The ring current model for antimatter

Jean Louis Van Belle, 26 March 2020

Summary

Richard Feynman suggested anti-particles behave like they are traveling back in time. We think that is nonsense: in a ring current model, one distinguishes matter and anti-matter by the *direction* of travel of the charge inside. That is all. Using (or abusing) Minkowski's notation, we may say the spacetime signature of an electron (or an antiproton) is + – – – while that of a positron (or proton) would be + + + +.

Indeed, in the ring current model of matter-particles, the magnetic moment alone does not allow one to distinguish between an electron with spin *up* and a positron with spin *down*. All we know is that the current that generates the magnetic moment must be different: one carries a negative charge, and the other carries a positive charge – and the *direction* of the *physical* current (the motion of the *zbw* charge) is opposite.

The question then becomes: what distinguishes the positive and a negative *zbw* charge inside the *zbw* electron and positron? We suggest that the assumption of a (finite) fractal structure, in which the *zbw* charge itself also spins, may provide a logical answer to that question.

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The ring current model for antimatter

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The concept of a lightspeed circular current is at the core of our model of matter-particles. In this paper, we want to think about two inter-related questions: what's the model for antimatter, and what's the nature of the *Zitterbewegung* (zbw) charge inside?[1] As our thoughts are not very firm on this, the paper will come across as being highly speculative—and it surely is! However, as with previous papers, we hope it will generate some more thinking and discussion, which may or may not lead to an improved result in some distant or not so distant future. 😊

Matter and antimatter ring currents

In previous papers, we wrote the magnetic moment of an electron as $\mu \approx 9.2847647043(28)\times10^{-24}$ J·T^{-1} (its *measured* value as published Committee on Data (CODATA) of the International Science Council) or as $\mu = q_e\hbar/2m$ (its theoretical value). We were actually a bit sloppy there: q_e is the *elementary* charge. It's the charge we associate with a proton or a *positron* – the latter being the electron's antimatter counterpart – and so it equal to *minus* the electron charge. We should, therefore, have put a minus sign everywhere. However, we were interesting in *magnitudes* only – and in particular the magnitude of the *anomalous* magnetic moment – and so we did not bother too much. It is now time to be more precise.

Consider a particular direction of the elementary current generating the magnetic moment. It is easy to see that the magnetic moment of an electron ($\mu = -q_e\hbar/2m$) and that of a positron ($\mu = +q_e\hbar/2m$) would be opposite. We may associate a particular direction of rotation with an angular frequency *vector* $\boldsymbol{\omega}$ which – depending on the direction of the current – will be up or down with regard to the plane of rotation.[2] We associate this with the spin property, which is also up or down.[3] We, therefore, have four possibilities[4]:

Matter-antimatter	**Spin up**	**Spin down**
Electron	$\mu_{-e} = -q_e\hbar/2m$	$\mu_{-e} = +q_e\hbar/2m$
Positron	$\mu_{+e} = +q_e\hbar/2m$	$\mu_{+e} = -q_e\hbar/2m$

[1] Erwin Schrödinger coined the term *Zitterbewegung* term while exploring solutions to Dirac's equation for a free electron. We refer to Oliver Consa (2018) for a brief historical overview of the development of the ring current model (https://vixra.org/abs/1809.0567). We must also assume the reader is somewhat familiar with our previous writings (https://vixra.org/author/jean_louis_van_belle). If not, the shortest introduction to it all is our new physics site (https://ideez.org/).

[2] To determine what is up or down, one has to apply the ubiquitous right-hand rule.

[3] Richard Feynman suggested time reversal for anti-particles. We think that is nonsense: it is reversal of *direction*, of course. Abusing or adapting Minkowski's notation, we may say the spacetime signature of an electron is a (+ – – –), while that of a positron would be (+ +++).

[4] The use of the subscripts in the magnetic moment may be confusing, but shouldn't be: we use –e for an electron and +e for a positron. We do so to preserve the logic of denoting the (positive) elementary charge as q_e.

This shows the ring current model also applies to antimatter. In fact, Richard Feynman suggested time reversal for anti-particles. We think that is nonsense: it is reversal of *direction*, obviously! Abusing Minkowski's notation, we may say the spacetime signature of an electron is a (+ – – –) while that of a positron would be (+ + + +).

The relevant question is this: what *exactly* distinguishes an electron with spin *up* and a positron with spin *down*? We cannot tell from the magnetic moment. Vice versa, the magnetic moment will be the same for an electron with spin *down* and a positron with spin *up*. So what makes an electron different from a positron then?

