Elementary Particles and Conservation Laws

Jean Louis Van Belle, 31 August 2019

Summary

This paper offers some basic epistemological reflections on the idea of elementary particles and the nature of quantum-mechanical conservation laws. We do so by applying Occam's Razor Principle to what we think of as an unnecessary 'multiplication of concepts' after 'the young wolves' (Feynman, Dyson, Schwinger etcetera) took over from the first-generation of quantum physicists (Planck, Einstein, Bohr, Heisenberg, Schrödinger, Dirac, Pauli, etcetera).

We argue they have failed to offer a convincing model of the strong force and that the weak force should not be analyzed as a force. Decay or disintegration processes should be analyzed in terms of classical laws: conservation of energy, linear and angular momentum, charge and – importantly – the Planck-Einstein relation. We argue the latter embodies the idea of the elementary *cycle*, which is obviously much more relevant than the idea of an elementary *particle*, as evidenced by the 2019 revision of SI units.

Contents

Elementary Particles and Conservation Laws

Jean Louis Van Belle[1], 31 August 2019

The idea of an elementary particle

What is an elementary particle? Common sense – and history – gives 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.

Gluons are *ghost* particles – *messenger* particles that are collectively referred to as *virtual* particles or, more commonly, as *bosons*[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 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.

This raises an obvious philosophical question: if quarks change color all of the time, can we think of them as being *stable*? Probably not, but physicists do not seem to have any issue with it: they refer to a whole 'zoo' of short-lived *transients* or even shorter-lived *resonances* as 'particles' and they, therefore, think there is no need to reserve the term 'particle' to refer to more *permanent* fixtures in our

[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 ()

[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*.

Universe.[5] They apply Paul Feyerabend's philosophy: *"Anything goes."* We are not so sure. If anything goes, nothing goes.

Physicists 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 incredible degrees 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:

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

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

Physicists also 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 idea of the charge radius of a quark is quite vague. 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*."[8]

When I read things like this, it triggers an obvious philosophical question: ***what's a particle stripped of all its attributes?***

Let's go back and 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'.[9]

---

[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] Source: http://www.sjsu.edu/faculty/watkins/quarksizes.htm
[9] 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.

The electron figure

While the Standard Model continues to think of an electron as a pointlike particle, common scattering experiments – since a hundred years or so – 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.[10] In any case, according to mainstream physics elementary particles should not have any internal structure: their properties are supposed to be *intrinsic* (read: *magical*[11]) 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'.[12] The ingrained fear of thinking of most physicists is somewhat strange because the venerable Richard Feynman bothered to devote several sections to the tricky question of the charge radius of an electron.[13] As mentioned above, 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).[14]

Why would we be interested in the question of what actually *defines* a particle? For starters, 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 have laws that directly relate

[10] 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.

[11] 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?

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

[13] 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.

[14] 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.

to the above-mentioned *flavors* of quarks (charm, strangeness, beauty (or bottomness), or just *light unflavored* stuff[15]).

We find this rather funny 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 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 the question of what makes neutrinos and antineutrinos actually different wide open.[16] We will explain this smart solution more in detail in the next section(s).

Let us conclude this section by a few notes on Dirac's fascination on electron-positron pair creation which – we admit – fascinates us too! However, as we show, 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. At this point, we will limit ourselves to noting 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

[15] 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

[16] 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.

atomic number.[17] 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. Full stop.

Physicists will cry wolf and say: 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 strong and, possibly, the weak force – if the weak force *is* a force, which I doubt it is[18] - and the *nature* of this 'strong' charge (which is very difficult because of this confusion between colors, flavors and *partial* electric charges, of course[19]), *then* we might find that the new force law – and the related classical laws conservation of energy, linear and angular momentum, and charge conservation – might explain all.

It should, *logically speaking*, that is: we mentioned a *if*, and a *then* above. We agree anything might happen. But nothing anything goes: we don't agree with Feyerabend. Not when trying to describe reality. 😊

[17] 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).

[18] 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).

[19] 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).

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 bundle theory, an object consists of its properties and its relations to other objects, and nothing more. He also wrote this: "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.

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: so why would physicists lump neutrinos and electrons together in the same category? They *define* both are *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[20], 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:

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

[20] 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/.

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.[21] 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?[22]

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:

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

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

[21] 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.

