Elementary particles and conservation laws: a realist interpretation of quantum mechanics

Jean Louis Van Belle, 31 August 2019

Summary

This paper offers some epistemological reflections on the idea of elementary particles, boson and quark-gluon theory, and the nature of quantum-mechanical conservation laws. We apply Occam's Razor Principle to what we think of as an unnecessary 'multiplication of concepts' by 'the young wolves' (Feynman, Dyson, Schwinger etcetera) as they were claiming their own territory by trying to distinguish themselves from the first-generation quantum physicists (Planck, Einstein, Bohr, Heisenberg, Schrödinger, Dirac, Pauli, etcetera).

We argue that their abandoning of Dirac's research agenda (a kinematic model of quantum mechanics) has failed. We have no convincing model of the strong force, and the idea of *virtual* particles *mediating* forces resembles 19th 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. 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.

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 recent development of intuitive 'mass without mass' models of the electron and the photon.

Contents

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The idea of an elementary particle

What *is* an elementary particle? History and common sense give us a pragmatic definition: a particle is elementary until a venerable physicist – based on conclusive experiments, *hopefully* – tells us it consists of even more elementary particles. Such definition is a modern adaptation of the etymological meaning of *a-tom*: something we cannot divide anymore. Until we can, of course.[2]

The idea of indivisibility may be confused with the idea of stability. Perhaps we should think of elementary particles as being *stable*. However, quarks would then not qualify as elementary particles because they change *color* all the time. Worse, they may also *change* flavor and become *another* quark. It is a rather complicated matter. The color changing comes from *gluons*. The *flavor* changing comes from… Well… Some *weak force*.

That's the Standard Model. It's weird, but it is what it is.

I forgot to mention bosons. Messenger particles, like gluons: *ghost* particles[3] that are supposed to *mediate* the strong force. Flavor changing is caused by the weak force. I don't know why physicists think a force needs to be *mediated* by ghost particles, and I also don't know why we'd refer to decay and disintegration processes as something that involves a *force*, but this 'multiplication of concepts' – Occam would be very unhappy about it[4] – has already happened (some physicists got Nobel Prizes for it) and we, therefore, need to try to make sense of it.

Quark-gluon theory raises an obvious philosophical question: if quarks change color all of the time, can we think of them as being *stable*? If their color changes all of the time, can we say the quarks themselves change all of the time?

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[1] Independent researcher: https://jeanlouisvanbelle.academia.edu/research..

[2] The Greek *a-tomos* combines *a-* (*not*) with *tomos*, from *temnein* (to cut).

[3] The only boson for which we have firm evidence is a photon. For all other bosons, we only have *indirect* 'evidence': signals, traces, two- or three-jet events that may or may not corroborate the hypothesis of virtual particles being actually *real* (as opposed to intermediary mathematical constructs). Unfortunately, a *real-life* photon (not those imaginary virtual photons that are supposed to *mediate* the electromagnetic force) lacks an essential bosonic property: it has no zero-spin state. This is one of the things I never understood. All courses on quantum mechanics – think of Feynman's treatment of the difference between bosons and fermions here (http://www.feynmanlectures.caltech.edu/III_04.html) – devote plenty of space to the theoretical distinction between fermions and bosons but, when it comes to specifics (I mean *real-life stuff* here), then the only boson we actually know (the photon) turns out to *not* be a typical boson because it can*not* have zero spin. This observation actually led us to explore an alternative (read: non-mysterious) explanation of one-photon Mach-Zehnder interference (http://vixra.org/abs/1812.0455)

[4] Occam's Razor Principle – aka as the *lex parsimoniae* – is a problem-solving principle according to which 'entities should not be multiplied without necessity': a theory with *less* concepts is to be preferred to one with *more*. Applied to physics, one could say that all mathematical objects should correspond to physical realities, *somehow*.

Maybe. Maybe not. Physicists do not seem to associate the idea of stability with particles: they refer to a whole 'zoo' of short-lived *transients* or even shorter-lived *resonances* as 'particles'. We would prefer to reserve the term 'particle' to refer to more *permanent* fixtures in our Universe but who are we?[5] And why would it matter? Can't we apply Paul Feyerabend's epistemological philosophy: *anything goes*, right? No. If *any* explanation works, then we don't have an explanation.

Physicists also think about elementary particles as being pointlike. That is incongruent because they have *measured* the *charge* radius of the particles they are looking at to an incredible degree of precision. The standard uncertainty for the (classical) electron radius, for example, is 1.3×10^{-24} m.[6] That distance is (much) smaller than the wavelength of the high-energy gamma-rays we use to measure it. Because Planck's constant is no longer being *measured* since the 2019 revision of SI units[7], the corresponding energy of a photon with such wavelength (1.3×10^{-24} m) would be equal to:

$$\mathrm{E}_{\gamma} = \frac{hc}{\lambda} = \frac{(4.135667696\ldots\times 10^{-15}\ \mathrm{eV\cdot s})\cdot(299{,}792{,}458\ \mathrm{m})}{1.3\times 10^{-24}\ \mathrm{m}} \approx 953{,}724{,}603\ \mathrm{TeV}$$

Almost 1 *exa*-electronvolt (EeV). We will let the reader *google* what this might correspond to on the energy and/or mass scale.

An incredible degree of precision? For the electron, yes. Not for quarks. Physicists have some *idea* about the charge radius of quarks but – in contrast to the above-mentioned degree of precision involved in measuring the charge radius of an electron – the measurements here are rather inconclusive. We get some theoretical upper limit on quark sizes – typically in the order of 10^{-18} m, so that's a *thousand* times smaller than the *femto*-meter scale[8] – but nothing like a typical charge radius. It's because of quark *confinement*.

This explanation for why we will probably never be sure quarks actually exist is also referred to as the *asymptotic freedom* assumption. For more information about the inferences on quark radii, we refer to a site which summarizes the quark *hypothesis* rather well:

> "The conventional theory argues that there are three kinds of each type of quark. It denotes these kinds by color although these kinds have nothing to do with visual color. The conventional theory holds that any baryon contains one quark of each color and so it is color neutral, white. Stripped of the color terminology the conventional theory maintains that quarks can have one of three different attributes and any baryon contains one of each of the three attributes. *These conjectures have become accepted as facts in physics*."[9]

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[5] Richard Feynman made it clear physicists do not need philosophers to help them structure their epistemology.
[6] See CODATA: https://physics.nist.gov/cgi-bin/cuu/Value?re|search_for=electron+radius. CODATA writes it in *femto*meter: $0.0000000013\times10^{-15}$ m.
[7] The speed of light had already been defined as being equal to 299,792,458 m/s *exactly* in 1983.
[8] See, for example, *Limits on the effective quark radius from inclusive ep scattering at HERA*, Physics Letters B Volume 757, 10 June 2016, Pages 468-472 (https://www.sciencedirect.com/science/article/pii/S0370269316300776).
ZEUS Collaboration
[9] Source: http://www.sjsu.edu/faculty/watkins/quarksizes.htm

When I read things like this, I can't help asking an obvious philosophical question: what is a particle stripped of all its attributes?

