Neutrinos as the photons of the strong force

Jean Louis Van Belle, 25 September 2019

Summary

This paper offers some rough ideas on doing away with the boson-fermion classification, and some more. We analyze the strong force as a proper *force*, which implies an analysis of the strong *charge* that it is supposed to act on. Such analysis is done through a dimensional analysis of Yukawa's potential equation. We then think of the neutrino as an oscillation, applying our one-cycle photon model to it. In other words, we think of it as a carrier of the strong *energy*, rather than as a carrier of the strong *force*.

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Introduction

In our previous paper[2], we complained about the 'multiplication of concepts' in the Standard Model of physics. More specifically, we wrote that the current modeling of the strong force – quark-gluon theory – is not very convincing: we may not understand what a force field actually *is*, but explaining it in terms of *virtual* particles carrying energy, momentum and other particle properties between *real* particles resembles 19th century *aether* theory: it looks like a superfluous concept.

We also think it is a crucial mistake to think of the weak force as a force. We think decay or disintegration processes should be analyzed in terms of *transient* or *resonant* oscillations and in terms of classical laws: conservation of energy, linear and angular momentum, charge and – importantly – the Planck-Einstein relation ($E = h \cdot f$).

Indeed, we argue the Planck-Einstein relation embodies the idea of the elementary *cycle* which – as a theoretical concept – has much more explanatory power than the idea of a *particle*. We feel vindicated by the 2019 revision of SI units (which abolished the mass unit as a fundamental unit) and the 'mass without mass' model of an electron.[3] Our photon model[4] embodies the same.

We think of electrons and photons as fundamental *oscillations*: the sum of the kinetic and potential energy of the oscillation is the energy of the electron and the photon itself, and Planck's quantum of action embodies the cycle, which is the product of the force, the distance over the loop, and the cycle time: $F \cdot T \cdot s = h$. Energy is force over a distance and, hence, this is equivalent to the Planck-Einstein relation: $E \cdot T = E/f = h$. If we measure time in the natural unit T, then the following *tautology* makes sense:

$$h = E \cdot T = h \cdot f \cdot T = h \cdot f/f = h$$

This reflects the idea that we should think of one cycle packing not only the electron (or photon) energy but also as packing one unit of *h*.

However, we also wrote that we aren't sure if these ideas can help us to model nucleons: how can we explain that protons and neutrons are much smaller than electrons and, at the same time, much heavier? We do not have any definite answer to that question, but we want to explore some thoughts that might inspire us to develop a more *realist* model of quantum physics.

Let us first think about the possible *nature* of the force that holds nucleons together.

[1] Independent researcher: https://jeanlouisvanbelle.academia.edu/research.
[2] See: Jean Louis Van Belle, *Elementary particles and conservation laws: a realist interpretation of quantum physics*, 31 August 2019.
[3] See: Jean Louis Van Belle, *Mass Without Mass*, 13 August 2019.
[4] See: Jean Louis Van Belle, *A Classical Quantum Theory of Light*, 13 June 2019.

The nature of the strong charge

The *idea* of the Yukawa potential is not bad. We write it as follows[5]:

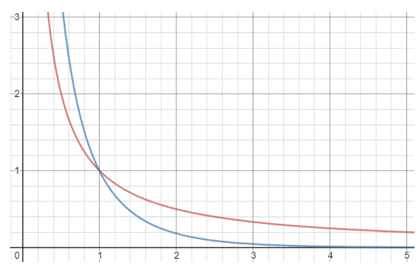
$$\mathrm{U}(r) = -\frac{\mathrm{g}_\mathrm{N}^2}{4\pi}\frac{e^{-r/a}}{r}$$

To make sure you understand what Yukawa tried to model, we'll remind you of the formula for the electrostatic (Coulomb) potential:

$$\mathrm{V}(r) = -\frac{\mathrm{q}_\mathrm{e}^2}{4\pi\varepsilon_0}\frac{1}{r}$$

The *structure* of these two formulas is exactly the same, *except for the* $e^{-r/a}$ *function*. Also note that we have the luxury of defining the unit for this new *nucleon* charge g_N so we don't need a proportionality constant (ε_0 or G if we think of gravity). I found it helpful to play with a graphing tool[6] to get a quick grasp of what might be going on here. We can simply things by forgetting about the 4π factor. This factor is common to both and, in any case, it is just the 4π factor in the formulas for the surface *area* ($4\pi r^2$) and the *volume* ($4\pi r^3$) of a sphere.[7] We may also want to think of the radius of the nucleus or the nucleon as a natural distance unit and, therefore, equate *a* to 1. We then get a plot like this (Figure 1).

Figure 1: The Yukawa versus the Coulomb potential



This graph shows that the two functions are equal to each other (and equal to unity) for $r = a = 1$. It's easy to show that's the case if $g_N^2 = (e/\varepsilon_0)\cdot q_e^2$:

$$\mathrm{U}(1) = \mathrm{V}(1) = 1 \Leftrightarrow -\frac{\mathrm{g}_\mathrm{N}^2}{4\pi}\frac{e^{-1}}{1} = -\frac{\mathrm{q}_\mathrm{e}^2}{4\pi\varepsilon_0}\frac{1}{1} \Leftrightarrow \mathrm{g}_\mathrm{N}^2 = \frac{e}{\varepsilon_0}\mathrm{q}_\mathrm{e}^2$$

What is this? Some kind of coupling constant showing the relative strength of both forces? Maybe, but probably not. Let us try to make sense of this. Our assumption that the two functions are equal to 1 for $r = a = 1$ is quite random. At the same time, the two functions have to cross *some*where if we want that Yukawa potential to serve the purpose it serves, and that is to show the nuclear force is stronger than

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[5] The Wikipedia article uses a mass factor but we prefer the original formula given in Aitchison and Hey's *Gauge Theories in Particle Physics* (2013). It is a widely used textbook in advanced courses and, hence, we will use it as a reference point.
[6] There are a few but I find the free online desmos.com graphing tool very intuitive. The easy parametrization of a function through the addition of a slider, for example, helps to get a quick understanding of the basic properties of some complicated function.
[7] Gauss' Law can be expressed in integral or differential form and these spherical surface area and volume formulas pop up when you go from one to the other. Hence, you shouldn't think of this 4π factor as something weird: it just shows that circles and spheres are more natural shapes to work with in physics.

