Smoking Gun Physics

Jean Louis Van Belle, 21 July 2019

Summary:

In this paper, we wonder whether the idea of virtual particles, gauge bosons and/or force-carrying particles in general, might be superfluous. It seems to resemble 19th century aether theory: perhaps we don't need it. The implication is clear: if that's the case, then we also don't need gauge theory and/or quantum field theory.

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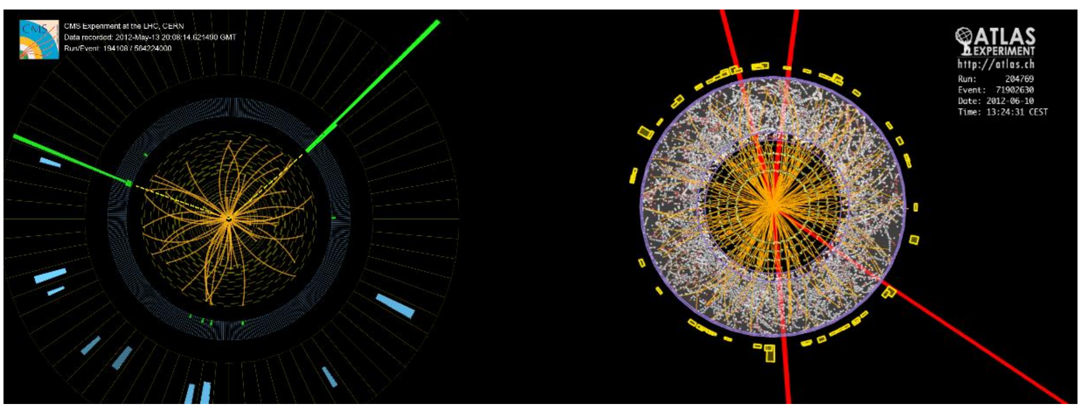
The nature of the Higgs particle

The images below visualize what is generally referred to as the first ‘evidence’ for the Higgs boson: (1) two gamma rays emerging from the CERN LHC CMS detector, and (2) the tracks of four muons in the CERN LHC ATLAS detector. These tracks result from the collision between two protons that hit each other at a velocity of 99.99999 per cent of the speed of light – which corresponds to a combined energy of about 7 to 8 TeV.[1] That’s huge. After the ‘discovery’ of the Higgs particle, the LHC was shut down for maintenance and an upgrade, and the protons in the LHC can now be accelerated to energies up to 7 TeV – which amounts to 14 TeV when they crash into each other. However, the higher energy level only produced more of the same so far.[2]



We put ‘evidence’ and ‘discovery’ between inverted commas because the Higgs particle is (and, rest assured, will *forever* remain) a *ghost* particle only: we cannot *directly* observe it. Theoretical physicists and experimentalists agree these traces are just *signatures* of the long-awaited God particle. It was long-awaited indeed: the title of the six-page ‘leaflet’ explaining the award of the 2013 Nobel Prize in Physics to François Englert and Peter Higgs is: “*Here, at last!*”[3] The long wait for it - and CERN's excellent media team - may explain why the Nobel Physics Committee and the Royal Swedish Academy of Sciences were so eager to award a Nobel Prize for this ! So we should ask ourselves: what's the hype, and what are the physics? And do the physics warrant the hype?

The facts are rather simple. We cannot directly observe the Higgs particle because it is just like all of the other ‘particles’ that come out of these collisions: they are too short-lived to leave a *permanent* trace. Indeed, when two protons hit each other at these incredible velocities, then all that’s left is *debris* flying around. This debris quickly disintegrates into other more debris –

until we're left with what we're used: *real* particles, like electrons or protons. Things that don't disintegrate.

The energy of the *debris* (the gamma rays or the muons) coming out of 'Higgs events' tells us the energy of the Higgs particle must be about 125 GeV. Besides its mass, it does not seem to have any other properties: no spin, no electric charge. It is, therefore, known as a *scalar* boson. In everyday language, that means it is just some (real) number. Newton had already told us that mass, as a *measure of inertia*, is just some real positive number—and Einstein taught us energy and mass are equivalent.