David Hume would tell us: nothing, and we believe he's got a point. Do quarks exist? What is the notion of a quark if we strip it from its presumed color or flavor? We will come back to this. Let us first think some more about the charge radius of an electron. An electron is a particle that has more 'particle-like' attributes than a quark or a gluon and we can, therefore, perhaps learn something from it. A lot of theorizing in high-energy physics is, effectively, based on generalizations of what is referred to as the 'electron figure'.[10]

The idea of an electron

While the Standard Model continues to think of an electron as a pointlike particle, simple scattering experiments – which have been carried out for over a hundred years now – show it does have a (charge) radius. In fact, it has *two*: the Thomson and the Compton radius. The *Zitterbewegung* hypothesis – which, always useful to remind ourselves, goes back to Schrödinger and Dirac – offers a wonderfully elegant geometric explanation of these two radii but the Zitterbewegung interpretation of quantum mechanics is *a minority interpretation* of quantum mechanics and, therefore, one can only read about it in minority discussion fora.[11] In any case, according to mainstream physics elementary particles should not have any internal structure: their properties are supposed to be *intrinsic* (read: *magical*[12]) and, therefore, one should not try to *derive* them from some electron model.

Indeed, the QED sector of the Standard Model is about electrons and photons, and the interactions between them, but the *gurus* tell us that we should not invest in electron and photon models because that would show disrespect to the Venerable. All of quantum-mechanical weirdness is to be understood in terms of quantum field theories whose experimental verification is 'highly convincing'.[13] The ingrained fear of thinking of most physicists is somewhat strange because the venerable Richard Feynman himself – in his seminal *Lectures* – bothered to write several deep reflections on the tricky question of the charge radius of an electron.[14] However, Feynman thinks of an electron as a *sphere of charge*. That's why he doesn't get all that far.

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[10] See: Ian J.R. Aitchison and Anthony J.G. Hey, *Gauge Theories in Particle Physics: A Practical Introduction*, Vol. 1, Chapter 1 (*The Particles and Forces of the Standard Model*), p. 3.

[11] This author spent a few days adding references and material on the Zitterbewegung *interpretation* of quantum mechanics to the Wikipedia *wiki* but these additions and (small) edits all got censored away (literally *all* of them). The author has, therefore, resorted to a new encyclopedia for wacks and created two entries there: https://www.vixrapedia.org/wiki/Zitterbewegung and https://www.vixrapedia.org/wiki/Realist_interpretation. The status of these two entries (fun or serious) is currently unclear. We invite readers to express their opinion by becoming a Vixrapedia contributor themselves and *adding* (rather than deleting) to these two wikis.

[12] When Feynman confidently writes that it is "safe" to assume "nobody understands quantum mechanics" (you should look up the *exact* reference for yourself), he basically abandons 'reason', doesn't he? A theory no one understands is usually referred to as 'useless' or 'crazy', right?

[13] See Aitchison and Hey (p. 3) and other standard textbooks. For more readable but even more mysterious explanations, we refer the reader to Wikipedia.

[14] See Feynman's calculations on a 'sphere of charge' and a 'spherical shell of charge': http://www.feynmanlectures.caltech.edu/II_05.html#Ch5-S7. His chapter on electromagnetic mass (http://www.feynmanlectures.caltech.edu/II_28.html) – a *full-blown* chapter on the topic! – is even more significant, I would think.

We prefer kinematic 'mass without mass' models of an electron, which we may broadly refer to as *Zitterbewegung* models. Not only do these explain the two radii but, in addition, they also logically explain all of the *intrinsic* properties (mass, spin, magnetic moment, etcetera).[15] It is also more in line with Dirac's *vision* of a 'good theory': he always thought of it as 'a scheme based on equations of motion.'[16]

Why would we be interested in the question of what actually *defines* a particle? These philosophical definitions are not needed to use quantum mechanics and *calculate*, right? Yes, they are. We have a lot of strange conservation laws in quantum mechanics (the conservation of the *lepton* and *baryon* number, for example) that are *directly* related to *the idea of a particle* and the associated particle *classifications*. Apart from *lepton* or *baryon* number conservation laws, we also have laws that directly relate to the above-mentioned *flavors* of quarks (charm, strangeness, beauty (or bottomness), or just *light unflavored* stuff[17]). In short, philosophy or epistemology matters greatly!

We find these lepton or baryon conservation laws weird because such conservation laws seem to reflect a medieval conservation law which was shown *not* to hold in the early stages of the emergency of high-energy physics as a scientific discipline: the conservation of the *number* of (charged or non-charged) particles. The Great Dirac wrote the following about that in the preface to the fourth and last edition of his seminal *Principles of Quantum Mechanics*:

> "In present-day high-energy physics, the creation and annihilation of charged particles is a frequent occurrence. A quantum electrodynamics which demands conservation of the number of charged particles is, therefore, out of touch with physical reality. So I have replaced it by a quantum electrodynamics which includes creation and annihilation of electron-positron pairs. […] It seems that the classical concept of an electron is no longer a useful model in physics, except possibly for elementary theories that are restricted to low-energy phenomena."

This modification is, in fact, the only significant change in Dirac's *Principles* between 1930 (first edition) and 1957 (fourth and last edition). Mainstream quantum-mechanical calculus takes this reality into account of this reality by substituting the charge conservation law by the *lepton number conservation* law, in which the lepton number is defined as the *difference* between the number of leptons (electrons) and the number of anti-leptons (positrons).

However, this conservation law does not work for some decay processes (neutron decay, inverse beta decay, electron capture by a proton and beta *plus* decay, basically), unless we define neutrinos as leptons too, which is – of course – what physicists did. This created another problem: neutrinos are neutral and, hence, the *matter-antimatter* classification does not apply to them. Physicists solved this theoretical issue by simply stating they *believe* neutrinos have an anti-matter counterpart and leaving

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[15] For a *fringe* interpretation within the larger minority interpretation, see: Jean Louis Van Belle, *Mass without mass*, 13 August 2019, http://vixra.org/abs/1908.0225. For more authoritative explanations, please *google* for Kerr-Newman electron models and/or their authors, e.g. Arkani-Hamed-Dimopoulos-Dvali, Burinskii, Celani-Vassallo-Di Tommaso etcetera. This research is slowly getting some 'highly convincing' experimental back-up.
[16] P.A.M Dirac, *Principles of Quantum Mechanics* (4th edition), Oxford University Press, 1958, p. 312.
[17] The *light unflavored* mesons are a group of 'particles' (or *transients*?) for whom all these strange quantum numbers are zero: $S = C = B = 0$. They are, therefore, supposed to consist of simple *u* and *d* quarks only. In fact, their equation should read: $S = C = B = T = 0$. The informed reader will understand why. See: http://pdg.lbl.gov/2019/tables/rpp2019-tab-mesons-light.pdf

the question of what makes neutrinos and antineutrinos actually different wide open.[18] We will explain this smart solution more in detail in the next section(s).

