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Research Article

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Predicting the Masses of the Electron, the Neutrino, the Proton, The Neutrino and Possibly the W-and Z-Bosons & Additional Prediction of a Small Non-Zero Mass for Gluons

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According to space particle dualism, gravity is a side effect of cardinal hypercharge [1]. Could something similar apply to inertia?

If that is the case, then one could try to predict the masses of different particles by simply looking at their charge. The proton has the same electric charge as the positron, but besides electric charge (intermediate by virtual photons), it also has a strong 'charge' or hypercharge, usually called 'flavor' (intermediate by gluons), and a weak charge (intermediate by W- and Z-bosons). That could be what makes it heavier than an electron.

The neutrino which has only a weak charge has almost no rest mass. And then we have all the massless particles which happen to be chargeless.

Elementary particle	Strength of force	Mass
Electron	$\alpha = \frac{k_e e^2}{\hbar c} \approx 1/137 = 7.2 \times 10^{-3}$	$0.5109989461 \frac{\text{MeV}}{c^2} = 9.109\,383\,56(11)$
Neutrino (sum of three 'flavors')	$\alpha_w = \sqrt{\frac{\tau_\Delta}{\tau_\Sigma}} = \sqrt{\frac{6 \times 10^{-24}\,\text{s}}{8 \times 10^{-11}\,\text{s}}} = 2.738612788 \times 10^{-7}$	$0.12 \frac{\text{eV}}{c^2} = 2.138958468 \times 10^{-37}\,\text{kg}$
Up-quark	$\alpha_s = 1$	$2.4 \frac{\text{MeV}}{c^2} = 4.277916936 \times 10^{-30}\,\text{kg}$
Down-quark	$\alpha_s = 1$	$4.8 \frac{\text{MeV}}{c^2} = 8.555833871 \times 10^{-30}\,\text{kg}$

The neutrino is 4,258,794 times lighter than the electron. This is quite a small mass and fits well with the weak charge of the neutrino, but the factors don't really match: the difference in strength of force is merely a factor of 26,646.

The reason might be the short range of the weak force, causing it to polarize much smaller regions of vacuum than the electromagnetic force which has no distance limit.

The quarks are a bit tricky: the rest mass values presented here are for isolated quarks without the gluon cloud around them, which do not exist in reality. It is a bit like an electron without virtual photons around it. Such an electron wouldn't have an electric charge. In the same way a quark without its gluons wouldn't have a hypercharge. That is why here it seems to be just 9.39 times heavier than an electron.

In reality quarks are combined in pairs of three, assembled to protons and neutrons. Here the proton is 1,836 times heavier and the neutron 1,838 times heavier than an electron. A third of that is 612 and 612.6 respectively. This is very roughly close to the difference between the strength of the electromagnetic force (represented by the electron) and the strong force (represented by the up- and down-quarks), which is also 3 orders of magnitude – at a distance of 10^{-15} m it is 137 times stronger than electromagnetism.

For the neutrino the comparison between charge and (inertia) mass was off by a factor of 160, while for the proton it was a much smaller factor of 4.5. That already shows that the relationship between charge and inertia isn't as simple as that between charge and gravity.

How could inertia rest mass be explained then?
The German physicist Klaus Lux suggested that the mass of particles might be equivalent to the energy of their force fields and he demonstrated that on the example of the electron (personal correspondence; 2018). In his words:

"... For that I assumed the electron to be a small spherical charged object with a field that is oriented perpendicular to its surface

and that reaches out into all directions and extends to infinity, corresponding to the field of a spherical capacitor whose inner sphere is filled with a charge and whose outer sphere has an infinite diameter ...”

[Disclaimer: The following calculation of the electyron mass is the intellectual property of Klaus Lux who gave me permission to use it in my book (personal correspondence; 2018)].