[22] 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.

bombarding protons with neutrinos leads to the creation of neutrons and *positrons*.[23] The process is written as:

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

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[24]. 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 high-energy radiation from cosmic rays or produced by other decay reactions.[25] What happens amounts to this:

$$\gamma + p^+ \rightarrow n^0 + e^+ + \nu_e^0$$

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[26] – 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

---

[23] 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.

[24] 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.

[25] 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.

[26] 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?

'particle' for the so-called 'particle zoo'[27] 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[28], 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.[29] 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.

Oh my! Electron-positron pair production. I dropped the term. *Dammit!* Now I need to talk about *that!* Pair production! *Who ordered that*?[30]

Electron-positron pair production

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.[31]

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

[27] 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.

[28] 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.

[29] 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.

[30] 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.

[31] 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).

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*. If Hume was still alive, he would have told us that we shouldn't be obsessed with the idea of a particle and, hence, 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. Full stop.

As mentioned, pair creation is not like gamma-rays spontaneously 'disintegrate' into electron-positron pairs. They don't: *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, alternative, the neutron should decay into a proton and emit an electron. Either way, charge is being conserved and we shouldn't think of it as being a Great Big Mystery.

[…] Or… Well… Perhaps we should. I didn't find any convincing story on how these partially charged *u* and *d* quarks or anti-quarks – with the help of gluons – can suddenly produce a positron and put on another robe to join some other circus and perform another dance: the neutron dance.

To Dirac I'd say I don't understand his *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 (I tried to edit a Wikipedia article so I know from first-hand experience that Wikipedia editors in this field are solid mainstream ultra-conservative physicists). It says 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.[32]

I am not quite sure here but I would think this, and 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?[33] Can't we just work with the idea of some new *charge*? In fact, 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

---

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

[33] 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*.

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·T·*s* = h, which we can also write as E·T = E/*f* = h. We briefly develop the idea elsewhere, so we won’t repeat ourselves here.[34] We will only want to highlight key results and think about a new research agenda.

The research agenda

Our oscillator model of an electron[35] gives us the intrinsic properties of an electron. Occam’s Razor Principle tells us we should associate the idea of an electron with its *properties* only. It’s *absolutely fascinating* that the oscillator model works for a muon electron as well. I hate repeating myself but – in this case – I think it’s useful to repeat the obvious. 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[36]) 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:

$$r_{\mathrm{C}} = \frac{c}{\omega} = \frac{c\cdot\hbar}{\mathrm{E}} \approx \frac{(3\times10^{8}\,\frac{\mathrm{m}}{\mathrm{s}})\cdot(6.582\times10^{-16}\mathrm{eV}\cdot\mathrm{s})}{105.66\times10^{-6}\mathrm{eV}} \approx 1.87\ \mathrm{fm}$$

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

[34] See: Jean Louis Van Belle, *Mass without mass*, 13 August 2019, http://vixra.org/abs/1908.0225. 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 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·Δ*t*·Δs product over the cycle.

[35] See reference above.

[36] 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

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[37]:

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

The calculated value falls within CODATA's uncertainty interval, so we cannot be conclusive. The result remains quite significant, though.[38]

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. We're at a dead end here. We need the *hypothesis* of some *stronger* force, i.e. a force that is stronger than the force that keeps our pointlike *electric* charge in some orbit.

How should we *model* this strong force? The *Philosopher* inside of me says we should not invent useless concepts. We don't need quarks or gluons to carry charge, momentum or energy. 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.

We also need to think of its *structure*. Our oscillator model doesn't work for protons or neutrons. We don't believe in quarks and gluons, but… Well… We need to come up with an alternative, don't we?

Conclusions

I did not write about the other properties of elementary particles. I hope you will understand. This is about forces. The *idea* of a force is that it *acts* on a *charge*. So 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.[39]

The QCD sector has *not* been solved—not as yet, that is. I am arrogant, but I know I am serving a useful purpose: physicists need a reality check. *They need to get back to basics and give some real answers*. A

---

[37] 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).

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

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

force is associated with a charge. Hence, physics should focus on a very limited number of *charges*, and the *structure* of the force acting upon them.

I can't help feeling physicists got lost, *somehow*. It shouldn't be that difficult to set it straight. We just need to acknowledge there are no easy analytical solutions to three-body problems—and more complicated problems, of course. 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.

Jean Louis Van Belle, 31 August 2019