The charge conservation law

Dirac was fascinated by electron-positron pair creation, and we are too! To be precise, we are actually more fascinated by electron-positron pair *annihilation* because the creation of a pair might be explained by proton and neutron *flavor* changes. Indeed, electron-positron pair production only happens when very-high energy photons (gamma-ray photons) hit heavy nuclei. To be precise, the photon is thought to "interact with the Coulomb field of the atomic nucleus", and the probability of an electron–positron pair to emerge from the photon increases with (i) the photon energy and (ii) the atomic number.[19] This is probably as mysterious as it sounds, so we will not try to add any comment—not *now*, that is.

The point to note is that the creation and annihilation of electron-positron pairs respects the *idea* of charge conservation. The *combined* charge of the *pair* is the same as that of the photon: zero. However, yes, it is obvious that it does *not* conserve the *number* of charged particles.

Should we care? I would think we should *not*, because high-energy physics studies processes that do *not* conserve particles—not in general (number of particles), and not in particular (number of electrons, protons, etcetera). Hence, while it's true this wonderful invention of a *lepton* number covers both $\gamma \leftrightarrow e^- + e^+$ processes as well as the above-mentioned neutron and proton *flavor* changing processes (neutron decay, inverse beta decay, electron capture by a proton and beta *plus* decay), it feels a bit artificial. Why wouldn't we stick to the simpler rule: total (*net*) charge in the Universe is conserved, *always*.

Indeed, if David Hume was still alive, he would have told us that we should *not* be obsessed with the idea of a particle and, hence, that we, therefore, should *not* be obsessed with the idea of Nature having to respect the idea of the conservation of the *number* of charged *particles*. It's just not relevant.

Of course, mainstream physicists will cry wolf: how, then, can we explain all these strange particle production, disintegration and decay processes? I have no clear-cut answer to that but I would say: the classical conservation laws – conservation of energy, linear and angular momentum, and charge conservation – are all related to the force. Hence, *if* we would be able to *understand* the *structure* of the

[18] See the various articles on neutrinos on Fermi National Accelerator Laboratory (FNAL), such as, for example, this one: https://neutrinos.fnal.gov/mysteries/majorana-or-dirac/. The common explanation is that neutrinos and anti-neutrinos have opposite spin. However, that doesn't make them two different particles, and it surely does not make one the anti-particle of the other. The question that needs to be answered is whether or not neutrinos and anti-neutrinos do what electrons and positrons do: matter and anti-matter particles should annihilate each other in a big flash. However, as far as we know, neutrinos and anti-neutrinos don't do that.

[19] The energy of the photon has to be *very* high because its energy (or mass equivalent) has to match the energies of the electron and the positron that's being produced, and some extra. Hence, we are talking high-energy gamma-ray photons here ($E_\gamma > 1.022$ MeV). The reader should note we are referring to the 1930 Meitner–Hupfeld experiment, which involved anomalous scattering of gamma rays by heavy elements. The effect is, effectively, the result of electron–positron pair production and annihilation. For a good overview and discussion, see: J.H. Hubbell, *Electron–positron pair production by photons: a historical overview*, June 2006 (https://www.sciencedirect.com/science/article/abs/pii/S0969806X0500263X).

strong and, possibly, the weak force – if the weak force *is* a force, which I doubt it is[20] - and the *nature* of this 'strong' charge (which is very difficult because of this confusion between colors, flavors and *partial* electric charges, of course[21]), *then* we might find that the new force law – and the related classical laws conservation of energy, linear and angular momentum, and charge conservation – explains all.

It should, *logically speaking*, right? Of course, there is an *if*, and a *then* above. Anything might happen, but that doesn't mean *anything goes*. We don't agree with Feyerabend. Not when trying to describe reality.

Hume's bundle theory

Perhaps we should not bother too much about definitions right now and just freewheel a bit about the possible *nature* of the particles we know. What is an electron? What is a photon? What is a proton? Should we think of unstable particles as proper particles? Do we believe gluons exist? Etcetera. Plenty of questions. Few answers.

Let us try to think things through by accepting that the idea of a particle may be less important than its *properties*. According to David Hume, any object is just a collection of properties and relations: a *bundle*, as he called it, which is why it's referred to as bundle theory. According to Hume, an object consists of its properties and its relations to other objects *only*: *nothing more*. He also wrote: "Neither can there be an object without properties nor can one even conceive of such an object."

For example, bundle theory claims that thinking of an apple compels one also to think of its color, its shape, the fact that it is a kind of fruit, its cells, its taste, or of one of its other properties. Thus, the theory asserts that the apple is no more than the collection of its properties. Hence, according to Hume, there is no substance (or 'essence') in which the properties inhere.

So let us *not* think too much about particles: let's think about their properties. Let's start with (electric) charge. Why start with charge? Why not with mass? Because Einstein's mass-energy equivalence relation tells us mass may not be fundamental. The new 2019 SI system of units also says as much: the kg is now defined in terms of other fundamental constants. Finally, there is the force concept: a force grabs onto a *charge*—an electric charge (for the electromagnetic force) or a *strong* charge (for the strong force). *Huh?* The strong charge? What's that? I don't know. Colors, flavors? We must diligently refer to the professional physicists and the concepts pioneered by the Venerable.

Hence, we will just think about electric charge. It's a good place to start.

[20] A force keeps *charges* together, or pushes them away. Something that causes things to fall apart should not be referred to as a force. Do we think some force is involved when a car crashes? Of course, we do, but we do *not* invent a new force explaining the disintegration of that car: classical mechanics will do. See: Jean Louis Van Belle, *Is the weak force a Force?*, 19 July 2019 (http://vixra.org/abs/1907.0330).

[21] See: Jean Louis Van Belle, *The Quark-Gluon Model Versus the Idea of Partons*, 2 July 2019 (http://vixra.org/abs/1907.0007) and Jean Louis Van Belle, *A Realist Interpretation of QCD?*, 16 July 2019 (http://vixra.org/abs/1907.0043).

Electric charge

Electric charge is a very obvious property of particles, so we should distinguish charged versus non-charged particles. Electrons versus photons and neutrinos, for example.

This raises an immediate question: why do physicists lump neutrinos and electrons together in the same category? They *define* both as *leptons*. What's the *defining* property of leptons? As mentioned above, physicists invented the term because they need it for a weird conservation law—one they invented when it became clear charge is not always being conserved. Think of neutron decay, inverse beta decay, or electron capture by a proton. Let us start with neutron decay. *Neutron decay?* Yes. A neutron is stable *inside of the nucleus* only. It decays outside. The mean lifetime of a free neutron – outside of the nucleus – is a bit less than 15 minutes[22], which is close to an eternity in high-energy physics but it is what it is: free neutrons *decay* into a proton and an electron. You (should) know this. The disintegration process is written as:

$$\mathrm{n^0 \rightarrow p^+ + e^- + \bar{\nu}_e^0}$$

As you can see, *total* charge is actually being conserved (a neutron is neutron, and the charge of the proton and the electron also add up to zero). However, physicists felt there was a need to invent a new conservation law: conservation of the lepton number. The lepton number is one of these weird quantum numbers. To be precise, it is defined as the *difference* between leptons and anti-leptons. On the left-hand side, we have no leptons (a neutron is *not* a lepton). On the right-hand side, we have one lepton: the electron (the proton is *not* a lepton either). Hence, that doesn't work. That's why the neutrino – sorry, the *anti*-neutrino – is there: it's an anti-lepton. One lepton minus one anti-lepton makes zero.