The capacity of a spherical capacitor in a vacuum is given by:

$$C = \frac{4\,\pi\,\varepsilon_0\,r\,R}{R - r}$$

With:

$$\varepsilon_0 = \frac{1}{\mu_0\,c^2} \approx \frac{10^7}{4\,\pi\,c^2} = 8.854\,187\,817\ \times 10^{-12}\ \mathrm{F \cdot m^{-1}}$$

When R → ∞, the capacity is given by:

$$C = \frac{10^7\,r}{c^2}$$

The capacity of a condensator is given by $C = Q/U$, and the energy of a charged condensator by:

$$W = \frac{1}{2}\,C\,U^2$$

Solving $C = Q/U$ for U yields $U = Q / C$ and inserting that into the equation for W yields:

$$W = \frac{Q^2}{2\,C}$$

Now we insert the equation for C and get:

$$W = \frac{Q^2\,c^2}{2\,\times 10^7\,r}$$

Inserting the electron charge e for Q, the classical electron radius r_e for r and dividing through c^2 yields:

$$m_e = \frac{e^2}{2\,\times 10^7\,r_e}$$

However, the true value for the electron mass is twice this value and thus given by the simpler equation:

$$m_e = \frac{e^2}{10^7\,r_e}$$

Which yields: $m_e = 9.109382913 \times 10^{-31}$ kg

With the measured value being: $9.109383561 \times 10^{-31}$ kg.

At this point it has to be admitted, that m_e was already part of r_e, which is given by:

$$r_e = \frac{e^2}{4\,\pi\,\varepsilon_0\,m_e\,c^2}$$

This may seem like circular reasoning, but it is in fact very desirable: only a theory in which all constants depend upon each other can be a theory devoid of free parameters.

Klaus Lux’s idea is not totally new. The idea of an electromagnetic explanation for inertia mass goes back to J. J. Tomson who first conceived it in 1881 [2]. Others worked it out in greater detail between 1882 and 1904. One of the most engaged among them

was Hendrik Lorentz (1892; 1904) [3,4]. They calculated the electromagnetic energy and mass of the electron as:

$$E_e = \frac{1}{2}\,\frac{e^2}{r_e};\ m_e = \frac{2}{3}\,\frac{e^2}{r_e\,c^2}$$

Which implied:

$$m_e = \frac{4}{3}\,\frac{E_e}{c^2}$$

Wilhelm Wien (1900) and Max Abraham (1902) then concluded that the total mass of bodies is identical to their electromagnetic mass [5,6].

The 4⁄3 factor violates special relativity and over the years there were many physicists showing how it disappears in a strictly relativistic treatment of the matter [7-10]. In 2011 Valery Morozov showed that a moving charged sphere has a flux of non-electromagnetic energy and this flux has an impulse that is exactly 1⁄3 of the sphere’s electromagnetic impulse.

The remaining factor of 1⁄2 in Klaus Lux’s calculation can probably be explained in a similar way.

For unclear reasons electromagnetic explanations of mass have been rejected in recent decades, giving way to the *Higgs mechanism*. Unlike the above explanations the Higgs mechanism doesn’t provide us with any predictions on the masses of different particles. It is puzzling how the energy in the electromagnetic field can be ignored as a source of mass by so many.

If the above considerations are correct, then the inertia mass of a particle is proportional to the energy stored in the polarized quantum vacuum around it.

We could now try to do the same calculations for the neutrino. First we have to determine the ‘classical radius of the neutrino’. Therefore we take the formula for the classical electron radius and scale down the charge e by multiplying it with the coupling constant of the weak force α_w. Furthermore we have to replace the electron mass m_e by the neutrino mass m_ν and the electric permeability constant of the vacuum ε_0 by another constant ε_{0_W} that is related to the weak force. This yields:

$$r_\nu = \frac{(e\,\alpha_W)^2}{4\,\pi\,\varepsilon_{0W}\,m_\nu\,c^2}$$

$$\alpha_W = \sqrt{\frac{\tau_\Delta}{\tau_\Sigma}} = 2.738612788 \times 10^{-7}$$