Interpreting the facts is tough. I am just an amateur physicists and so my opinion won't count for much. However, I can't help feeling Higg's theory just confirms the obvious. For starters, we should be very hesitant to use the term 'particle' for the Higgs boson because its lifetime is of the order of 10^{-22} s. Think of it as the time an electron needs to go from electron orbital to another. Even at the speed of light – which an object with a rest mass of 125 GeV/c^2 cannot aspire to attain – a particle with such lifetime cannot travel more than a few *tenths* of a femtometer: about 0.3´10^{-15} m, to be precise. That's not something you would associate it with the idea of a particle: a *resonance* in particle physics has the same lifetime.

That's why we'll never *see* the Higgs boson—just like we'll never *see* the $W^{\pm}$ and Z bosons whose mass it's supposed to explain. Neither will none of us ever *see* a quark or a gluon: physicists tell us the *signals* that come out of colliders such as the LHC or, in the 1970s and 1980s, that came out of the PETRA accelerator in Hamburg, the Positron-Electron Project (PEP) at the Stanford National Accelerator Laboratory (SLAC), and the Super Proton-Antiproton Synchrotron at CERN, are *consistent* with the hypothesis that the strong and weak forces are *mediated* through particles known as bosons (force carriers) but – truth be told – the whole idea of forces being *mediated* by bosons is just what it is: a weird theory.

Are virtual particles the successor to the *aether* theory?

Maybe we should first discuss the most obvious of all bosons: the photon. Photons are real. Of course, they are. They are, effectively, the particles of light. They are, in fact, the only bosons we can effectively *observe*. In fact, we've got a problem here: the only bosons we can effectively *observe* – photons – do *not* have all of the theoretical properties of a boson: as a spin-1 particle, the theoretical values for its angular momentum are ± $\hbar$ or 0. However, photons don't have a zero-spin state. Never. This is one of the things in mainstream quantum mechanics that has always irked me. All courses in quantum mechanics spend like two or three chapters on why bosons and fermions are different (spin-one versus spin-1/2), but when it comes to the specifics - real-life stuff - then the only boson we actually know (the photon) turns out to *not* be a typical boson because it can't have zero spin. [Physicists will, of course, say the most important property of bosons is that they you can keep piling bosons on top of bosons, and you can do that with photons. Bosons are supposed to like to be together, because we want to keep adding to the force without limit. But... Well... I have another explanation for that. It's got to do with the fact that bosons don't - or shouldn't - carry charge. But I don't want to start another digression on that. Not here.]

So photons - the only *real-life* bosons we've ever observed - aren't typical bosons. More importantly, no course in physics has ever been able to explain why we'd need photons in the role of *virtual* particles. Why would an electron in some atomic orbital continuously exchange photons with the proton that holds it in its orbit? When you ask that question to a physicist, he or she will start blubbering about quantum field theory and other mathematical wizardry—but he or she will never give you a clear answer. I'll come back to this in the next section of this paper.

I don't think there is a clear answer. Worse, I've started to think the whole idea of some particle *mediating* a force is nonsense. It's like the 19th-century *aether* theory: we don't need it. We don't need it in electromagnetic theory: Maxwell's Laws – augmented with the Planck-Einstein relation – will do. We also don't need it to model the strong force. The *quark-gluon* model – according to which quarks change color all of the time – does *not* come with any simplification as compared to a simpler *parton* model:

1. The quark-gluon model gives us (at least) two quarks[4], two anti-quarks and nine gluons, so that adds up to 13 different objects.
2. If we just combine the idea of a parton – a pointlike carrier of *properties* – with… Well… Its properties – the possible electric charges (±2/3 and ±1/3) and the possible color charges (red, green and blue) – we've got 12 partons, and such 'parton model' explains just as much.[5]

I also don't think we need it to model the weak force. Let me be *very* clear about my intuition/sentiment/appreciation—whatever you want to call it:

> **We don't need a Higgs theory to explain why W/Z bosons have mass because I think W/Z bosons don't exist: they're a figment of our imagination.**

Why do we even need the concept of a *force* to explain why things fall apart? The world of unstable particles – *transient* particles as I call them – is a different realm altogether. Physicists will cry wolf here: CERN's Super Proton-Antiproton Synchrotron produced evidence for W^+, W^- and Z bosons back in 1983, didn't it?