The obvious answer is this, of course: try to bring two electrons together, and then try to bring an electron and a positron together, and you will see two *very* different things happening. 😊 However, we are looking for some *intrinsic* property here. The answer is this, obviously: in the electron with spin *up*, we have the same current as in the positron with spin *down*, but it is because we have *an opposite charge* (negative instead of positive) *spinning in the opposite direction* (up instead of down, or right versus left—whatever you want to call it).

[…]

Are we kicking the can down the road here?

Yes and no. That depends on your answer to the next question: what is the difference between a negative and a positive *zbw* charge? There is an obvious answer to this question too, of course: one is positive and the other is negative! However, that does not satisfy us. If all is motion or spin, then we should, perhaps, think of some fractal structure here[5]: the *zbw* charge may also be spinning, and one direction of spin may be associated with a positive *zbw* charge, while the other would be associated with the opposite direction. However, I would think such answer *surely* amounts to kicking the can down the road!

Let us postpone the discussion for a while by trying to think of the *spatial* dimension of the *zbw* charge.

The spatial dimension of the *zbw* charge

To explain the anomaly in the magnetic moment of an electron, we assumed that the *zbw* charge had some tiny but non-zero spatial dimension. We, therefore, distinguished an *effective* radius, which we denoted as r, from the theoretical radius, which is equal to the *Compton* radius $a = \hbar/mc$. We made abstraction from the higher-order factors in the anomaly and only Schwinger's factor in the following calculation of r:

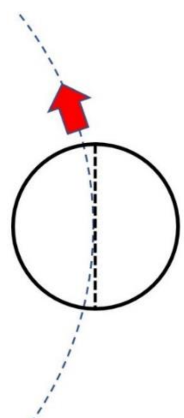
[5] The reader should note that we do *not necessarily* assume the fractal structure must be infinite. On the contrary, we think it may only go two levels down. These two levels would be associated with the *orbital* angular momentum of the *zbw* charge and the *spin* angular momentum of the charge itself.

$$\left.\begin{array}{c}\frac{\mu_r}{\mu_a}=\frac{\frac{q_e vr}{2}}{\frac{q_e}{2m}\hbar}=\frac{v\cdot r}{c\cdot a}=\frac{\omega\cdot r^2}{\omega\cdot a^2}=\frac{r^2}{a^2}\\ \frac{\mu_r}{\mu_a}\approx 1+\frac{\alpha}{2\pi}\end{array}\right\}\Leftrightarrow r\approx\sqrt{1+\frac{\alpha}{2\pi}}\cdot a\approx 1.00058\cdot\frac{\hbar}{mc}$$

The reader should note this is a rather good approximation: using the CODATA value for μ_r (and for α, of course) and our theoretical value for μ_a ($-q_e\hbar/2m$), the reader can check the μr/μa ratio is equal to about 99.99982445% of 1 + α/2π.[6] Hence, the accuracy is better than two parts in a million, which makes us think the higher-order factors may not be needed.[7] The only thing that is left to explain is this: why would the effective radius be *larger* than the theoretical one? In fact, the *effective* velocity must then also be *larger* than *c*. Indeed, the Planck-Einstein relation gives *one frequency* – not two – and we can, therefore, calculate the effective velocity *v* like this:

$$1=\frac{\omega}{\omega}=\frac{v/r}{c/a}\Leftrightarrow v=\frac{r}{a}\cdot c=\frac{\sqrt{1+\frac{\alpha}{2\pi}}\cdot a}{a}\cdot c=\sqrt{1+\frac{\alpha}{2\pi}}\cdot c\approx 1.00058\cdot c$$

We get the same ratio. How can the effective velocity be *larger* than *c*? It is related to the concept of the *effective center of charge*, which we can probably best understand by illustrating the (imagined) *physicality* of the situation—depicted below.



Indeed, if the *zbw* charge is whizzing around at the speed of light, and we think of it as a charged sphere or shell, then its effective *center of charge* will *not* coincide with its mathematical center (read: the center of the circle). Why not? Because the ratio between (1) the charge that is outside of the disk formed by the radius of its orbital motion and (2) the charge inside, will be slightly *larger* than 1/2. Indeed, the reader should carefully note the small triangular areas – two little *slices*, really – between the diameter line of the smaller circle (think of it as the *zbw* charge) and the larger circle (which represent the orbital of its *Zitterbewegung* or oscillatory motion).