ε_{0_W} can be determined by taking the formula for ε_0 and replacing α by α_W.
e is of course again replaced by $e\ \alpha_w$. This yields:

$$\varepsilon_{0_W} = \frac{2\ \alpha_W}{(e\ \alpha_W)^2}\ \frac{h}{c} = 628.801983\ \text{F m}^{-1}$$

$$r_\nu = 1.267402294 \times 10^{-35}\ \text{m}$$

For C we take the equation with a finite radius R in order to account for the finite range of the weak force and set $R_W = 10^{-15}$ m. Replacing all the constants as above yields:

$$C = \frac{4\ \pi\ \varepsilon_{0_W}\ r_\nu\ R_W}{R_W - r_\nu}$$

Inserting this into the equation for W yields:

$$W = \frac{Q^2\ (R_W - r_\nu)}{8\ \pi\ \varepsilon_{0_W}\ r_\nu\ R_W}$$

Inserting $e\ \alpha_w$ for Q and dividing through c^2 yields:

$$m_\nu = \frac{(e\ \alpha_W)^2\ (R_W - r_\nu)}{8\ \pi\ \varepsilon_{0_W}\ r_\nu\ R_W\ c^2}$$

$$m_\nu = 1.069479234 \times 10^{-37}\ \text{kg}$$

Again same as with the electron the true mass is twice this value, so it is given by:

$$m_\nu = \frac{(e\ \alpha_W)^2\ (R_W - r_\nu)}{4\ \pi\ \varepsilon_{0_W}\ r_\nu\ R_W\ c^2}$$

$$m_\nu = 2.138958468 \times 10{-}37\ \text{kg}$$

With the measured value being: $2.138958468 \times 10^{-37}$ kg – exactly the same (!).

$R_W - r_\nu$ actually reduces to R_W, because r_ν is too small to make a difference when subtracted.
It is obvious that the whole equation depends crucially on R_W, the range of the weak force, a number which depends on the mass of the W- and Z-bosons. The heavier they are, the lighter is the neutrino, but the neutrino mass is not used when calculating R_W.

From the above it should be clear that the electron's and the neutrino's mass are both sourced from their electromagnetic energy. The electron's mass is its electromagnetic mass and the neutrinos mass is its 'weak mass'.

Often people doubt that accuracy of the weak force coupling constant, because it is derived by comparing two different particle decays, and this may seem a bit arbitrary to many. The above calculation shows that it is an accurate measure for the strength of the weak force.

The fact that we used different formulas for the electron and the neutrino, one for forces with unlimited range and one for forces with a limited range R shows that at least for the neutrino we don't just get the mass we inserted when calculating the 'classical radius'. It is this limited range that explains the original discrepancy to a factor of 160. Had we used the formula for unlimited range, we would have been again off by this factor.

Will this scheme work for the quarks, protons and neutrons as well? Most of the proton's mass is sourced from the gluon field in between the constituent quarks. We can therefore hardly talk about the mass of a single quark. Rather we have to look at the mass of the proton, or more precisely a third of this mass.

Nevertheless we will be talking about the 'classical radius of the quark' and not of the proton, because the proton is not an elementary particle. We again take the formula for the classical electron radius and this time we scale up the charge e by dividing it through the fine structure constant α. Furthermore we have to replace the electron mass m_e by a third of the proton mass $m_p/3$ and the electric permeability constant of the vacuum ε0 by another constant ε_{0_S} that is related to the strong force. This yields:

$$r_q = \frac{3\ (e/\alpha)^2}{4\ \pi\ \varepsilon_{0_S}\ m_p\ c^2}$$

$$\alpha = \frac{k_e\ e^2}{h\ c} = 7.297352571 \times 10^{-3}$$

ε_{0_S} can be determined by taking the formula for ε_0 and replacing α by α^{-1}.
e is of course again replaced by e/α. This yields:

$$\varepsilon_{0_S} = \frac{2}{\alpha\ (e/\alpha)^2}\ \frac{h}{c} = 1.256637061 \times 10^{-6}\ \text{F m}^{-1}$$

$$r_q = 6.091895339 \times 10^{-19}\ \text{m}$$

For C we take the equation with a finite radius R in order to account for the finite range of the weak force and set $R_s = 3 \times 10^{-15}$ m. Replacing all the constants as above yields:

$$C = \frac{4\ \pi\ \varepsilon_{0_S}\ r_q\ R_S}{R_S - r_q}$$

Inserting this into the equation for W yields:

$$W = \frac{Q^2\ (R_S - r_q)}{8\ \pi\ \varepsilon_{0_S}\ r_q\ R_S}$$

Inserting e/α for Q and dividing through c^2 yields:

$$m_q = \frac{(e/\alpha)^2\ (R_S - r_q)}{8\ \pi\ \varepsilon_{0_S}\ r_q\ R_S\ c^2}$$

$$m_q = 2.787137084 \times 10^{-28}\ \text{kg}$$

Again same as with the electron and the neutrino, the true mass is twice this value, so it is given by:

$$m_q = \frac{(e/\alpha)^2\ (R_S - r_q)}{4\ \pi\ \varepsilon_{0_S}\ r_q\ R_S\ c^2}$$

$$m_q = 5.574274167 \times 10^{-28} \text{ kg}$$

A proton contains three quarks. If we multiply the above quark mass by three, we get:

$$m_p = 1.67228225 \times 10^{-27} \text{ kg}$$

With the measured value being: $1.672621898(21) \times 10^{-27}$ extremely close. Even higher precision could be reached by using more precise values for R_S.

However, the proton does not only have a strong charge, but electric charge as well. The corresponding mass (the mass of the electron) has to be added to the above calculated mass. Doing so yields:

$$m_p = 1.673193188 \times 10^{-27} \text{ kg}$$

Above we used $R_S = 3 \times 10^{-15}$ m as the range of the strong force. In fact this is the range of the residual strong force, caused by the little rest charge that remains due to spacial inhomogeneities in the distribution of the different color charges inside the proton. The strong force is the strongest at a distance of 1.1×10^{-15} m. Beyond this distance, which is the typical distance between nuclei, it drops off rather rapidly (see figure 1).

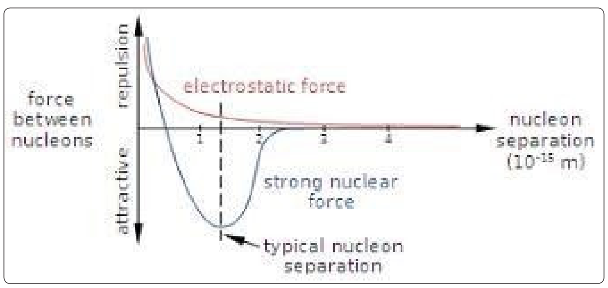

Figure 1: The strength of the strong force in dependence to the distance.

If we set $R_S = 1.1 \times 10^{-15}$ m instead and then add the electron mass to our result, we get:

$$m_p = 1.672606524 \times 10^{-27} \text{ kg}$$

This is a 5 digits match with the measured value. For the electron we had a 6 digits match and for the neutrino a 10 digits match. Considering the rather complicated nature of the strong force, this is a result much better than expected.

What about the neutron? Why is it 2.5 electron masses heavier than the proton? When the neutron is outside the nucleus, it decays with a half life of 10.5 min, into a proton, an electron and an anti-neutrino. This is known as beta decay and while the opposite, namely a proton turning into a neutron, while emitting a positron and a neutrino, is possible too, it never happens outside the nucleus, because there the proton doesn't have any extra energy that could allow it to turn into a particle heavier than itself.

For turning into a proton, an electron and an anti-neutrino, the neutron certainly needs some extra mass energy. Although a neutrino has a very small rest mass, in beta decays it can easily have a bigger mass energy than the electron. If the available energy was very small, such an equal distribution of impulse among electron and anti-neutrino would be impossible.

It is reasonable that the electron needs a bit more energy than just the energy associated with its rest mass, say 1.25 of it, and for enabling an equal distribution of impulse, the same amount of energy should be available for the neutron as well, adding up to 2.5 m_e.

This is by no means a rigorous derivation of the neutron mass, but being just a small multiple of the electron mass heavier than the proton, shows that it is most likely related to the beta decay.