the Coulomb force *inside* of the nucleus and, vice versa, that the electrostatic force is stronger outside. The equation above suggests we can, therefore, calculate the *physical* dimension of Yukawa's nucleon charge:

$$\mathrm{g_N^2} = \frac{e}{\varepsilon_0}\mathrm{q_e^2} \Leftrightarrow [\mathrm{g_N}] = \left[\frac{\mathrm{q_e}}{\sqrt{\varepsilon_0}}\right] = \frac{\mathrm{C}}{\sqrt{\frac{\mathrm{C^2}}{\mathrm{N\cdot m^2}}}} = \sqrt{\mathrm{N}}\cdot\mathrm{m}$$

This looks nonsensical, and it is: this $\mathrm{N^{1/2}\cdot m}$ dimension can't work, right? Right. We made a logical mistake. We started off by saying that the idea of a nucleon charge is something new: we associate some potential with it. However, we should not think of it as electrostatic charge. We have no positive or negative charge, for example: all nucleons – positive, negative or neutral[8] – share the same charge and should attract each other by the same (strong) force. Hence, we need to define some new *unit* for it. The *Einstein*, but that name is used for some other unit already.[9] In my previous papers on the topic of the Yukawa potential[10], I suggested the *Yukawa* but I now think there is too much association between that name and the presumed unit of the Yukawa potential.[11] I, therefore, propose the *dirac*.[12] However, for reasons of consistency we will continue to use the charge symbol we used in previous papers: Y.

We should, indeed, remind ourselves that Yukawa left a constant out of his equation because he had the luxury of defining some new unit: the nuclear or nucleon charge. However, it is obvious that the Yukawa potential would also need a factor like ε_0 *to fix the physical dimensions*. A force – any force – grabs onto a charge and, hence, if we think some new force is involved, then we also need some new *physical* unit. Let us calculate this new unit. It should be one, right? No. What we are saying here is that we should insert a *physical proportionality constant* whose numerical value is one. We will denote this physical proportionality constant as υ_0 and, in analogy with ε_0 being referred to as the electric constant, we may refer to it as the *nuclear constant*. We, therefore, re-write Yukawa's potential formula as follows:

$$\mathrm{U}(r) = -\frac{\mathrm{g_N^2}}{4\pi\upsilon_0}\frac{e^{-r/a}}{r}$$

The numerical value of υ_0 is one but its *physical* dimension needs to ensure the physical dimension of both sides of the equation are the same. It is, therefore, similar to the physical dimension of the electric constant ε_0: instead of $\mathrm{C^2/N\cdot m^2}$, we write: $[\upsilon_0] = \mathrm{Y^2/N\cdot m^2}$. It is easy to see this does what ε_0 does for the

[8] Negative? We only have neutrons and protons, don't we? Maybe. Maybe not. We can *imagine* anti-atoms and, hence, anti-protons.
[9] Believe it or not, but the *Einstein* is defined as a one *mole* (6.022×10^{23}) of photons. It is used, for example, when discussing photosynthesis: we can then define the flux of light – or the flux of photons, to be precise – in terms of *x* micro-einsteins per second per square meter. For more information, see the Wikipedia article on the Einstein as a unit: https://en.wikipedia.org/wiki/Einstein_(unit). If we would truly want to honor Einstein, I would suggest we re-define the Einstein as the unit of charge of the nucleon.
[10] See: *The nature of Yukawa's force and charge*, 19 June 2019 and *Who needs Yukawa's wave equation?*, 23 June 2019
[11] The Wikipedia article on the Yukawa potential associates the 1/m unit with the potential. This doesn't make much sense, but it is what it is.
[12] We note that Dirac's colleagues at Cambridge seem to have defined the *dirac* as 'one word per hour' but we think there is no scope for confusion here.

electric potential: it gives us a U(r) expressed in *joule* (N·m), which is the unit we want to see for potential energy.

Let us do some thinking by going through some more calculations. If we have a potential, we can calculate the force. In fact, we *should* calculate the force, because we should not be thinking in terms of terms of equating potential but in terms of *equating forces*.

Strong force calculations

We need to see what we get when equating forces instead of potentials. To do this, we should use this force formula:

$$\mathrm{F} = -\frac{\mathrm{dU}}{\mathrm{d}r} = -\frac{\mathrm{dV}}{\mathrm{d}r}$$

Let us think about the minus signs here. The forces should be opposite, right? Right, but the formula should take care of that. We should keep our wits with us here, so let us remind ourselves of whatever is that we are trying to do here. We are thinking of two protons here, and these two protons carry an electric charge (q_e) as well as what we vaguely referred to as a nuclear charge (g_N). The electric charge pushes them away from each other, but the nucleon charge pulls them together. At some in-between point, the two forces are equal but opposite. So we should find some value for a force – expressed in *newton*. A force is a force, even if we know it *acts* on a charge. A unit charge, to be precise. So… Well… We have two *different* unit charges here: q_e versus g_N. We express one in *Coulomb* units, and the other in this new unit: the *dirac*. What does that mean? Let us go through the calculations and see where we get. The Coulomb force is easy to calculate:

$$\mathrm{F_C} = -\frac{\mathrm{dV}}{\mathrm{d}r} = -\frac{\mathrm{d}\left(-\frac{\mathrm{q_e^2}}{4\pi\varepsilon_0}\frac{1}{r}\right)}{\mathrm{d}r} = \frac{\mathrm{q_e^2}}{4\pi\varepsilon_0}\frac{\mathrm{d}\left(\frac{1}{r}\right)}{\mathrm{d}r} = -\frac{\mathrm{q_e^2}}{4\pi\varepsilon_0}\frac{1}{r^2}$$

This is just Coulomb's Law, of course! The calculation of the nucleon force – or should we say: nucle*ar*? – is somewhat more complicated because of the $e^{-r/a}$ factor[13]:

$$\mathrm{F_N} = -\frac{\mathrm{dU}}{\mathrm{d}r} = -\frac{\mathrm{d}\left(-\frac{\mathrm{g_N^2}}{4\pi\upsilon_0}\frac{e^{-\frac{r}{a}}}{r}\right)}{\mathrm{d}r} = \frac{\mathrm{g_N^2}}{4\pi\upsilon_0}\frac{\mathrm{d}\left(\frac{e^{-\frac{r}{a}}}{r}\right)}{\mathrm{d}r}$$

$$= \frac{\mathrm{g_N^2}}{4\pi\upsilon_0}\cdot\frac{\frac{\mathrm{d}\left(e^{-\frac{r}{a}}\right)}{\mathrm{d}r}\cdot r - e^{-\frac{r}{a}}\cdot\frac{\mathrm{d}r}{\mathrm{d}r}}{r^2} = \frac{\mathrm{g_N^2}}{4\pi\upsilon_0}\cdot\frac{-\frac{r}{a}\cdot e^{-\frac{r}{a}} - e^{-\frac{r}{a}}}{r^2} = -\frac{\mathrm{g_N^2}}{4\pi\upsilon_0}\cdot\frac{(\frac{r}{a}+1)\cdot e^{-\frac{r}{a}}}{r^2}$$