This raises another obvious question: if neutrinos are neutral, then what's the difference between a neutrino and an anti-neutrino? It is a good question, and physicists do *not* have any answer to it. I am not joking: the specialists in the matter say they have no idea and that a neutrino and an anti-neutrino may well be one and the same thing.[23] If that's the case, then we might as well write ν_e for both. However, we'll stick to convention for the time being. If we wouldn't do that, then the lepton number rule wouldn't work anymore—not that I care, but I need to show some respect for conventional wisdom here, right?[24]

[22] There are two different ways of measuring the mean lifetime of neutrons, and they yield slightly different values. See: https://www.quantamagazine.org/neutron-lifetime-puzzle-deepens-but-no-dark-matter-seen-20180213/.

[23] See the various articles on neutrinos on Fermi National Accelerator Laboratory (FNAL), such as, for example, this one: https://neutrinos.fnal.gov/mysteries/majorana-or-dirac/. The common explanation is that neutrinos and anti-neutrinos have opposite spin. However, that doesn't make them two different particles, and it surely does not make one the anti-particle of the other. The question that needs to be answered is whether or not neutrinos and anti-neutrinos do what electrons and positrons do: matter and anti-matter particles should annihilate each other in a big flash. However, as far as we know, neutrinos and anti-neutrinos don't do that.

[24] Theoretical physicists have busied themselves with a scheme that distinguishes between Majorana and Dirac neutrinos. If neutrinos are their own antiparticles, then they are Majorana neutrinos. Otherwise they should be referred to as Dirac neutrinos. The classification is useless because no one has observed neutrino-neutrino or neutrino-antineutrino annihilation.

The inverse happens as well: a proton can *capture* an electron to, somehow, *become* a neutron. It usually happens with proton-rich nuclei absorbing an inner atomic electron, usually from the K or L electron shell, which is why the process is referred to as K- or L-electron capture:

$$\mathrm{p^+ + e^- \to n^0 + \nu_e^0}$$

Once again, we have a neutrino providing the *nickel-and-dime* to ensure energy conservation. Note that, in order to conserve the lepton number, the neutrino has to be the anti-anti-particle of the neutrino in the neutron decay equation, so it is a regular neutrino—not that we can distinguish it from its anti-matter counterpart but that's a minor detail. Physicists need to save their conservation laws.

In both reactions, we have an *electron* ensuring that the *sum* of all charges on one side of the equation matches the sum of all charges on the other. Hence, instead of inventing this weird lepton number, we could, perhaps, just postulate a simpler conservation law: total charge in the Universe is being conserved? I am just thinking aloud. I am sure there must be another reason why physicists invented leptons but I just can't think of a good one right now.

We have an electron in both processes here: protons turning into neutrons and vice versa. Could a *positron* do the trick? A positron is a *real* anti-matter particle. It's not like this anti-neutrino that we can't quite define. As you probably, the answer is positive: in 1951, Cowan and Reines proved that bombarding protons with neutrinos leads to the creation of neutrons and *positrons*.[25] The process is written as:

$$\mathrm{\bar{\nu}_e^0 + p^+ \to n^0 + e^+}$$

This is a very interesting process because it makes you wonder about energy conservation: the energy of a neutron and a positron (the particles on the right-hand side of the equation) add up to a bit more than 940 MeV. Hence, the energy *difference* with the proton (on the left-hand side) is about 1.8 MeV. Can the incoming neutrino have such energy? The answer is positive: neutrinos can have any energy[26]. In fact, we may usefully remind ourselves that Wolfgang Pauli postulated the existence of neutrinos in 1930 to account for rather large variations in the measured energy of the electron coming out of beta decay processes. Hence, the order of magnitude is surprising but reasonable. One should also note the energy might go elsewhere: if a proton turns into a neutron, then the atom will preserve the charge balance by ejecting an electron – so that electron can also take some energy with it.

There is another interesting process involving positron emission by a proton. It's referred to as beta *plus* decay. It happens inside unstable nuclei. It's a relatively rare thing, and the term that's used for it (β^+ *decay*) is somewhat inappropriate because it should not be thought of as confirming the proton decay hypothesis. Indeed, as far as we know, protons do *not* decay spontaneously: they need to be *hit* by something and – as shown by the energy calculations for the Cowan-Reines experiment – they need to be hit by something that is *highly* energetic. To be precise, β^+ decay is thought of as being *induced* by

[25] The Wikipedia article on the Cowan-Reines experiment offers a very good account not only of the history of the experiment but also of the history of the discovery of neutrinos. See: https://en.wikipedia.org/wiki/Cowan%E2%80%93Reines_neutrino_experiment.

[26] See: https://neutrinos.fnal.gov/types/energies/. Also see the IceCube (South Pole Neutrino Observatory) experiments (https://icecube.wisc.edu/info/neutrinos), which have detected TeV neutrinos.

high-energy radiation from cosmic rays or produced by other decay reactions.[27] What happens amounts to this:

$$\gamma + \mathrm{p}^{+} \rightarrow \mathrm{n}^{0} + \mathrm{e}^{+} + \nu_{\mathrm{e}}^{0}$$

Here also, energy will be conserved not only because of the incoming photon and that neutrino – this this time we write it as a *regular* one because we've got it on the left-hand side of the equation conservation equation now[28] – but also because the atom will eject an electron to make sure it stays neutral.

This triggers yet another interesting question: why would an atom want to stay neutral? Good question. We can answer this the *nerdy* way: atoms are neutral *by definition*. However, that doesn't answer the question. It's got to do with stability.

One of the things that has always struck me is that there is not much theoretical research on why a very limited number of particles – like this temporary *ion* ejecting an electron to become a stable atom once again – are stable and – conversely – why most are not. It is a crucial question. In fact, I find the term 'particle' for the so-called 'particle zoo'[29] rather odd: I always felt we should, perhaps, reserve the term 'particle' for *permanent* fixtures in our Universe – not for *resonances* or *transients*.

I relate it to the distinction between low- and high-energy physics, which is also not well defined. At the same time, it is quite obvious that the distinction between low-energy and high-energy physics is highly useful—even if artificial. Low-energy physics can be interpreted in terms of classical physics: the only force that matters is the electromagnetic force (and gravity, of course), and we study stable particles: we talk of nuclei (or protons and neutrons[30], perhaps), electrons and photons. Charge, energy, momentum (linear or angular) is always being conserved.

In contrast, high-energy physics studies what might be going on *inside* of the nucleus, and we study non-stable particles: the *debris* and the *transient* oscillations that come out of high-energy particle collisions. It is fair to say that high-energy physics studies what may or may not have happened in the first seconds, minutes or days after the presumed Big Bang.[31] High-energy experiments in labs and colliders emulate these conditions and phenomena: high-energy collisions followed by disintegration processes. High-energy physics studies weird phenomena such as electron-positron pair production from very-high energy photons.