Of course the question remains, why is it the neutron which is heavier and not the proton? Maybe a world in which protons could decay in an out of themselves, would be way too fragile. While neutron decay increases the number of positively charged protons and negatively charged electrons, proton decay would lead to both protons and electrons disappearing; creating a world without charge.

Something that remains unexplained in this model is the fact that the W- and Z-bosons have such huge masses, apparently regardless of their charge.

The Higgs mechanism which is now regarded to be the explanation for the existence of rest mass by most physicists, was originally conceived as an explanation for the masses of the W- and Z-bosons only.

The calculations in this present paper should have made clear now, that the Higgs mechanism should not have been extended beyond its original purpose. Doing so means to both overcomplicate things and to introduce arbitrary parameters into the theory.

After all the Higgs mechanism involves a field too, similar to the force fields we discussed above. It might well be that the masses of the W- and Z-bosons are somehow related to the energy of this field. If they are the only particles receiving their mass through the Higgs mechanism, then they must be the only particles interacting with the Higgs-boson, and thus their mass should be related to that of the Higgs-boson. This raises the question where the Higgs-boson itself receives its mass from.

It is as if the weak force was some strange mutation of the electromagnetic force where all the mass or charge of the electrons went into the photons. And indeed, the heavier the W- and Z-bosons are, the weaker is the mass and hypercharge of the neutrino. If the different forces are just variations of the same underlying geometrical structure, then such inversions are indeed to be expected.

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If the weak force is such a variation of the electromagnetic force, then its inverse could be the strong force. The transmitter particles of the strong force, the gluons, different from the massless photons of the electromagnetic force, do have a charge, namely the strong hypercharge. As mentioned before the self-interaction of gluons makes it very hard to figure out how much energy individual gluons carry, let alone know if they have any non-zero mass. If the strong force is some form of inverse analogy to the weak force, then we could expect the gluon to have a mass that stands in the same relation as the mass of the neutrinos to the mass of the W- and Z-bosons; since the W-bosons have electric charge, we will be looking at the Z-boson only.

This would lead to the following mass for gluons:

$$\frac{m_g}{m_q} = \frac{m_\nu}{m_Z}$$

$$m_g = \frac{m_\nu \, m_q}{m_Z}$$

Using the average between the up and the down quark for *mq* yields:

$$m_g = 8.096495577 \times 10^{-42} \text{ kg}$$

It is hard to isolate the quark mass strictly. Using a third of the proton mass instead yields:

$$m_g = \frac{m_\nu \, m_p}{3 \, m_Z}$$

$$m_g = 7.339822104 \times 10^{-40} \text{ kg}$$

Obviously such a small mass can't slow down gluons much. Similar to neutrinos, which are estimated to have a mass of 2.14×10^{-37} kg (average of three flavors), gluons would move very close to the speed of light.

Our above hypothesis established a mass relation between fermions and their corresponding gauge bosons. It wasn't able to predict the mass of the W- and Z-bosons. Is there any clue as to how it could be derived?

According to space particle dualism theory the radius of elementary spaces is given by:

$$R_E = \frac{2 \, G_E \, E}{c^4}$$

$$G_E = \frac{k_e \, e^2}{m_p^2} = 8.246441821 \times 10^{25} \text{ N m}^2 \text{ kg}^{-2}$$

At a certain energy the elementary space grows over the particle's wavelength. That energy can be calculated as:

$$\frac{4 \, G_E \, E}{c^4} = \frac{h \, c}{E}$$

$$E_{crit} = \sqrt{\frac{h \, c^5}{4 \, G_E}}$$

$$E_{crit} = 2.2 \times 10^{-9} \text{ J}$$

When we translate into a mass we get $2.447830123 \times 10^{-26}$ kg. This is somewhat close to the mass of the W- and Z-bosons, which are at about 4×10^{-27} kg.

According to space particle dualism elementary spaces can merge as soon as they exceed the critical energy; the energy which makes them grow larger than their wavelength. The discrepancy of about one order of magnitude could then possibly be related to the running of coupling.

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