This gives us the condition for the nuclear and electrostatic forces to be equal:

$$\frac{\mathrm{q_e^2}}{4\pi\varepsilon_0}\frac{1}{r^2} = \frac{\mathrm{g_N^2}}{4\pi\upsilon_0}\cdot\frac{\left(\frac{r}{a}+1\right)\cdot e^{-\frac{r}{a}}}{r^2} \Leftrightarrow \frac{\mathrm{q_e^2}}{\mathrm{g_N^2}} = \frac{\varepsilon_0}{\upsilon_0}\cdot\left(\frac{r}{a}+1\right)\cdot e^{-\frac{r}{a}}$$

[13] We need to take the derivative of a quotient of two functions here. We invite the reader to double-check the calculations as well as our logic here.

This condition is not very restrictive. Let us analyze this:

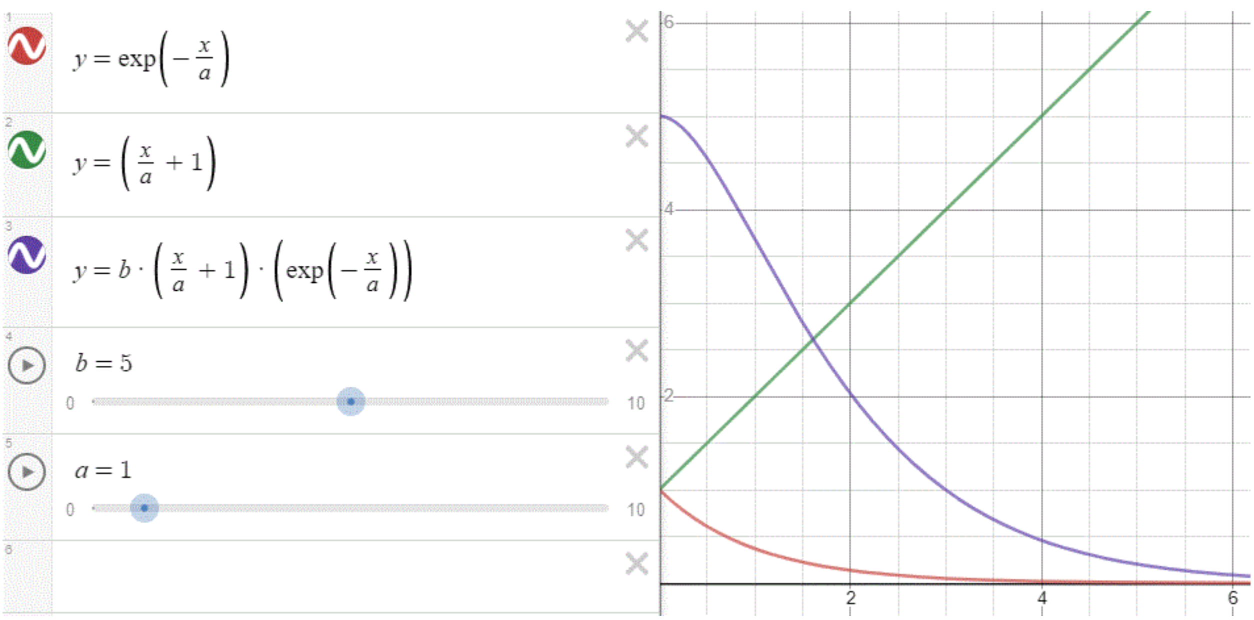
1. We know the $e^{-r/a}$ function already: it decreases from 1 for $r = 0$ to zero as r increases. The range parameter a determines the *shape* of this function. Indeed, an $N_0 \cdot e^{-\lambda \cdot t}$ function describes exponential decay, and the $\lambda = 1/a$ parameter gives us the decay rate. It is interesting to note that the *inverse* of the decay rate ($\tau = 1/\lambda$) would give you the mean lifetime, so that's a natural scaling constant. This is compatible with our interpretation of a as some natural distance unit.

2. The numerical value of υ_0 is one, so that doesn't influence the shape of the function. In contrast, the electric constant ε_0 causes the $e^{-r/a}$ factor to decrease from ε_0 to 0 over the domain (as opposed to decreasing from 1 to 0). Hence, it determines the maximum value for our $\varepsilon_0 \cdot (r/a + 1) \cdot e^{-r/a}$ function.

3. Finally, the $(r/a + 1)$ factor is just a linear function which also alters the shape of our function: it makes it look like (half) of a (normal) distribution function but you shouldn't think of our condition as a distribution because a distribution function will have a *squared* exponent. we don't have that here: the $-r/a$ exponent is linear in r.

Figure 2 shows how this thing looks like for $a = 1$ and $\varepsilon_0 = 5$.[14]

Figure 2: The shape of the q_e^2/g_N^2 ratio function



What can we do with this? Plenty of things. We can think of some wild assumption again: didn't we assume the two forces would be equal if r was equal to a? To be precise, we should say: if r is about the same order of magnitude of a. Let us just equate the two and, besides equating the two distances, also re-scale and use $r = a$ as the natural distance unit. So we write: $r = a = 1$. Our condition then becomes:

[14] The order of magnitude of a will be 10^{-15} m, while the order of magnitude of ε_0 – when using SI units – is 10^{-12}. Hence, one should not attach any importance to the values we use here. They just serve to illustrate the shape of this function.

$$\frac{q_e^2}{g_N^2} = \frac{\varepsilon_0}{\upsilon_0}\cdot\left(\frac{a}{a}+1\right)\cdot e^{-\frac{a}{a}} = \frac{2}{e}\cdot\frac{\varepsilon_0}{\upsilon_0} \approx 3.26\times10^{-12}\,\frac{C^2}{Y^2}$$

Is this a sensible value? We can't say much about this because of the weird physical dimension of the ratio: what's the square of the *coulomb*/*dirac*? it's the dimension of the electric constant. Let us re-write this thing using the expression for ε_0 in terms of the fine-structure constant: $\varepsilon_0 = q_e^2/2\alpha hc$:

$$\frac{q_e^2}{g_N^2} = \frac{2}{e}\cdot\frac{\varepsilon_0}{\upsilon_0} \Leftrightarrow g_N^2 = \frac{e\cdot\upsilon_0}{2\cdot\varepsilon_0}\cdot q_e^2 = \frac{e\cdot\upsilon_0\cdot 2\alpha hc}{2\cdot q_e^2}\cdot q_e^2$$

$$\Leftrightarrow g_N^2 = e\cdot\alpha\cdot h\cdot c\cdot\upsilon_0$$

What a weird formula ! What's *that* all about? Good question.