[6] The reader may wonder about the minus signs but can see the minus signs cancel each other in the ratio.

[7] The professional physicist will immediately note that the relative uncertainty in the CODATA value is *smaller* than that: 3×10^{-10}, to be precise. However, we are talking a *ratio* here, rather than the absolute value and, in any case, we should leave the work of calculating higher-order factors to the professionals anyway—if only because we have no understanding of mainstream mathematical toys (quantum field theory).

We know the professional physicist will probably shake his or her head here and sigh: *you cannot possibly believe the illustration above might represent something real, right?*

We actually do. Why? We think it is a much easier and, therefore, *better* explanation than the mainstream explanation of the anomalous magnetic moment—especially because its history is somewhat dubious.[8]

Let us, therefore, examine this presumed spatial dimension of the *zbw* charge somewhat more in detail. The analysis above does *not* allow us to conclude that the radius or diameter of the *zbw* charge must be this or that value. The radius of the *zbw* charge and the difference between the effective and theoretical (Compton) radius of an electron – as calculated above – are very different. In fact, the latter must be some (small) fraction of the former. When doing some calculations, one immediately observes something very weird. The Thomson scattering radius is equal to this:

$$r_e = \alpha r_C = \alpha \frac{\hbar}{\mathrm{m_e} c} = \frac{\mathrm{q_e^2}}{4\pi\varepsilon_0 \hbar c}\frac{\hbar}{\mathrm{m_e} c} = \frac{\mathrm{q_e^2}}{4\pi\varepsilon_0 \mathrm{E_e}}$$

Now, if we would associate this with the radius of the *zbw* charge – which may or may not make sense – then we find that the *ratio* between the fine-structure constant (α) and the $\sqrt{1+\frac{\alpha}{2\pi}} \approx 1.00058$ factor is also (almost) equal to α. To be precise, we get this[9]:

$$\frac{\alpha}{\sqrt{1+\frac{\alpha}{2\pi}}} \approx \frac{0.007297\ldots}{1.00058\ldots} = 0.007293\ldots$$

Is this numerology? Maybe. The fine-structure constant is a very small number, and so we would get something similar with any number that has the same order of magnitude. Indeed, the calculation above amounts to this:

$$\frac{\alpha}{\sqrt{1+\frac{\alpha}{2\pi}}} \approx \alpha \Leftrightarrow \frac{\alpha}{\alpha\sqrt{1+\frac{\alpha}{2\pi}}} = \frac{\alpha}{\sqrt{\alpha^2+\frac{\alpha^3}{2\pi}}} \approx \frac{\alpha}{\sqrt{\alpha^2}} = \frac{\alpha}{\alpha} = 1$$

Hence, yes: the difference is the $\alpha^3/2\pi$ in the square root, and that's exceedingly small because of (1) the small value of α and (2) the square root. It may be a coincidence, of course, but because we have nothing else to work with, we would probably like to assume the *hard-core charge* inside of our electron (or our positron) will involve a factor equal to α, which gives us a radius of the order of $\alpha\hbar/mc$.

This raises an interesting question: how do we know our *zbw* charge is pointlike? Perhaps it is a true *ring* of charge: a toroidal structure rather than a pointlike structure. That is a good question, but the answer to it may be remarkably boring: a relativistically correct analysis of the *charge distribution* that's associated with a spherical charge moving in a circle at the speed of light seems to how it may be equivalent to a toroidal ring of charge.

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[8] See Oliver Consa, *Something is rotten in the state of QED*, 1 February 2020 (https://vixra.org/abs/2002.0011).

[9] We calculated this ratio using the CODATA point estimate of the fine-structure constant, but we do not show all of the digits. Indeed, we truncated the digits to show the difference: 0.007293… as opposed to α = 0.007297…