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[27] As far as we know, protons do *not* decay spontaneously: they need to be hit by something and – as shown by the energy calculations for the Cowan-Reines experiment – they need to be hit by something that is *highly* energetic. For more details, see: https://en.wikipedia.org/wiki/Positron_emission.

[28] It's a pretty ridiculous rule but you can see we need a lepton now. Why? Think for yourself. Physicists tell us the proton is an anti-lepton so we need to balance stuff by throwing some name at it, right?

[29] We refer to the hundreds of unstable particles that have been discovered over the past 70 years or so. These are listed, with their properties and decay reactions, by the Particle Data Group.

[30] Neutrons are only stable in the nucleus: free neutrons decay. We should also mention neutrinos because these are stable particles too. We will come back to both.

[31] Seconds and minutes are probably more relevant than days or weeks. According to standard theory, the Universe was an extremely high-energy environment some 14 billion years ago, before it expanded and cooled down. Needless to say, high-energy conditions still prevail in stars and other chunks of matter that need more time to cool down.

Oh my! Electron-positron pair production. I dropped the term. Now I need to talk about *that!* Pair production! *Who ordered that*?[32]

Electron-positron pair creation and annihilation

Electron-positron pair production happens when very-high energy photons (gamma-ray photons) hit heavy nuclei. To be precise, the photon is thought to "interact with the Coulomb field of the atomic nucleus", and the probability of an electron–positron pair to emerge from the photon increases with (i) the photon energy and (ii) the atomic number.[33]

The creation and annihilation of electron-positron pairs respects the *idea* of charge conservation. The *combined* charge of the *pair* is the same as that of the photon: zero. However, it does *not* conserve the *number of charged particles*. Dirac duly noted that in the preface to the fourth and last edition of his seminal *Principles of Quantum Mechanics*, in which he recognized the significance of electron-positron pair creation and annihilation:

> "In present-day high-energy physics, the creation and annihilation of charged particles is a frequent occurrence. A quantum electrodynamics which demands conservation of the number of charged particles is, therefore, out of touch with physical reality. So I have replaced it by a quantum electrodynamics which includes creation and annihilation of electron-positron pairs. […] It seems that the classical concept of an electron is no longer a useful model in physics, except possibly for elementary theories that are restricted to low-energy phenomena."

This modification is, in fact, the only significant change in Dirac's *Principles* between 1930 (first edition) and 1957 (fourth and last edition). Mainstream quantum-mechanical calculus takes this reality into account of this reality by substituting the charge conservation law by the *lepton number conservation* law, in which the lepton number is defined as the *difference* between the number of leptons (electrons) and the number of anti-leptons (positrons).

We wonder why. It's true this wonderful invention of a *lepton* number covers both $\gamma \leftrightarrow e^- + e^+$ processes as well as the above-mentioned processes (neutron decay, inverse beta decay, electron capture by a proton and beta *plus* decay), but that's only because we decided to also label neutrinos as leptons which – I hope you see my point now – is a bit arbitrary, right? Honestly, I don't quite understand why anyone would object to a simpler rule: total (*net*) charge in the Universe is conserved, *always*. Again, if Hume was still alive, he would have told us that we shouldn't be obsessed with the idea of a particle and, therefore, that we shouldn't be obsessed with the idea of Nature having to respect the idea of the conservation of the *number* of charged *particles*. It's just not relevant.

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[32] This phrase refers to I.I. Rabi's presumed reaction to the discovery of the muon by Anderson and Neddermeyer in 1936. The reference is appropriate because we also have to thank Carl Anderson for the discovery of the positron.

[33] The energy of the photon has to be *very* high because its energy (or mass equivalent) has to match the energies of the electron and the positron that's being produced, and some extra. Hence, we are talking high-energy gamma-ray photons here ($E_\gamma > 1.022$ MeV). The reader should note we are referring to the 1930 Meitner–Hupfeld experiment, which involved anomalous scattering of gamma rays by heavy elements. The effect is, effectively, the result of electron–positron pair production and annihilation. For a good overview and discussion, see: J.H. Hubbell, *Electron–positron pair production by photons: a historical overview*, June 2006 (https://www.sciencedirect.com/science/article/abs/pii/S0969806X0500263X).

As mentioned, electron-positron pair creation doesn't happen because gamma-rays spontaneously 'disintegrate' into electron-positron pairs. They do not: *the presence of a nucleus is required*. Plain common-sense tells us the process is likely to be something like this: the photon causes a proton to emit a positron (that's the β+ decay process we described above), so the proton turns into a neutron and something else needs to happen now: the atom needs to eject an electron or, more likely, a neutron decays into a proton and emits an electron. Hence, charge is being conserved and we shouldn't think of it as being a Great Big Mystery.

You'll say: that's *not* the mainstream explanation of what's happening. It isn't. The mainstream interpretation is this: these partially charged *u* and *d* quarks or anti-quarks – with the help of gluons – can suddenly produce a positron, and then they put on another robe to join some other circus and perform another dance: the neutron dance.

Is *that* convincing? For me, it isn't. Hence, to Dirac I'd say: why this *panicky* reaction? Why would Dirac think that the classical concept of an electron is no longer useful? An electron is a permanent fixture – even if we can create it, *together with a positron*, from these pair-production experiments. Pair production only happens when the photon is fired into a nucleus, and the generalization to 'other' bosons 'spontaneously' disintegrating into a particle and an anti-particle is outright pathetic. What happens is this: we fire an enormous amount of electromagnetic energy into a nucleus (the equivalent mass of the photon has to match the mass of the electron and the positron that's being produced) and, hence, we destabilize the stable nucleus. However, Nature is strong. It will throw out the spanner in the works. The question is: *how exactly?*

The nature of protons and neutrons

I might be mistaken but plain logic would seem to imply the following conclusion: if protons absorb electrons – or, alternatively, emit positrons – to become neutrons, and vice versa (neutrons ejecting electrons to become protons), then the *natural unit* of charge is ± 1, right? Not 1/3 or 2/3: those must be mathematical abstractions. *Nothing real*, in other words.

Hey! What about neutrons absorbing positrons to become a proton? That's possible too. I didn't check the details but I'll trust Wikipedia here. Indeed, I tried to edit a Wikipedia article so I know from first-hand experience that the editors of wikis in this field are solid mainstream ultra-conservative physicists: they say that positron capture by neutrons in nuclei that contain an excess of neutrons is also possible, but is hindered because positrons are repelled by the positive nucleus, and quickly annihilate when they encounter electrons.[34] Any case, the process is there and I would think this validates my alternative explanation of what might be going on.

Furthermore, I tend to think that Occam's Razor Principle tells us the idea of quarks – carrying some partial electric charge as well as some *strong* charge (color or flavor, whatever: let us leave that question open as for now) – is logically inconsistent: if protons and neutrons absorb or emit electrons and positrons, then we should think of these *elementary* charges as being *real*, somehow. Why do we need the *quark* or *parton* assumption?[35] Can't we just work with the idea of some new *charge*?