The elementary nuclear charge

The $g_N^2 = e\alpha hc\upsilon_0$ is a weird formula: we have the product of two pure numbers (Euler's number and the fine-structure constant), two physical constants (Planck's constant and the speed of light) and then a physical proportionality constant whose *numerical* value is one. In fact, although it has no physical dimension, we should probably think of the fine-structure constant as a physical constant too, so we have one mathematical constant (e) and three physical constants (α, h and c). The *physical* dimension of this product is that of (physical) action (h), velocity (c) and that *nuclear* factor υ_0, or whatever else you want to call it. The dimensions come out alright, so that's somewhat encouraging:

$$[g_N^2] = [e\alpha hc\upsilon_0] = (\text{N·m·s})\cdot(\text{m/s})\cdot(\text{Y}^2/\text{N·m}^2) = \text{Y}^2$$

Hence, we can re-write the condition for the two forces to be equal as:

$$g_N^2 = e\alpha hc\upsilon_0 = e\alpha hc\ \text{Y}^2$$

That doesn't look to bad: we get a (squared) dirac charge expressed in (squared) charge units, with a *numerical* value that is equal to $e\alpha hc = 3.94\ldots\times10^{-27}$. Hence, we can now calculate the *value* of the nuclear charge as the square root of this value:

$$g_N = 6.27723\ldots\times10^{-14}\ \text{Y}\ (\textit{dirac})$$

As you can see, our new *dirac* unit is a big unit: the *elementary* nuclear charge – our *nucleon*, that is – carries only a fraction equal to $6.27723\ldots\times10^{-14}$ of it. That's not something to worry about. The *Coulomb* is a huge unit too: the *elementary* charge – the electron – carries only 1.6×10^{-14} of it.

Let us do one more calculation. Let's calculate the Yukawa and Coulomb potentials at $r = a = 1$[15]:

$$U(1) = -\frac{g_N^2}{4\pi\upsilon_0}e^{-1} = -\frac{e\alpha hc\upsilon_0}{4\pi\upsilon_0 e} = -\frac{\alpha hc}{4\pi}$$

$$V(1) = -\frac{q_e^2}{4\pi\varepsilon_0} = -\frac{q_e^2\cdot 2\alpha hc}{4\pi\cdot q_e^2} = -\frac{\alpha hc}{2\pi} = 2\cdot U(1)$$

[15] When doing a dimensional analysis of the two potentials, you should not forget the $[1/r] = \text{m}^{-1}$ dimension. It is necessary to obtain the J = N·m dimension for potential energy.

We find that the Coulomb potential is *twice* the Yukawa potential at the distance where the two forces are equal but opposite.

Now that we're playing, we may want to quickly calculate the ratio of υ_0 and ε_0. We can do so by, once again, equating the forces and the associated potentials at a distance *r* = *a* = 1.

$$\frac{g_N^2}{4\pi\upsilon_0}\frac{e^{-1/1}}{1} = \frac{1}{2}\frac{q_e^2}{4\pi\varepsilon_0}\frac{1}{1} \Leftrightarrow \frac{\upsilon_0}{\varepsilon_0} = \frac{e}{2}\frac{g_N^2}{q_e^2}$$

This is consistent with the result we had already obtained. At this point, you may have become impatient and say: this has nothing to do with the title of this paper, which is about neutrinos. We beg you to be patient and continue to go through these *prolegomena*. We need to think about one thing more in regard to this new nuclear force: what's its range? What's the value of the *scaling* parameter *a*?

The nuclear radius

The scaling parameter (*a*) must be obtained empirically: very large nuclei are not stable because the repulsive electrostatic force becomes larger than the attractive nuclear force. The largest *stable* nucleus is that of Pb-208. However, here we are not measuring the distance between two charges: we have a whole lot of them: 82 protons and 126 neutrons. It is easy to see that the calculation of electrostatic and nuclear forces is going to be very complicated ! Various models and formulas are used. High-energy *electron* scattering experiments yield the following approximate formula for the size of a nucleus[16]:

$$r = r_0 \cdot \sqrt[3]{\mathrm{A}}$$

A is the nucleon number (so that's 208 here), and the r_0 parameter is about 1.2 to 1.25 fm (10^{-15} m), which gives us a value of about 7.1 fm.[17] I've always wondered how these *electron* scattering experiments actually work because the classical electron radius is actually *larger* than the charge radius of an individual proton or neutron (about 2.8 fm versus a bit less than 1 fm).

We're not going to spend too much time on this, except for noting the formula seems to imply that protons and neutron are pretty much stacked together like hard spheres of a constant size (just like marbles, really) into a sphere.[18]

According to Aitchison and Hey[19], the range parameter to be used in Yukawa's potential formula is about 2 fm, which is about the size of *deuteron*, i.e. the nucleus of deuterium, which consists of a proton and a neutron bound together. To be precise, the charge radius of deuteron is about 2.1 fm.

That all makes sense, *intuitively*, so we won't dwell on it here.

We now want to come to the meat of the matter in this paper: we know that protons can capture electrons, and we also know that free neutrons decay into protons. These processes involve neutrinos. Hence, there is an interesting question here: if the energy state of an atomic changes – because

[16] One can *google* various references here. We let the reader enjoy himself.
[17] See, for example, https://faculty.sfcc.spokane.edu/inetshare/autowebs/asab/phys103/ch31.pdf
[18] We will let the reader check the Wikipedia article on sphere packing (https://en.wikipedia.org/wiki/Sphere_packing) and combine it with the wiki on the atomic nucleus.
[19] See: *The Particles and Forces of the Standard Model*, p. 3, in: Ian J.R. Aitchison and Anthony J.G. Hey, *Gauge Theories in Particle Physics: A Practical Introduction*, 2013.

electrons go from one orbital to another – the atom absorbs or emits a photon, and the energy of this photon will account for the energy difference. Is that a similar process?

In other words: should we think of neutrinos as the photons for the strong force? Before we reflect on that question, we will briefly remind you of how we think of photons.