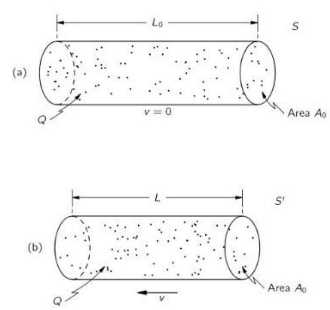
Relativistic charge densities

If we imagine our pointlike charge to have a radius, then it is only logical to assume it has some volume too. Feynman's classical calculations of the equally classical electron radius assume an electron is, effectively, some tiny *sphere* or *shell* of charge.[10] This gives our toroidal or disk-like electron[11] some *volume*. Now, the charge of a particle is an *invariant* scalar quantity. It does, therefore, *not* depend on the frame of reference. However, **the charge *density* of a charge distribution will vary in the same way as the relativistic mass of a particle**. To be precise, the charge density as calculated in the moving reference frame (ρ) will be related to the charge density in the inertial frame of reference (ρ_0) as follows[12]:

$$\rho = \frac{1}{\sqrt{1 - v^2/c^2}} \cdot \rho_0$$

This effect is entirely due to the relativistic length contraction effect. It is an interesting calculation, so let us quickly go through it. From special relativity theory, we know that the dimensions that are *transverse to the motion* – you should, of course, think of the radius of our *zbw* charge here! – remain unchanged.[13] Hence, the area $A = A_0$ is the same in the inertial (*S*) as well as in the moving reference frame (*S'*). However, the length L will be *shorter*, and this relativistic length contraction will be given by the same Lorentz factor: $L = L_0/\gamma$.[14]

Figure 1: The relativity of charge densities[15]



[10] See Feynman's *Lecture* on electromagnetic mass (https://www.feynmanlectures.caltech.edu/II_28.html). The only inconvenience is that – depending on the form factor that is used – Feynman ends up with a 1/2, 2/3 or – using another approach to the calculations – a 3/4 factor. So he only gets a *fraction* of the classical electron radius.
[11] For a discussion on the form factor in classical calculations of the anomalous magnetic moment (amm), see our discussion of the calculations of the amm of Oliver Consa (https://vixra.org/abs/2001.0264).
[12] See: Feynman's *Lectures*, *The Relativity of Magnetic and Electric Fields* (https://www.feynmanlectures.caltech.edu/II_13.html#Ch13-S6).
[13] We may remind the reader that Einstein – in his original 1905 article on special relativity – did actually introduce a distinction between the "longitudinal" and "transverse" mass of a moving charge. See p. 21 of the English translation of Einstein's article on special relativity, which can be downloaded from: http://hermes.ffn.ub.es/luisnavarro/nuevo_maletin/Einstein_1905_relativity.pdf. We feel the two concepts may be related to the equally relative distinction between the electrostatic and magnetic forces.
[14] Note we *divide* by the Lorentz factor here or, what amounts to the same, multiply with the *inverse* Lorentz factor.
[15] Source: Feynman's Lectures, Vol. II, Chapter 13, Fig. 13-11

Substituting the *total* charge Q by q_e, we can write this:

$$q = \rho \cdot L \cdot A = \rho \cdot L \cdot A_0 = \rho_0 \cdot L_0 \cdot A_0 \Leftrightarrow \rho = \gamma \cdot \rho_0 = \frac{\rho_0}{\sqrt{1 - v^2/c^2}}$$

You may think the argument depends on a form factor: we are talking the volume of a cylindrical shape here, aren't we? Not really.[16] We could divide any volume (cylindrical, spherical or whatever other shape) into an infinite set of infinitesimally small cylindrical volumes and obtain the same result: the $\rho = \gamma \cdot \rho_0$ formula is also valid for the charge density as used in the general formula for an electric current, which is equal to: $I = \rho \cdot v \cdot A$. The velocity in this formula is just the velocity of the charge, and A is the same old cross-section of whatever 'wire' we would be looking at. Applying the relativistic formula above, and equating v to c, we can now calculate the current in terms of some *stationary* charge or – to be more precise – in terms of the *stationary charge distribution* ρ_0:

$$I = \rho \cdot v \cdot A = \frac{\rho_0}{\sqrt{1 - v^2/c^2}} \cdot v \cdot A$$

Hence, we get the same seemingly nonsensical division of zero by zero for $v = c$. How should we interpret this? We are not sure. We think it makes any meaningful discussion of the shape of the *stationary charge distribution* very difficult: a spherical charge moving in a circle at the speed of light is, therefore, probably equivalent to a toroidal ring of charge. As such, the discussions on such shape factor may distract from some more fundamental reality, which is and remains difficult to gauge or understand.

