hbar}{c}}}{l_p^2}$ |
| Electric field | $\sqrt{k_e \frac{c^7}{\hbar G^2}} = \frac{c\sqrt{\hbar c \times 10^{-7}}}{l_p^2}$ | $\frac{c\sqrt{\hbar c}}{l_p^2}$ | $\frac{c\sqrt{\hbar}}{l_p^2}$ | $\frac{\sqrt{\hbar c}}{l_p^2}$ |
| The Coulomb force Planck charges | $F = k_e \frac{q_p q_p}{r^2} = \hbar \frac{c}{r^2}$ | $F = c^2 \frac{q_p q_p}{r^2} = \hbar \frac{c}{r^2}$ | $F = c \frac{q_p q_p}{r^2} = \hbar \frac{c}{r^2}$ | $F = \frac{q_p q_p}{r^2} = \hbar \frac{c}{r^2}$ |

## 4. Similarities between the Coulomb Force and the Newton Force?

The Coulomb Planck force is

$$F = k\frac{q_p q_p}{r^2} = \hbar\frac{c}{r^2} \tag{32}$$

The end result is also the same as the other alternatives above. This means the Coulomb force in the special case for two Planck forces is identical to the Newton gravitational force for two Planck masses at the distance of the Planck length.

$$F_N = G\frac{m_p m_p}{r^2} \tag{33}$$

Now inserting the Planck mass formula $m_p = \sqrt{\frac{\hbar c}{G}}$ for the Planck mass in the formula above and we get

$$F_N = G\frac{\sqrt{\frac{\hbar c}{G}}\sqrt{\frac{\hbar c}{G}}}{r^2} = \hbar\frac{c}{r^2} \tag{34}$$

In other words, the Coulomb force for two Planck charges is identical to the Newton gravitational force between two Planck masses as we also have pointed out in [24] [29]. However, one should be aware that the Newton gravitational force formula in its standard form only is valid for the case when one mass is insignificant compared to the other one, that is when $M \gg m$. So in the case, we work with two identical masses, like two Planck masses the formula is not really valid. When both gravitational bodies act significantly on each other one must use a gravitational parameter $\mu = G(M + m)$, in other words, a real two-body problem. This in our view[1] means that the similarity between the Newton force and the Coulomb force for respectively two Planck masses and two Planck charges should be interpreted with great care.

Several even recent attempts or suggestions have been made in relation to unifying gravity and the Coulomb force, see, for example, Davidson and Owen [30], Caillon [31], Zegarra *et al.* [32], Pilot [33] and Sharafiddinov [34]. These and other possibilities should be investigated further based on the simplification of the Coulomb force and electric units as suggested above. A new theory that unifies gravity and quantum mechanics related to the Planck scale known as collision space-time [35] should also be interesting to investigate with respect to this.

## 5. Conclusions

We have suggested how to reformulate the elementary and Planck charge as well as the Coulomb constant to simplify and demystify the Coulomb force. In this view, there is no need for a separate constant, for we can simply replace the

[1]Our view have somewhat changed since our working paper [24] in 2016, where we had not taken into account that the Newton gravity force not is valid for two equal masses when on its standard form $F = G\frac{Mm}{r^2}$.

Coulomb constant with $c$ in the new formulation or even use no Coulomb constant at all. The standard choice of units and formulation for how to describe the charge seems to have over-complicated several electric units. However, this should be discussed and investigated carefully before any choices are made.

In light of this, further work should also investigate possible relations between the Coulomb force and the Newtonian gravitational force.

## Conflicts of Interest

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

## References


[1] Coulomb, C.A. (1785) Premier mémoire sur l'électricité et le magnétisme. In: *Histoire de l Académie Royale des Sciences*, Imprimerie Royale, Paris, 569-577.

[2] Walker, J., Halliday, D. and Resnick, R. (2007) Fundamentals of Physics. Wiley Publishing, Hoboken.

[3] Stock, M., Davis, R., de Mirandes, E. and Milton, M.J.T. (2019) The Revision of the SI—The Result of Three Decades of Progress in Metrology. *Metrologia*, **56**, Article ID: 022001. https://doi.org/10.1088/1681-7575/ab0013

[4] Garg, A. (2018) The Two Cultures: Si and Gaussian Units in Electromagnetism. *European Journal of Physics*, **39**, Article ID: 045205. https://doi.org/10.1088/1361-6404/aac233

[5] Goldfarb, R.B. (2017) The Permeability of Vacuum and the Revised International System of Units. *IEEE Magnetics Letters*, **8**, Article ID: 1110003. https://doi.org/10.1109/LMAG.2017.2777782

[6] Stock, M. and Witt, T.J. (2006) CPEM 2006 Round Table Discussion Proposed Changes to the SI. *Metrologia*, **43**, 583-587. https://doi.org/10.1088/0026-1394/43/6/014

[7] Millikan, R.A. (1913) On the Elementary Electrical Charge and the Avogadro Constant. *Physical Review*, **2**, 109-143. https://doi.org/10.1103/PhysRev.2.109

[8] Piquemal, F. and Feltin, N. (2009) Determination of the Elementary Charge and the Quantum Metrological Triangle Experiment. *European Journal of Physics Special Topics*, **172**, 267-296. https://doi.org/10.1140/epjst/e2009-01054-2

[9] Martin-Delgado, M.A. (2020) The New SI and the Fundamental Constants of Nature. *European Journal of Physics*, **41**, Article ID: 063003. https://doi.org/10.1088/1361-6404/abab5e

[10] Spavieri, G., Rodriguez, M. and Sanchez, A. (2018) Thought Experiment Discriminating Special Relativity from Preferred Frame Theories. *Journal of Physics Communications*, **2**, Article ID: 085009. https://doi.org/10.1088/2399-6528/aad5fa