[34] https://en.wikipedia.org/wiki/Neutron#Competition_of_beta_decay_types

[35] When it became clear that protons and neutrons had some internal structure, Richard Feynman came up with the idea of partons. Pais and Gell-Mann turned it into the idea of *quarks*.

In fact, we may ask an even bolder question: do we actually need the idea of a new charge and, hence, of a new *force*? I think we do. I'll explain why in the next section. However, I'll also explain why I don't believe in quarks and gluons – or in the idea of 'matter' versus 'force' particles in general: the dichotomy between fermions and bosons is useless, but I am getting ahead of myself here. Let's briefly revert back to the *concept* or *idea* of a particle, even if I said – a couple of times already – we should, perhaps, just think of it as a *bundle* of properties.

Particles as oscillations

I think of stable elementary particles as oscillations, and I do so in pretty classical terms: no string theory required. I was inspired by Schrödinger's *Zitterbewegung* idea, which made me think of an electron as a *perpetuum mobile*: an oscillation that keeps going without any friction or loss of energy. Erwin Schrödinger stumbled upon the *zbw* 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)

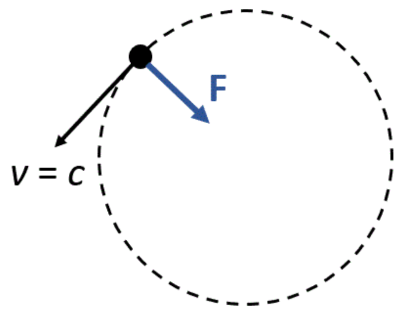
Oscillations involve a force, a cycle time and a distance (the distance over the cycle loop), and I think particles are stable because the product of that force, the cycle time and the distance over the loop is equal to Planck's quantum of action: $F \cdot T \cdot s = h$, which we can also write as $E \cdot T = E/f = h$. We fully developed the idea elsewhere[36], so we will just give a cursory overview here.

The oscillator model of an electron[37] assumes an electron consists of a pointlike charge with zero rest mass. Note that pointlike doesn't mean it has no dimension whatsoever: we actually think the anomalous magnetic moment can be explained because the radius of this pointlike charge is equal to the classical electron radius, which is a fraction (α) of the electron's Compton radius. Pointlike means we consider the pointlike charge has no internal structure. In contrast, we think the electron – as a whole – has a structure. What structure? It's that high frequency oscillatory motion of small amplitude. That's why the electron itself has a different radius: the Compton radius. The idea is illustrated below.

[36] See: Jean Louis Van Belle, *Mass without mass*, 13 August 2019, http://vixra.org/abs/1908.0225.

[37] Schrödinger coined the term *Zitterbewegung* for it, which refers to a shaking or trembling motion. David Hestenes is to be credited with the revival of this model in the 1980s. However, we prefer a more general term.

Figure 1: The electron as a current ring



We have a pointlike charge in a circular orbit here. Its tangential velocity equals the product of the radius and the angular velocity: $v = a \cdot \omega$ formula. The tangential velocity is the speed of light: $v = c$. Hence, the *rest* mass of this pointlike charge must be zero. However, there is *energy* in this oscillation, and we think of the rest mass of the electron as the equivalent mass of the energy in the oscillation. This hybrid description of the electron is Wheeler's idea of mass without mass: the mass of the electron is the equivalent mass of the energy in the oscillation of the pointlike charge.

We can now calculate the Compton radius. The calculation is mysteriously simple. The tangential velocity tells us the radius is equal to $a = c/\omega$. The Planck-Einstein relation ($E = \hbar \cdot \omega$) then allows us to substitute ω ($\omega = E/\hbar$). Finally, 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 *Zitterbewegung* 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.[38] The point is: you will now intuitively understand why we can write Planck's quantum of action as the product of the electron's energy and the cycle time:

$$h = \mathrm{E} \cdot \mathrm{T} = \mathrm{h} \cdot f \cdot \mathrm{T} = \mathrm{h} \cdot f/f = h$$

Hence, we should, effectively, think of one cycle packing not only the electron's energy but also as packing one unit of h.

Our hypothesis amounts to a realist interpretation of the wavefunction (and quantum mechanics in general) and is consistent with the new *definition* of Planck's quantum as per the 2019 revision of SI

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[38] 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.

units: h = 6.62607015×10^{-34} J·Hz^{-1}. Note that the formula assumes the force is constant over the cycle. If the force varies, we should integrate the ΔF·Δt·Δs product over the cycle.[39]

The properties of an electron

The oscillator model of an electron gives us the properties of an electron. We can calculate the current:

$$\mathrm{I} = \mathrm{q_e} f = \mathrm{q_e}\frac{\mathrm{E}}{h} \approx (1.6 \times 10^{-19}\ \mathrm{C})\frac{8.187 \times 10^{-14}\ \mathrm{J}}{6.626 \times 10^{-34}\ \mathrm{Js}} \approx 1.98\ \mathrm{A}\ (ampere)$$

This is huge: a household-level current at the sub-atomic scale. However, this result is consistent with the calculation of the magnetic moment, which is equal to the current times the area of the loop and which is, therefore, equal to:

$$\mu = \mathrm{I} \cdot \pi a^2 = \mathrm{q_e}\frac{\mathrm{m}c^2}{h} \cdot \pi a^2 = \mathrm{q_e} c \frac{\pi a^2}{2\pi a} = \frac{\mathrm{q_e} c}{2}\frac{\hbar}{\mathrm{m}c} = \frac{\mathrm{q_e}}{2\mathrm{m}}\hbar$$

It is also consistent with the presumed angular momentum of an electron, which is that of a spin-1/2 particle. The oscillator model implies the energy – or effective mass – of the electron is spread over the disk. If we assume it is spread *uniformly*[40], we can use the 1/2 form factor for the moment of inertia (*I*):

$$\mathrm{L} = I \cdot \omega = \frac{ma^2}{2}\frac{c}{a} = \frac{mc}{2}\frac{\hbar}{mc} = \frac{\hbar}{2}$$

We now get the correct g-factor for the pure spin moment of an electron:

$$\boldsymbol{\mu} = -\mathrm{g}\left(\frac{\mathrm{q_e}}{2\mathrm{m}}\right)\mathbf{L} \Leftrightarrow \frac{\mathrm{q_e}}{2\mathrm{m}}\hbar = \mathrm{g}\frac{\mathrm{q_e}}{2\mathrm{m}}\frac{\hbar}{2} \Leftrightarrow \mathrm{g} = 2$$

We refer the reader to our other papers for a more detailed discussion of the model and other calculations.[41] The point is: this model gives us all of the so-called *intrinsic* properties of the electron. The mystery is gone. We have a similar *realist* interpretation of the photon.[42]

Furthermore, it also works for the muon electron. However, it does *not* seem to work for the proton – we will show that in a minute – and that's why the hypothesis of some *strong* force comes quite naturally. While we agree with the hypothesis, we have serious doubts on how this strong force is being *modelled* in mainstream quantum theory. More on that later.