No. The evidence is just the same as the 'evidence' for the Higgs boson: we produce a short-lived blob of energy which disintegrates in no time (10^{-22} s or 10^{-23} s is no time, really) and, for some reason no one really understands, we think of it as a force carrier: something that's supposed to be very different from the other blobs of energy that emerge while it disintegrates into *jets* made up of other transients and/or resonances. The end result is always the same: the various blobs of energy further dis- and reintegrate as stable particles (think of protons, electrons and neutrinos[6]). There is no good reason to introduce a bunch of weird *flavor* quantum numbers to think of how such processes might actually occur. In reality, we have a very limited number of permanent fixtures (electrons, protons and photons), hundreds of *transients* (particles that fall apart) and thousands of resonances (excited states of the transient and non-transient stuff).

You'll ask me: so what's the difference between them then?

Stable particles respect the $E = h \cdot f = \hbar \cdot \omega$ relation—and they do so *exactly*. For non-stable particles – transients – that relation is slightly off, and so they die. They die by falling apart in more stable configurations, until we are left with stable particles only. As for resonances, they are just that: some excited state of a stable or a non-stable particle. Full stop. No magic needed.[7]

Photons as bosons

Photons are real and, yes, they carry energy. When an electron goes from one state to another (read: from one electron orbital to another), it will absorb or emit a photon. Photons make up light: visible light, low-energy radio waves, or high-energy X- and γ-rays. These waves carry energy and – when we look real close – they are made up of photons. So, yes, it's the photons that carry the energy.

Saying they carry electromagnetic energy is something else than saying they carry electromagnetic *force* itself. A force acts on a charge: a photon carries no charge. If photons carry no charge, then why would we think of them as carrying the force?

I wrote I've always been irked by the fact that photons - again, the only *real-life* bosons we've ever observed - don't have all of the required properties of the theoretical force-carrying particle physicists invented: the 'boson'. If bosons exist, then the bosons we associate with the strong and weak force should also not carry any charge: color charge or... Well... What's the 'weak' charge? Flavor? *Come on guys !* Give us something we can believe in.

That's one reason – for me, at least – why the idea of gluons and W/Z bosons is non-sensical. Gluons carry color charge, and W/Z bosons carry electric charge (except for the Z boson – but we may think of it as carrying both positive and negative charge). They shouldn't. Let us quickly review what I refer to as a 'classical' quantum theory of light.[8]

If there is one quantum-mechanical rule that no one never doubts, it is that angular momentum comes in units of $\hbar$: Planck's (reduced) constant. When analyzing the electron orbitals for the simplest of atoms (the one-proton hydrogen atom), this rule amounts to saying the electron orbitals are separated by an amount of *physical action* that is equal to $h = 2\pi \cdot \hbar$. Hence, when an electron jumps from one level to the next – say from the second to the first – then the atom will lose one unit of h. The photon that is emitted or absorbed will have to pack that somehow. It will also have to pack the related energy, which is given by the Rydberg formula:

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

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

$$\mathrm{E}\cdot\mathrm{T} = h \Leftrightarrow \mathrm{T} = \frac{h}{\mathrm{E}} \approx \frac{4.135 \times 10^{-15}\,\mathrm{eV}\cdot\mathrm{s}}{10.2\ \mathrm{eV}} \approx 0.4 \times 10^{-15}\ \mathrm{s}$$

This corresponds to a wave train with a length of $(3\times10^8\ \mathrm{m/s})\cdot(0.4\times10^{-15}\ \mathrm{s}) = 122$ nm. That is the size of a large molecule and it is, therefore, much more reasonable than the length of the wave trains we get when thinking of transients using the supposed Q of an atomic oscillator.[9] In fact, this length is the wavelength of the light ($\lambda = c/f = c\cdot\mathrm{T} = \mathrm{h}\cdot c/\mathrm{E}$) that we would associate with this photon energy.

We should quickly insert another calculation here. If we think of an electromagnetic oscillation – as a beam or, what we are trying to do here, as some *quantum* – then its energy is going to be proportional to (a) the square of the amplitude of the oscillation – and we are *not* thinking of a quantum-mechanical amplitude here: we are talking the amplitude of a *physical* wave here – and (b) the square of the frequency. Hence, if we write the amplitude as *a* and the frequency as ω, then the energy should be equal to $\mathrm{E} = \mathrm{k}\cdot a^2\cdot\omega^2$, and the k in this equation is just a proportionality factor.