Photons as the carriers of electromagnetic energy

Angular momentum comes in units of $\hbar$. In the context of an atom, this rule amounts to the electron orbitals are separated by a amount of *physical action* that is equal to $h = 2\pi\cdot\hbar$. Hence, when an electron jumps from one level to the next – say from the second to the first – then the atom will lose one unit of h. The photon that is emitted or absorbed will have to pack that somehow. It will also have to pack the related energy, which is given by the Rydberg formula:

$$\mathrm{E}_{n_2} - \mathrm{E}_{n_1} = -\frac{1}{{n_2}^2}\mathrm{E}_R + \frac{1}{{n_1}^2}\mathrm{E}_R = \left(\frac{1}{{n_1}^2} - \frac{1}{{n_2}^2}\right)\cdot\mathrm{E}_R = \left(\frac{1}{{n_1}^2} - \frac{1}{{n_2}^2}\right)\cdot\frac{\alpha^2\mathrm{m}c^2}{2}$$

To focus our thinking, let us consider the transition from the second to the first level, for which the $1/1^2 - 1/2^2$ is equal 0.75. Hence, the photon energy should be equal to $(0.75)\cdot\mathrm{E}_R \approx 10.2$ eV. Now, if the total action is equal to h, then the cycle time T can be calculated as:

$$\mathrm{E}\cdot\mathrm{T} = h \Leftrightarrow \mathrm{T} = \frac{h}{\mathrm{E}} \approx \frac{4.135\times10^{-15}\,\mathrm{eV}\cdot\mathrm{s}}{10.2\ \mathrm{eV}} \approx 0.4\times10^{-15}\ \mathrm{s}$$

This corresponds to a wave train with a length of $(3\times10^8\ \mathrm{m/s})\cdot(0.4\times10^{-15}\ \mathrm{s}) = 122$ nm. This is, in fact, the wavelength of the light ($\lambda = c/f = c\cdot\mathrm{T} = \mathrm{h}\cdot c/\mathrm{E}$) that we would associate with this photon energy and we, therefore, refer to this model as the *one-cycle photon model*. It is important to note this model does not think of the photon as a wave train: it is a pointlike electromagnetic oscillation traveling through space.[20]

While we do not want to go into too much detail here, we should quickly insert one more remark. If we think of the photon as a one-cycle electromagnetic oscillation – respecting the integrity of Planck's quantum of action – then its energy should still be proportional to (a) the square of the amplitude of the

[20] That is the size of a large molecule and it is, therefore, much more reasonable than the length of the wave trains we get when thinking of transients using the supposed Q of an atomic oscillator. Indeed, our one-cycle photon model should be contrasted with the idea of the photon as a wave trains, such as the one which Feynman develops in his *Lectures* (I-32-3). In his analysis, Feynman thinks about a sodium atom, which emits and absorbs sodium light, of course. Based on various assumptions – assumption that make sense in the context of the blackbody radiation model but *not* in the context of the Bohr model – he gets a Q of about 5×10^7. Now, the frequency of sodium light is about 500 THz (500×10^{12} oscillations per second). Hence, the *decay time* of the radiation is of the order of 10^{-8} seconds. So that means that, after 5×10^7 oscillations, the amplitude will have died by a factor $1/e \approx 0.37$. That seems to be very short, but it still makes for 5 million oscillations and, because the wavelength of sodium light is about 600 nm (600×10^{-9} meter), the analysis yields a wave train with a very considerable length: $(5\times10^6)\cdot(600\times10^{-9}$ meter$) = 3$ meter. *Surely you're joking, Mr. Feynman!* A photon with a length of 3 meter – or longer? While one might argue that relativity theory saves us here (relativistic length contraction should cause this length to reduce to zero as the wave train zips by at the speed of light), this just doesn't feel right – especially when one takes a closer look at the assumptions behind.

oscillation[21] and (b) the square of the frequency. Hence, if we write the amplitude as a and the frequency as ω, then the energy should be equal to $E = k \cdot a^2 \cdot \omega^2$. The k is just a proportionality factor.

At the same time, relativity theory tells us the energy will have some equivalent mass, which is given by Einstein's mass-equivalence relation: $E = m \cdot c^2$. Hence, the energy will also be proportional to this equivalent mass. It is, therefore, very tempting to equate k and m. However, we can only do this if c^2 is equal to $a^2 \cdot \omega^2$ or – what amounts to the same – if $c = a \cdot \omega$. This is the tangential velocity formula and, hence, we should wonder: *what* tangential velocity? The a in the $E = k \cdot a^2 \cdot \omega^2$ formula that we started off with is an amplitude: why would we suddenly think of it as a radius now? We will not repeat ourselves here[22] but the answer is this: a photon is circularly polarized. *Always*. Its angular momentum is $+\hbar$ or $-\hbar$. There is no zero-spin state.[23] Hence, if we think of this classically, then we will associate it with circular polarization and, using natural units, the tangential velocity of the end point of the electric field vector is equal to the speed of light. This, in fact, is the intimate connection between our oscillator model of an electron and the photon model.[24]

However, these remarks distract from the purpose here. The point is this: an analysis of the atom in low-energy physics (which amounts to saying we're only looking at the QED sector of the Standard Model, thinking about the electromagnetic force only) suggests the photon is Nature's vehicle to provide the necessary *nickel-and-dime* to ensure energy conservation. Low-energy physics does *not* involve the creation or destruction of electric charge. In contrast, in high-energy physics, we do need to account for electron-positron pair creation and annihilation.

This requires a different analysis which, in our humble opinion, should also involve the strong force. If photons carry *electromagnetic* energy, then neutrinos might carry an energy we should associate with the strong force: a *strong* energy.

Is this fanciful? Maybe. Maybe not. Energy is force over a distance. Electromagnetic energy is electromagnetic energy over a distance. If we are consistent, which we try to be, then some kind of concept of strong energy – a *strong* force over some distance – should make sense as well, but let us be more precise. Before we get into the nitty-gritty, we should re-explore the idea of a proton—or of a *nucleon* in general.

[21] We are *not* thinking of a quantum-mechanical amplitude here: we are talking the amplitude of a *physical* wave here (an *electromagnetic* oscillation).

[22] We refer to our *Classical Quantum Theory of Light* paper for the full-blown argument (13 June 2019).

[23] It is one of those many little things in mainstream quantum mechanics that bothers me. All courses in quantum mechanics spend one or more chapters on why bosons and fermions are different (spin-one versus spin-1/2) but, when it comes to the specifics, then the only boson we actually know (the photon) turns out to *not* be a typical boson because it can't have zero spin. Feynman gives some haywire explanation for this in section 4 of *Lecture* III-17. We will let you look it up (Feynman's *Lectures* are online) but, as far as I am concerned, I think it's really one of those things which makes me appreciate Prof. Dr. Ralston's criticism of his own profession: "*Quantum mechanics is the only subject in physics where teachers traditionally present haywire axioms they don't really believe, and regularly violate in research*." (John P. Ralston, *How To Understand Quantum Mechanics*, 2017, p. 1-10)

[24] Our manuscript (http://vixra.org/abs/1901.0105) offers more detailed reflections here based on a physical interpretation of the *de Broglie* wavelength.