[11] Spavieri, G., Gillies, G., Haug, G. and Sanchez, A. (2019) Light Propagation and Local Speed in the Linear Sagnac Effect. *Journal of Modern Optics*, **66**, 2131-2141. https://doi.org/10.1080/09500340.2019.1695005

[12] Damourab, T. and Polyakovc, A.M. (1994) The String Dilation and a Least Coupling Principle. *Nuclear Physics B*, **423**, 532-558. https://doi.org/10.1016/0550-3213(94)90143-0

[13] Conlon, J. (2015) Why String Theory? CRC Press, Boca Raton.

https://doi.org/10.1201/9781315272368

[14] Planck, M. (1899) Natuerliche Masseinheiten. Der Königlich Preussischen Akademie Der Wissenschaften.

[15] Planck, M. (1906) Vorlesungen über die Theorie der Wärmestrahlung. J.A. Barth, Leipzig, 163.

[16] Cahill, K. (1984) The Gravitational Constant. *Lettere al Nuovo Cimento*, **39**, 181-184. https://doi.org/10.1007/BF02790586

[17] Cohen, E.R. (1987) Fundamental Physical Constants. In: Sabbata and Melniko, V.N., Eds., *Gravitational Measurements*, *Fundamental Metrology and Constants*, Kluwer Academic Publishers, Amsterdam, 59-89. https://doi.org/10.1007/978-94-009-2955-5_5

[18] Haug, E.G. (2017) Can the Planck Length Be Found Independent of Big G? *Applied Physics Research*, **9**, 58-66. https://doi.org/10.5539/apr.v9n6p58

[19] Haug, E.G. (2020) 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*, **4**, Article ID: 075001. https://doi.org/10.1088/2399-6528/ab9dd7

[20] Haug, E.G. (2021) Demonstration That Newtonian Gravity Moves at the Speed of Light and Not Instantaneously (Infinite Speed) as Thought! *Journal of Physics Communication*, **5**, Article ID: 025005. https://doi.org/10.1088/2399-6528/abe4c8

[21] Haug, E.G. (2022) Planck Speed: The Missing Speed of Physics? Absolute Still without Breaking Lorentz Symmetry! *European Journal of Applied Physics*, **4**, 11-18. https://www.ej-physics.org/index.php/ejphysics/article/view/144 https://doi.org/10.24018/ejphysics.2022.4.1.144

[22] Haug, E.G. (2022) Planck Length, Planck Time and Speed of Gravity when Taking into Account Relativistic Mass with No Knowledge of G, h or C. Hal Archive. https://hal.archives-ouvertes.fr/hal-03669505/document

[23] Haug, E.G. (2022) Progress on Composite View of the Newtonian Gravitational Constant and Its Link to the Planck Scale. *Universe*, **8**, Article No. 454. https://doi.org/10.3390/universe8090454

[24] Haug, E.G. (2016) Unification of Gravity and Electromagnetism: Gravity-Electromagnetism: A Probability Interpretation of Gravity. https://vixra.org/abs/1604.0208

[25] de Beaurega, C. (1961) Comptes Rendus Physique. 249.

[26] Lundgren, A.P. (2008) Charged Black Hole in a Canonical Ensemble. *Physical Review D*, **77**, Article ID: 044014. https://doi.org/10.1103/PhysRevD.77.044014

[27] Buczyna, J.R., Unnikrishnan, C.S. and Gillies, G.T. (2011) Standard and Derived Planck Quantities: Selected Analysis and Derivations. *Gravitation and Cosmology*, **17**, 339-343. https://doi.org/10.1134/S0202289311040037

[28] Haug, E.G. (2021) Quantum Gravity Hidden in Newton Gravity and How to Unify It with Quantum Mechanics. In: Krasnoholovets, V., Ed., *The Origin of Gravity from the First Principles*, NOVA Publishing, New York, 133-216.

[29] Haug, E.G. (2019) Extraction of the Speed of Gravity (Light) from Gravity Observations Only. *International Journal of Astronomy and Astrophysics*, **9**, 97-114. https://doi.org/10.4236/ijaa.2019.92008

[30] Davidson, A. and Owen, D.A. (1986) On the Newton-Coulomb Unification. *Physics Letters B*, **166**, 123-126. https://doi.org/10.1016/0370-2693(86)91361-4

[31] Caillon, J.C. (2018) A Possible Unification of Newton's and Coulomb's Forces.

*Physics Letters A*, **382**, 3307-3312. https://doi.org/10.1016/j.physleta.2018.09.005

[32] Zegarra, L.B.R., Gutierrez, M.C., Obeso, F.A.V., Quispe, L.T. and Armas, L.E.G. (2021) A Simple Way of Unifying the Formulas for the Coulomb's Law and Newton's Law of the Universal Gravitation: An Approach Based on Membranes. *Physics Essays*, **34**, 68-78. https://doi.org/10.4006/0836-1398-34.1.68

[33] Pilot, C. (2021) Q-Theory: A Connection between Newton's Law and Coulomb's Law? *Journal of High Energy Physics*, *Gravitation and Cosmology*, **7**, 632-660. https://doi.org/10.4236/jhepgc.2021.72037

[34] Sharafiddinov, R.S. (2021) An Allgravity as a Grand Unification of Forces. *Physics Essays*, **34**, 397-409. https://doi.org/10.4006/0836-1398-34.3.397

[35] Haug, E.G. (2022) Unified Quantum Gravity Field Equation Describing the Universe from the Smallest to the Cosmological Scales. *Physics Essays*, **35**, 61-71. https://doi.org/10.4006/0836-1398-35.1.61