[39] For an example of how such calculus should be done, see: See: Jean Louis Van Belle, *Mass without mass*, 13 August 2019 (http://vixra.org/abs/1908.0225).

[40] This is a very essential point: it is the *essence* of the oscillator model. It is also a very deep and philosophical point. We say the energy is in the motion, but it's also in the oscillation. According to Hestenes, half of the energy is magnetic (the magnetic flux through the ring) and the other half is the kinetic energy of the pointlike charge. However, the oscillator model implies a different interpretation. The two interpretations should be equivalent but this equivalence still needs to be firmly demonstrated. See: Jean Louis Van Belle, *Mass without mass*, 13 August 2019, http://vixra.org/abs/1908.0225.

[41] See: Jean Louis Van Belle, *Mass without mass*, 13 August 2019, http://vixra.org/abs/1908.0225.

[42] See: Jean Louis Van Belle, *A Classical Quantum Theory of Light*, 13 June 2019, http://vixra.org/abs/1906.0200.

Applying the oscillator model to muons and nucleons

The electron has two heavier versions but they are unstable:

1. The muon energy is about 105.66 MeV, so that's about 207 times the electron energy. Its lifetime is much shorter than that of a free neutron but longer than that of other unstable particles: about 2.2 *micro*seconds (10^{-6} s). The difference 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.

2. The energy of the tau electron (or tau-*particle* as it is more commonly referred to[43]) is about 1776 MeV, so that's almost 3,500 times the electron mass. Its lifetime is extremely short: 2.9×10^{-13} s, so we think of it as some resonance or very *transient* particle.

According to the oscillator model, we should find a Compton radius for the muon that is equal to:

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

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

$$1.173444110\times10^{-14}\ \mathrm{m}\ \pm 0.000000026\times10^{-14}\ \mathrm{m}$$

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[44]:

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

The calculated value falls within CODATA's uncertainty interval, so we cannot be conclusive. The result is quite significant, though.[45] 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.[46] Why? The process conserves charge as well as energy and linear

[43] In light of its short lifetime, I would prefer to refer to it as a resonance. I like to reserve the term 'particle' for *stable* particles. Within the 'zoo' of unstable particles Longer-living particles may be referred

[44] 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).

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

[46] 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).

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*?[47]

The muon is interesting because we might 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. Should we think of the muon as the pointlike charge inside of a proton?

Probably not. 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 positron itself? 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, effectively, some other force and, therefore, some other *charge* might be involved. Despite all of the claims of mainstream physicists, we think the nature of this force is currently not well understood.

OK. The *Compton* radius doesn't work but perhaps we can use the radius of the pointlike charge itself? The classical electron radius is an interesting concept because it explains *elastic* scattering experiments, and it also allows us to explain the anomalous magnetic moment in classical terms (no need for quantum field theory).[48] 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:

$$r_{\mathrm{e}} = \frac{\mathrm{e}^2}{\mathrm{m}c^2} = \alpha \cdot r_{\mathrm{C}} = \alpha \frac{\hbar}{\mathrm{m}c} \approx 2.818 \ldots \times 10^{-15}\ \mathrm{m}$$

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 seems to be no escape: we probably do need to accept some non-electromagnetic force is involved.

[47] 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.

[48] See: Jean Louis Van Belle, *The Anomalous Magnetic Moment: Classical Calculations*, 11 June 2019 (http://vixra.org/abs/1906.0007).

Of course, it is not only the above-mentioned inconsistency about the proton radius. There is another obvious reason to think of another force, of course: when everything is said and done, we also do need to explain why protons can stay together inside of a nucleus.[49]

How should we *model* this strong force? The philosopher inside of me says we should not invent useless concepts. We don't need bosons to carry charge, momentum or energy *between* elementary particles. Having said that, we do need to explain the small radius – and the enormous mass/energy density – of protons and neutrons. It can only be done by accepting there is some *strong* force and, hence, some strong *charge*. To simplify matters, we should assume it does *not* interact with the electric charge but we are not quite sure of that.

We quickly get into muddy waters here. What would a realist interpretation of quantum mechanics look like? We have no definite answer to that, but we do have an idea of how it might look like.

A realist interpretation of quantum mechanics

The idea of a force is the central idea. A force *acts* on a *charge*. Hence, we need to specify the charge, and we need to specify *how* the force will act upon it (the *structure* of the force). In the QED sector, we feel everything is pretty much settled: we got all of the intrinsic properties of an electron out of our analysis of the *zbw* model of an electron, which is based on the *idea* of a charge and some force acting upon it. We also have a photon model – and much more.[50]

The QCD sector has *not* been solved—not as yet, that is. We need to think about the nature of the strong force, which I refer to as the *Yukawa* force in order to distinguish the idea from the mainstream quark-gluon conceptualization of the strong force.[51] Physicists need to get back to basics here. Of course, we need to acknowledge we may not have easy analytical solutions: if the Yukawa force would effectively have some ternary structure (as opposed to a binary structure, like the electromagnetic force), then the lack of an analytical solution to three-body problems should make us think. However, one thing stands out for me: multiplying concepts – which is what has happened since World War II – cannot be the solution. Occam tells us as much.

A realist interpretation of quantum electrodynamics may be loosely defined as a theory based on a model of the electron and the photon explaining (1) their intrinsic properties (e.g. radius or geometry, magnetic moment, angular momentum) and (2) the interactions between them (e.g. Thomson versus Compton scattering). We are pleased to see that there is a renewed interest in electron models as a result of Hestenes' interpretation of the presumed *Zitterbewegung* of an electron, which inspired us to build our own electron model based on Wheeler's mass without mass concept.

Of course, a realist theory should also have a consistent explanation of what the wavefunction actually represents, including these weird 360/720 degree symmetries. We think we have done this.[52] Finally, a realist electron model should also explain phenomena such as the anomalous magnetic moment,

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[49] We offer some reflections on this in another paper: Jean Louis Van Belle, *Electrons as Gluons?*, 28 August 2019 (http://vixra.org/abs/1908.0430).

[50] See: *A Classical Quantum Theory of Light*, 13 June 2019 (http://vixra.org/abs/1906.0200).

[51] See: *The Nature of Yukawa's Nuclear Force and Charge*, 19 June 2019 (http://vixra.org/abs/1906.0311) and *Who Needs Yukawa's Wave Equation?*, 24 June 2019 (http://vixra.org/abs/1906.0384).

[52] See: *Euler's Wave Function: the Double Life of* -1, 30 October 2018 (http://vixra.org/abs/1810.0339).

electron orbitals, electron orbitals and their energies, and much more. It should, for example, be able to explain Schrödinger's differential wave equation in terms of geometries.[53]

The electron model also needs to be complemented by a photon model. This model should explain quantum-mechanical phenomena such as one-photon Mach-Zehnder interference.