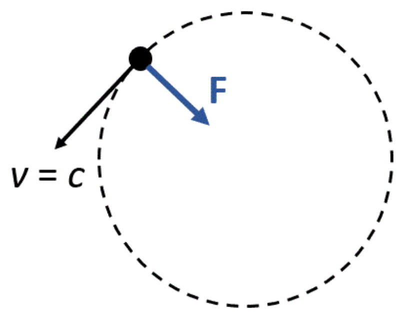
The idea of a proton

A photon is a oscillation of the electromagnetic *field* but it does not carry any electric charge. This is why the concept of *virtual* photons is not appealing: if we believe that two electric charges produce some electromagnetic *field* that keeps them together, then we don't *virtual photons* to carry energy or momentum between them.

This makes us think of neutrinos as oscillations of the strong field: they don't carry the strong charge, but if two strong charges are kept together by some strong field – in other words, if the Yukawa potential and the strong charge that causes it are *real* – then the idea of a counterpart of the photon for the strong force makes sense. Let us try to think this through.

We already noted we have a problem when trying to apply our mass without mass model to the proton. Let us briefly recap it. We think of a particle as an oscillation of a pointlike charge. To be precise, we think of it as a pointlike charge in a circular orbit: a current ring (Figure 3)

Figure 3: A particle as a current ring



We think of the pointlike charge as having zero rest mass. Hence, its tangential velocity equals the speed of light: $c = v = a \cdot \omega$. There is, obviously, *energy* in this oscillation, and we think of the rest mass of the particle as the equivalent mass of the energy in the oscillation. This hybrid description of a particle is our interpretation of Wheeler's mass without mass idea: the mass of the particle is the equivalent mass of the energy in the oscillation of the pointlike charge. It works like a charm for the electron. The calculation of its (Compton) radius is now self-evident. The Planck-Einstein relation ($E = \hbar \cdot \omega$) allows us to substitute ω for $E/\hbar$ in the tangential velocity formula, and we can then use Einstein's mass-energy equivalence relation ($E = m \cdot c^2$) to calculate the radius as the ratio of Planck's (reduced) quantum of action and the product of the electron mass and the speed of light:

$$a = \frac{c}{\omega} = \frac{c \cdot \hbar}{\mathrm{E}} = \frac{c \cdot \hbar}{\mathrm{m} \cdot c^2} = \frac{\hbar}{\mathrm{m} \cdot c} = \frac{\lambda_{\mathrm{C}}}{2\pi} = r_{\mathrm{C}} \approx 0.386 \times 10^{-12}\ \mathrm{m}$$

This can be easily interpreted: each *cycle* of the oscillation packs (i) one *fundamental* unit of physical action (h) and (ii) the electron's energy ($E = mc^2$). Indeed, the Planck-Einstein relation can be re-written as $E/T = h$. The $T = 1/f$ in this equation is the cycle time, which we can calculate as being equal to:

$$\mathrm{T} = \frac{h}{\mathrm{E}} \approx \frac{6.626 \times 10^{-34}\ \mathrm{J \cdot s}}{8.187 \times 10^{-14}\ \mathrm{J}} \approx 0.8 \times 10^{-20}\ \mathrm{s}$$

That's a *very* small amount of time: as Dirac notes, we can*not* directly verify this by experiment.[25] The point is: we can now intuitively understand Planck's quantum of action as the product of the electron's energy and the cycle time:

$$h = E \cdot T = h \cdot f \cdot T = h \cdot f/f = h$$

Our little theory works for the heavier variant of an electron as well. The muon energy is about 105.66 MeV, so that's about 207 times the electron energy. Its lifetime is fairly short but all is relative—it's still much longer than most other unstable particles: about 2.2 *micro*seconds (10^{-6} s).[26] Applying our oscillator model to the muon, we get a Compton *radius* that is equal to:

$$r_C = \frac{c}{\omega} = \frac{c \cdot \hbar}{E} \approx \frac{(3 \times 10^8 \frac{m}{s}) \cdot (6.582 \times 10^{-16} eV \cdot s)}{105.66 \times 10^{-6} eV} \approx 1.87 \text{ fm}$$

The CODATA value for the Compton *wavelength* of the muon is the following:

$$1.173444110 \times 10^{-14} \text{ m} \pm 0.000000026 \times 10^{-14} \text{ m}$$

If you divide this by 2π - to get a *radius* instead of a wavelength – you get the same value: about 1.87×10^{-15} m. So our oscillator model seems to work for a muon as well! Why, then, is it not stable? The only explanation is that the oscillation might be *slightly* off, so let us be more precise in our calculation and use CODATA values for all variables here[27]:

$$\lambda_C = \frac{2\pi}{2\pi} \cdot \frac{\left(299{,}792{,}458 \frac{m}{s}\right) \cdot (6.62607015 \times 10^{-34} eV \cdot s)}{1.6928338 \times 10^{-11} \text{ J}} \approx 1.1734441131 \ldots \times 10^{-14} \text{ m}$$

[25] The cycle time of short-wave ultraviolet light (UV-C), with photon energies equal to 10.2 eV is 0.4×10^{-15} s, so that gives an idea of what we're talking about. You may want to compare with frequencies of X- or gamma-ray photons. As we're referring to Dirac here, it is probably useful to remind ourselves we are, effectively, going back to Schrödinger's 'discovery' of the *Zitterbewegung* of an electron. Erwin Schrödinger stumbled upon this idea when he was exploring solutions to Dirac's wave equation for free electrons. It's always worth quoting Dirac's summary of it: "The variables give rise to some rather unexpected phenomena concerning the motion of the electron. These have been fully worked out by Schrödinger. It is found that an electron which seems to us to be moving slowly, must actually have a very high frequency oscillatory motion of small amplitude superposed on the regular motion which appears to us. As a result of this oscillatory motion, the velocity of the electron at any time equals the velocity of light. This is a prediction which cannot be directly verified by experiment, since the frequency of the oscillatory motion is so high and its amplitude is so small. But one must believe in this consequence of the theory, since other consequences of the theory which are inseparably bound up with this one, such as the law of scattering of light by an electron, are confirmed by experiment." (Paul A.M. Dirac, Theory of Electrons and Positrons, Nobel Lecture, December 12, 1933)

[26] Its presumed longevity should not be exaggerated, however: the mean lifetime of charged pions is about 26 *nano*seconds (10^{-9} s), so that's only 85 times less.