The effective mass of the *zbw* charge

The quintessential question is: how does a naked charge – in a circular current – acquire an effective mass? This is a deep mystery which we can only analyze mathematically, and even such mathematical analysis leaves us somewhat bewildered because we are applying equations to limiting situations. To be precise, we are calculating the $m_v = \gamma m_0$ product for γ (the Lorentz factor) going to 1 divided by 0 (*zero*), while the *rest* mass m_0 is also supposed to be equal to zero. Indeed, with $m_0 \to 0$ and $v \to c$, we are dividing zero by zero in Einstein's relativistic mass formula:

$$m_v = \gamma \cdot m_0 = \frac{1}{\sqrt{1 - v^2/c^2}} \cdot m_0$$

We have not tried to solve this problem mathematically. Instead, we suggested a geometric solution, according to which the effective mass of our pointlike charge (which we denoted as $m_\gamma = m_{v=c}$) must be equal to 1/2 of the (rest) mass of the electron:

$$m_\gamma = m_{v=c} = \frac{m_e}{2}$$

[16] Note that the argument actually does *not* use the $V = \pi \cdot a^2 \cdot L$ formula, which is the formula one would use for the volume of a cylindrical shape. The argument only depends on the mathematical shape of the formula for electric current only ($\rho \cdot v \cdot A$) which, unsurprisingly, is the same as the $q = \rho \cdot L \cdot A$ formula: current is measured as charge per time unit, while a length may be expressed as the product of time and velocity. The reader may want to do a quick dimensional analysis of the equations to check the logic and appreciate the points made here.

We refer to our previous paper(s) for the detail.[17]

Let us return to the question we asked earlier: what makes a positive *zbw* charge a positive *zbw* charge, and what makes a negative one negative? The digressions above seemed to have distracted us, isn't it?

Maybe. Maybe not. We feel they are necessary when *speculating* about very difficult questions like this. They help us to get a feel for what might or might not be the case.

What makes antimatter antimatter?

We do not believe in *negative* space. Directions can be negative—in the sense that it is *opposite* to some other direction, but there is no such thing as negative space.

We also do not believe there is something like *negative* mass—just in case you think it might have something to do with that: any mass in our ring current or *Zitterbewegung* model is the *equivalent* mass of the energy in the oscillation, and that energy is positive. It's a textbook application of Wheeler's 'mass without mass' idea, and so we don't believe in *negative* energies—*not* the energy of an oscillation, that is.

So what is left to differentiate a positive and a negative *zbw* charge, then?

We are not sure, but thinking of the electron as some kind of fractal structure is very appealing: the *zbw* charge may also be spinning around its own axis – we would expect such additional motion, right?[18] – and one direction of spin may be associated with a positive *zbw* charge, while the other would be associated with the opposite direction.

Let me advance one more argument here: the anomalous magnetic moment of a muon is almost the same as that of an electron. Indeed, the CODATA values for the magnetic moment of an electron and a muon respectively are this[19]:

$$a_e = 1.00115965218128(18)$$

$$a_\mu = 1.00116592089(63)$$

This tells us that the radius of the *zbw* charge seems to shrink with the size of the particle ! Indeed, the classical electron radius is about 2.8 *femto*meter, so that's about 1.5 time *larger* than the (Compton) radius of a muon (about 1.87 fm). Hence, if the *zbw* charge inside a muon would be as large as, presumably, the radius of the *zbw* charge inside an electron, it would not fit in! And, if it did, we would get a *much* larger value for the anomaly: the difference between the effective and theoretical Compton radius would be *huge*, indeed!

In our paper(s) on the proton, we show we can apply the same reasoning to the proton, which is even

[17] See our *Metaphysics of Physics* paper, and especially annex 2 (https://vixra.org/abs/2001.0453).

[18] It is related to the ubiquitous distinction between *orbital* and *spin* angular momentum, both in classical as well as in quantum mechanics.

[19] It is confusing to use the symbol *a* to denote the anomaly: we are, indeed, *not* talking about the radius but about the anomaly here! However, we are just following the CODATA convention here.

smaller (only 0.83-0.84 fm, so that's another 2.22 times *smaller*).[20]

So, yes, the spatial dimensions (read: the *size*) of the *zbw* charge does seem to shrink as per the size of the larger particle? The idea of a fractal structure, therefore, makes sense, and the difference between a positive and a negative charge may be in the positive/negative direction of the spin of the *zbw* charge.

It sounds like a (very) shaky assumption and, yes, it feels very much like kicking the can down the road—to me too! Please let me know what you'd be thinking of. Something *not* involving (other) hocus-pocus, *please*? 😊

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[20] To calculate the proton radius, one must take into account a very different angular momentum, it seems. We refer the reader to the Matter page of our physics site for a quick overview (https://ideez.org/matter/).