In short, a realist interpretation of quantum mechanics implies a return to Dirac's research agenda: a return to *kinematic models*. We like to quote Dirac's last paragraph in the last edition of his Principles of Quantum Mechanics in this regard:

> "Now there are other kinds of interactions, which are revealed in high-energy physics and are important for the description of atomic nuclei. These interactions are not at present sufficiently well understood to be incorporated into a system of equations of motion. Theories of them have been set up and much developed and useful results obtained from them. But in the absence of equations of motion these theories cannot be presented as a logical development of the principles set up in this book. We are effectively in the *pre-Bohr era* with regard to these other interactions. It is to be hoped that with increasing knowledge a way will eventually be found for adapting the high-energy theories into a scheme based on equations of motion, and so unifying them with those of low-energy physics." (*Principles of Quantum Mechanics*, 4th edition, p. 312)

He wrote this in 1958 but kept repeating his dissatisfaction with the mainstream approach till the end of his life. In 1975, for example, Dirac wrote the following about the perturbation theory he himself had contributed to:

> "I must say that I am very dissatisfied with the situation because this so-called 'good theory' involves neglecting infinities. […] This is just not sensible mathematics. Sensible mathematics involves neglecting a quantity when it is small – not neglecting it just because it is infinitely great and you do not want it!"

The Wikipedia article on Dirac[54], from which the quote above was taken, notes that "his refusal to accept renormalization resulted in his work on the subject moving increasingly out of the mainstream." It also quotes his final judgment on quantum field theory which, significantly, is entitled "*The Inadequacies of Quantum Field Theory*" (1984):

> "These rules of renormalisation give surprisingly, excessively good agreement with experiments. Most physicists say that these working rules are, therefore, correct. I feel that is not an adequate reason. Just because the results happen to be in agreement with observation does not prove that one's theory is correct."

The paper ends with these words: "I have spent many years searching for a Hamiltonian to bring into the theory and have not yet found it. I shall continue to work on it as long as I can and other people, I hope, will follow along such lines."

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[53] We made a start with this but the idea needs to be further developed. See: *A Geometric Interpretation of Schrödinger's Wave Equation*, 12 December 2018 (http://vixra.org/abs/1812.0202).
[54] See: https://en.wikipedia.org/wiki/Paul_Dirac.

It's not just Dirac (and Einstein, of course): the whole first generation of quantum physicists – including Schrödinger, Pauli and Heisenberg himself - became increasingly skeptical about the theory they had created. Even John Stewart Bell did not believe his own No-Go Theorem and hoped that some "radical conceptual renewal" would demonstrate its irrelevance.[55]

Bell died from a cerebral hemorrhage in 1990 – the year he was nominated for the Nobel Prize in Physics, but the Nobel Prize is not awarded posthumously so he did not get it. While acknowledging Bell's genius and regretting his untimely death, I feel it's good his No Go Theorem is not associated with a Nobel Prize: it would have enshrined current dogma. In fact, we think it is about time the Nobel Prize Committee members start awarding physicists that challenge – rather than confirm – the status quo. We have doubts on some of the Nobel Prize awards – including the one for Higgs and Englert after the experimental 'confirmation' of the 'reality' of the Higgs particle. Why the hurry?[56]

If anything, we think 'radical conceptual renewal' should *not* involve the assumption of virtual or other *ghost* particles *mediating* a force: 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.[57] Indeed, the current situation seems to repeat the context. In 1878, Maxwell famously wrote the following about the *aether* theory in the Encyclopedia Britannica:

> "Aethers were invented for the planets to swim in, to constitute electric atmospheres and magnetic effluvia, to convey sensations from one part of our bodies to another, and so on, until all space had been filled three or four times over with aethers. ... The only aether which has survived is that which was invented by Huygens to explain the propagation of light."[58]

However, while all contemporary scientists were aware of the problems and the inconsistencies, aether theory was so entrenched that it was simply assumed to exist until – about ten years later (in 1887, to be precise) – Michelson and Morley *experimentally* proved the theory was rubbish. Even then, it took almost 20 years before physicists – physicists of the stature of Henri Poincaré, Hendrik Antoon Lorentz and Albert Einstein, that is[59] – were able to accept it was a redundant hypothesis.

We have been living with Gell-Mann's quark-gluon *conjecture* for more than 50 years now[60] and it seems to have become a permanent *fixture* of the scientific mindset now.[61] We have little hope this paper –

[55] John Stewart Bell, Speakable and unspeakable in quantum mechanics, pp. 169–172, Cambridge University Press, 1987, quoted in: https://en.wikipedia.org/wiki/John_Stewart_Bell.

[56] For a critical review, see: Jean Louis Van Belle, *Smoking Gun Physics*, 21 July 2019 (http://vixra.org/pdf/1907.0367v2.pdf).

[57] See: Jean Louis Van Belle, *Smoking Gun Physics*, 21 June 2019 (http://vixra.org/abs/1907.0367)

[58] Quoted from https://en.wikipedia.org/wiki/Luminiferous_aether.

[59] *Feynman's Lecture* on special relativity theory (http://www.feynmanlectures.caltech.edu/I_15.html) is one of the few that also credits the genius of J.H. Poincaré and H.A. Lorentz for 'solving' the puzzle.

[60] Gell-Mann and Zweig both advanced a full-blown version of quark theory in 1964. However, the theory was preceded by the invention of various *strange* conservation laws in the 1950s. See, for example, Feynman's treatment of kaons in his 1963 *Lectures* (http://www.feynmanlectures.caltech.edu/III_11.html#Ch11-S5).

[61] My attempts to inject some more creative (skeptical?) thinking into Wikipedia editing processes have left me rather skeptical in this regard. It is a rather morbid thing to say, but Gell-Mann's demise earlier this year may perhaps induce some more eminent physicists to say what should be said: *the Emperor wears no clothes.*

one of the many that are out there in the Universe – will change anything to that, but we feel obliged to keep the revolution going.

We also think our interpretation of the (in)stability of particles – our interpretation of the Planck-Einstein relation (E = h·*f*) as modeling an elementary *cycle* – will be an essential building block in any realist theory, but it will need further refinement: a better explanation of the *fine-tuning* problem, and of how all non-stable 'particles' (all particles in the 'particle zoo', that is) decay or disintegrate. The idea of *transient* or *resonant* oscillations of known charges needs to be further fleshed out. A more detailed analysis – if possible – of the muon disintegration process may provide precious ideas in this regard.

In short, we feel Dirac's agenda needs to be pursued much more aggressively: kinematic models of elementary particles should be studied a lot more than they currently are. As for our own oscillator model, we should note that it may serve didactic purposes only. We are, effectively, very impressed by much more advanced kinematic models including Alexander Burinskii's Kerr-Newman electron (2008, 2016), which combines quantum theory and *gravity* without modifications of the Einstein-Maxwell equations.[62]

Such more advanced models allow for a conceptual bridge with mainstream quantum mechanics, grand unification theories and string theory. As such, they are likely to be more acceptable than mine.

Jean Louis Van Belle, 31 August 2019

[62] See: Alexander Burinskii, *The Dirac–Kerr–Newman electron*, 19 March 2008 (https://arxiv.org/abs/hep-th/0507109). Also see: Alexander Burinskii, *Weakness of gravity as illusion which hides true path to unification of gravity with particle physics*, 14 October 2017 (https://arxiv.org/abs/1710.08769).