[27] In the new calculation, we will also express Planck's quantum of action and the muon energy in *joule* so as to get a more precise wavelength value. Note that the $2\pi/2\pi = 1$ factor in the ratio is there because we calculate a wavelength (which explains the multiplication by 2π) and because we do *not* use the reduced Planck constant (which explains the division by 2π).

The calculated value falls within CODATA's uncertainty interval, so we cannot be conclusive. The result is quite significant, though.[28] We believe there is a firm need for a more fundamental analysis of the muon disintegration process. Indeed, the muon decays into an electron and, because of the conservation of angular momentum, *two* neutrinos.[29] Why? The process conserves charge as well as energy and linear and angular momentum. But *why* is the muon's *mean* lifetime (about 2.197 *micro*-seconds) what it is? And what explains the shape of the probability distribution (or decay time) function, *exactly*?[30]

We have no idea, and such reflections are not the subject of this paper. We only talked about the muon because we might briefly entertain the following idea: the muon has an anti-matter counterpart whose *electric* charge is equal to that of the proton and – who knows? – perhaps it's like the neutron: unstable *outside* of the nucleus, but stable inside of some other oscillation. Hence, we may want to think of the muon as the pointlike charge inside of a proton, perhaps?

The answer is a resounding: *No!* Why not? Because its measured radius is larger than the proton radius. OK. Then we should use the *tau*-positron. No. We can't do that. The energy (or equivalent *mass*) of the tau-positron is *larger* than that of the proton. What about the anti-matter counterpart of the electron—the positron? All of the formulas in the oscillator model for an electron work for a positive charge as well, don't they? They do, but we get weird results.

If we try the mass of a proton (or a neutron—almost the same) in the formula for the Compton radius, we get this:

$$a_{\mathrm{p}} = \frac{\hbar}{\mathrm{m_p} \cdot c} = \frac{\hbar}{\mathrm{E_p}/c} = \frac{(6.582 \times 10^{-16}\ \mathrm{eV} \cdot s) \cdot (3 \times 10^{8}\ m/s)}{938 \times 10^{6}\ \mathrm{eV}} \approx 0.21 \times 10^{-15}\ \mathrm{m}$$

That's about 1/4 of the actual radius as measured in scattering experiments. A factor of 1/4 is encouraging but not good enough. This indicates that we should effectively think of the proton as some *bundle* of a strong and an electric charge. That's quite difficult, because we believe in the classical electron radius as something that's real.[31] We, therefore, believe that the positron has the same radius, and that radius – which we get from *elastic* scattering experiments – is actually , and it also allows us to explain the anomalous magnetic moment in classical terms (no need for quantum field theory). However, the problem is that this classical electron radius – aka as Thomson or Lorentz radius – is also *larger* than the proton (and neutron) radius. To be precise, it's equal to:

[28] As for the tau electron, we are not aware of any experimental value of its Compton wavelength. Hence, a calculation isn't useful here.

[29] If you *google* this, you will find these two neutrinos are thought of as a neutrino and anti-neutrino respectively. However, as mentioned, we do not believe neutral particles have *anti*-matter counterparts. We believe a neutrino is a neutrino, but its *spin* direction can, effectively, be up or down (read: in one direction or the other).

[30] This article offers an excellent overview of *mainstream* muon research: T. P. Gorringea and D.W. Hertzog, *Precision Muon Physics*, 4 June 2015 (https://arxiv.org/pdf/1506.01465.pdf). The decay time reflects a typical decay function. For an example of a practical experiment, see: https://arxiv.org/ftp/arxiv/papers/1608/1608.06936.pdf.

[31] The *reality* of the classical electron radius also allows us to explain the anomalous magnetic moment in classical terms (no need for quantum field theory). See our 11 June 2019 paper: *The Anomalous Magnetic Moment: Classical Calculations*.

$$r_e = \frac{e^2}{mc^2} = \alpha \cdot r_C = \alpha \frac{\hbar}{mc} \approx 2.818 \ldots \times 10^{-15} \text{ m}$$

This is about 3.5 times *larger* than the measured proton or neutron radius. It is even larger than the measured radius of the deuteron nucleus, which consists of a proton and a neutron bound together: the deuteron radius is about 2.1 fm.

There is no escape here: we need to accept some other force is involved, and we also need to explain why it seems to *shrink* the classical radius of the unit charge. We quickly get into muddy waters here, and so let us get back to the topic of this paper: neutrinos as carriers of strong energy.

Neutrinos as the carriers of strong energy

In our previous paper, we made it clear that we do *not* believe that the idea of an *anti*-neutrino is useful: neutrinos are electrically neutral and, hence, that's all that should be said about the matter. Their spin direction may be up or down but the philosophical discussion on whether neutrinos are Majorana or Dirac neutrinos is a no-brainer.[32] We, therefore, write the four principal nuclear processes involving neutrinos (ν^0 particles) as follows:

1. Neutron decay: $n^0 \rightarrow p^+ + e^- + \nu^0$
2. Electron capture by a proton: $p^+ + e^- \rightarrow n^0 + \nu^0$
3. Positron emission by a proton: $\nu^0 + p^+ \rightarrow n^0 + e^+$
4. Positron emission by a proton: $\gamma + p^+ \rightarrow n^0 + e^+ + \nu^0$

The latter two processes are very different[33] but yield the same: a proton emits a *positron* and becomes a neutron. These three or four processes show that the idea of a proton (and a neutron) as a *bundle* of (i) electric charge(s) and (ii) strong charge makes sense. We have a plural for electric charges because we think of a neutron as combining the positive *and* negative unit charge. That is consistent – we believe – with the mass difference between the proton and the neutron.[34]

These *flavor*-changing processes are thought of as involving the *weak* force in mainstream theory, but we think that's a misnomer. The strong and the weak force must be two sides of the same coin: what keeps stuff together must also explain why stuff falls apart, right?

The *emission* or *absorption* of electrons and positrons takes care of the (electric) charge conservation law. Indeed, we deliberately use the plural here because these processes involve *pair* production and annihilation and, as such, these processes do respect the (electric) charge conservation law.[35]

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[32] We know this challenges the *lepton number conservation law* but we explained why this doesn't bother us. See: *Elementary Particles and Conservation Laws: a Realist Interpretation of Quantum Mechanics*, 31 August 2019

[33] The first is the 1951 Cowan-Reines experiment (bombarding protons with neutrinos). The second describes β^+ decay. We refer to our paper (reference above) for a more detailed description.