However, relativity theory tells us the energy will have some equivalent mass, which is given by Einstein's mass-equivalence relation: $\mathrm{E} = \mathrm{m}\cdot c^2$. This equation tells us the energy of a photon is proportional to its mass, and the proportionality factor is c^2. So we have two proportionality relations now, which (should) give us the same energy. Hence, $\mathrm{k}\cdot a^2\cdot\omega^2$ must be equal to $\mathrm{m}\cdot c^2$, *somehow*.

How should we *interpret* this? It is, obviously, very tempting to equate k and m, but we can only do this if c^2 is equal to $a^2\cdot\omega^2$ or – what amounts to the same – if $c = a\cdot\omega$. You will recognize this as a tangential velocity formula. The question is: the tangential velocity of *what*? The *a* in the $\mathrm{E} = \mathrm{k}\cdot a^2\cdot\omega^2$ formula that we started off with is an amplitude: why would we suddenly think of it as a radius now? Because our photon is circularly polarized. To be precise, its angular momentum is $+\hbar$ or $-\hbar$. There is no zero-spin state. Hence, if we think of this classically, then we will associate it with circular polarization.

However, these properties do not make it a *boson* or, let me be precise, these properties do not make it a *virtual* particle. Again, I've haven't seen a textbook – advanced or intermediate level – that answers this simple question: why would an electron in some *stable* atomic orbital – it does not emit or absorb any energy – continuously exchange *virtual* photons with the proton that holds it in its orbit?

How would that photon look like? It would have to have some energy, right? And it would have to pack to physical action, right? Why and how would it take that energy - or that action (I like the German *Wirkung* much better in terms of capturing that concept) - away from the electron orbital? In fact, the *idea* of an electron orbital combines the idea of the electron and the proton—and their mutual attraction. The physicists who imagine those virtual photons are making a philosophical category mistake. We think they're making a similar mistake when advancing the *hypothesis* of gluons and W/Z bosons.

Conclusions

We think the idea of *virtual* particles, gauge bosons and/or force-carrying particles in general is superfluous. The whole idea of bosons mediating forces resembles 19th century *aether* theory: we don't need it. The implication is clear: if that's the case, then we also don't need gauge theory and/or quantum field theory.

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[1] We took this from the above-mentioned leaflet. A proton has a *rest* energy of 938,272 eV, more or less. An energy equal to 4 TeV (the *tera*- prefix implies 12 zeroes) implies a Lorentz factor that is equal to $\gamma = E/E_0 = 4´10^{12}/938,272$ » $1´10^6$. Now, we know that $1 - \beta^2 = c^2/c^2 - v^2/c^2 = 1/\gamma^2 = 1/\gamma^2$ » $1´10^{-12}$. The square root of that is of the order of a *millionth*, so we get the same order of magnitude.

[2] To be fair, the high-energy collisions also resulted in the production of some more short-lived 'particles', such as new variants of *bottomonium*: mesons that are supposed to consist of a *bottom* quark and its anti-matter counterpart.

[3] See: https://www.nobelprize.org/uploads/2018/06/popular-physicsprize2013-1.pdf. Higgs' theory itself – on how gauge bosons can acquire non-zero masses – goes back to 1964 and was put forward by three individual research groups. See: https://en.wikipedia.org/wiki/1964_PRL_symmetry_breaking_papers.

[4] We write *at least* because we are only considering *u* and *d* quarks here: the constituents of all stable or fairly stable matter (protons and neutrons, basically).

[5] See: Jean Louis Van Belle, *A Realist Interpretation of QCD*, 16 July 2019.

[6] If we think of energy as the *currency* of the Universe, then you should think of protons and electrons as bank notes, and neutrinos as the coins: they provide the *change*.

[7] See: Jean Louis Van Belle, *Is the Weak Force a Force?*, 19 July 2019.

[8] This is a very much abbreviated summary. For a more comprehensive analysis, see: Jean Louis Van Belle, *A Classical Quantum Theory of Light*, 13 June 2019.

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