[34] The neutron's energy is about 939,565,420 eV. The proton energy is about 938,272,088 eV. The difference is 1,293,332 eV. That's almost 1.3 MeV. The electron energy gives us close to 0.511 MeV of that difference – so that's only 40% – but its *kinetic* energy can make up for a lot of the remainder. We then have the neutrino to provide the change—the *nickel-and-dime*, so to speak. So, yes, energy is conserved. More detailed energy conservation equations are provided in an earlier paper which wonders whether we can think of *electrons as gluons*.

[35] See the above-mentioned paper: these processes do *not* conserve the number of charged particles but, using the perspective offered by David Hume's epistemological *bundle* theory, that shouldn't matter.

However, there clearly is a need for the idea of a photon-like particle that ensures the conservation of *strong* energy. If we have two forces, we have two charges. If we have two forces, we also have two different energies: if we distinguish between a strong force and an electromagnetic force – acting on a strong and an electric charge respectively – then we should also distinguish between *electromagnetic* from *strong* energy.

Hence, the idea of neutrinos taking care of the energy equation when some *shake-up* involves a change in the energy *state* of a nucleus makes perfect sense to me. I hope it does to you too. If so – or if *not* so – please let me know why. We have, effectively, seen a multiplication of concepts since World War II, and we don't think it has reduced the confusion. We need to explain quantum-mechanical phenomena in much simpler terms. We need to get back to basics. We don't need a Great Unification Theory. We need a Great Simplification Theory. We need to think of the strong force as a force. How it *couples* to the electromagnetic force is a great mystery but, as no one has seriously invested in trying to think about that coupling[36], we shouldn't feel depressed about that.

The idea of a force being *mediated* by ghost particles feels like a simplistic, medieval or Ptolemaic *in-between* theory. We need to tackle these fundamental questions *head-on*. Invoking deep mysteries and other hocus-pocus no longer satisfies the public.

Pair production

Electron-positron pair production always involve the presence of a nucleus. This makes one think the interaction is with the nucleus. In other words, it is *not* just a photon magically transforming into an electron-positron pair. We will rather want to assume that the incoming photon results in (i) positron emission by a proton and (ii) neutron decay. Hence, reactions (1) and (4) above combine to produce this:

$$\gamma + p^+ + n^0 \rightarrow (n^0 + e^+ + \nu^0) + (p^+ + e^- + \nu^0) = n^0 + p^+ + e^+ + e^- + \nu^0 + \nu^0$$

This combined reaction effectively gives us an electron-positron pair, with no impact on the nucleus (we have one proton and one neutron left and right). If this is correct, then we should also see two neutrinos. I am not sure if there has been any research in this regard.

Conclusions

We will let the reader think about our non-mainstream interpretation of the strong force. We think the idea of treating it like a proper force – i.e. some more thorough thinking about magnitudes and the nature of the associated charge – might help to do what has never been done before, and that is to think how the electromagnetic and strong force might actually *couple*.

The idea of *bosons* mediating the force has prevented that: each force comes with its own bosons in the Standard Model, and they don't seem to talk to each other.[37] The idea of elementary particles – fermions, bosons, quarks, gluons, whatever – needs to be abandoned. We need to focus on the *properties* of particles, and these are described in terms of forces and, therefore, charges. If we understand the *charges*, then we understand the Universe.

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[36] Again, I think of the idea of a force being *mediated* by ghost particles as a simplistic, medieval or Ptolemaic *in-between* theory.

[37] If they do, it's through the invention of yet another boson: the boson that gives mass to (some of) them.

We still have a long way to go here, and we think the post-WWII effort has largely been useless, unfortunately. The 'young wolves' (the likes of Feynman, Dyson, Schwinger etcetera) only multiplied concepts. We should get back to the original agenda – and *intuitions* – of the first-generation quantum physicists: Planck, Einstein, Bohr, Heisenberg, Schrödinger, Dirac, Pauli, etcetera. That agenda may be summarized in one simple question: what use is a theory no one can understand?

This question refers, obviously, to widely used quotes. One of the most quoted is attributed to Richard Feynman: "*I think I can safely say that nobody understands quantum mechanics*." I studied Feynman's *Lectures* very much in detail and, therefore, I had to *google* this quote—to see when and where he said this, *exactly*. I found that the quote is from a transcript of the *Messenger Lecture Series at Cornell, 1964*: Lecture 6, to be precise—which I haven't verified. In any case, the reader can check his introduction to his *Lectures on Quantum Physics* (Vol. III of his famous *Lectures on Physics*), where he writes the same in more prosaic but similar terms:

> "Because atomic behavior is so unlike ordinary experience, it is very difficult to get used to, and it appears peculiar and mysterious to everyone—both to the novice and to the experienced physicist. *Even the experts do not understand it the way they would like to*, and it is perfectly reasonable that they should not, because all of direct, human experience and of human intuition applies to large objects. We know how large objects will act, but things on a small scale just do not act that way. So we have to learn about them in a sort of abstract or imaginative fashion and not by connection with our direct experience."

It should be obvious, by now, that we don't agree with Feynman: we think the ideas of space, time, force, energy, charge and what have you are *directly* connected with our direct experience. Hence, we feel *society* is entitled to an explanation of reality – if only because taxpayer money finances academia – to an explanation of reality in terms of such every-day direct-experience ideas. If such explanations cannot be provided, further financing of costly high-energy experiments is of no use whatsoever.

Theoretical physicists may hate philosophers (Feynman clearly did), but they need to study Occam's Razor Principle: I think it's rather hard to deny we've effectively seen an unnecessary 'multiplication of concepts' in theoretical physics since the 'young wolves' took over. We feel their abandoning of Dirac's research agenda (a kinematic model of quantum mechanics) has failed.

We readily agree this paper may not offer a convincing model of the strong force, but it's about time physicists acknowledge the idea of virtual particles mediating forces does resemble 19th aether theory: it looks like a superfluous concept. They, therefore, need to motivate why they keep *supporting* and *believing* in it. They also need to explain why they think of the weak force as a force: an explanation of why stuff stays together (the theory of the nucleus and of nucleons) should also explain why stuff falls apart. The plain admission that there is no explanation of the magnetic moment of a proton or a neutron in terms of first principles[38] is a shame: we should all[39] step up and do a better job.

Jean Louis Van Belle, 25 September 2019

[38] See various Wikipedia articles. I checked but the original language seems to have been toned down by anonymous editors.

[39] With 'all', I mean: amateur physicists and academics alike. To be clear: I am only an amateur physicist.