# Testing QED: The Other Game in Town

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**Abstract**: The measurement of the anomalous magnetic moment and its theoretical explanation in terms of perturbative quantum electrodynamics (QED) are always presented as the 'high-precision test' in (modern) quantum electrodynamics. This paper argues an explanation in terms of the classical *Zitterbewegung* or – preferably – the Dirac-Kerr-Newman electron model might be possible. Indeed, the author of the latter model (Burinskii, 2016) has updated it to incorporate the most recent theoretical developments – which include compatibility with the supersymmetric Higgs field theory and string theory based on the Landau-Ginzburg (LG) field model. However, as far as we can see, his model does reduce to the classical Zitterbewegung model in the classical limit (i.e. when assuming only general relativity and classical electromagnetism).

As Dirac noted, a *direct* verification of these models is not possible because of the very high frequency of the oscillatory motion (the *zbw* charge moves at the speed of light) and the very small amplitude (the Compton radius). However, logic tells us that the *form factor* that comes out of the Dirac-Kerr-Newman model can easily be used in models that do *not* involve micro-motion at the speed of light. In other words, we should be able to *indirectly* verify whether these models make sense or not by inserting the form factor in models that involve relativistically slow motion of an electron around a nucleus (atomic orbitals) or – in this particular case – the motion of an electron in a Penning trap.

Even if the results would only remotely explain the anomaly, we would still have achieved two very significant scientific breakthroughs. First, it would show that these seemingly irrelevant micro-models can be validated externally. More importantly, it would prove that an alternative (classical) explanation of the anomalous magnetic moment would be possible.

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# Testing QED: The Other Game in Town

## Introduction

Let us briefly remind the reader of the context. We recently suggested[1] that it might be possible to explain the anomalous magnetic moment based on some *form factor* that would come out of a classical electron model. While we initially thought about these things from a learning perspective only – we just wanted to possibly identify a better *didactic* approach to teaching quantum mechanics – the idea seems to have taken some life on its own now.[2]

What is a 'classical' electron model? We use this term to refer to any theory of an electron that does *not* invoke perturbation theory. We do not like perturbation theory because of the very same reason that made the founding fathers (Heisenberg, Dirac, Pauli, ...) skeptical about the theory they had created.[3] Interestingly, Ivan Todorov – whose paper notes the above – also speaks of the theoretical value of the spin angular momentum ($g_{spin}$ = 2) as a "dogma" and mentions two letters of Gregory Breit to Isaac Rabi, which may be interpreted as Breit defending the idea that an intrinsic magnetic moment "of the order of $\alpha\mu_B$" may not be anomalous at all.[4] Needless to say, the issue is quite controversial because a classical explanation of the anomalous magnetic moment would question some of the rationale behind the award of two Nobel Prizes for physics.

Let us be precise here. Polykarp Kusch got (half of) the 1955 Nobel Prize "for his precision determination of the magnetic moment of the electron."[5] As such, we should *not* associate him with the theory behind. Having said that, the measurement obviously corroborated the new theories of what Todorov refers to as "the younger generation" of physicists – in particular Richard Feynman, Julian Schwinger and Shinichiro Tomonaga, who got their 1965 Nobel Prize for "for their fundamental work in quantum electrodynamics, with deep-ploughing consequences for the physics of elementary particles" – for the *theory*, that is.

What Brian Hayes refers to as "the tennis match between experiment and theory" [6] seems to be a game without end. The question is: is there another game in town? We think there might be one.

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[1] Jean Louis Van Belle, *The Not-So-Anomalous Magnetic Moment*, 21 December 2018, http://vixra.org/pdf/1812.0233v3.pdf. The paper should, preferably, be read in conjunction with a more recent paper on how the fine-structure constant relates the various layers in the motion of an electron: *Layered Motions: The Meaning of the Fine-Structure Constant*, 23 December 2018, http://vixra.org/pdf/1812.0273v3.pdf.

[2] Our physics blog attracts a fair amount of comments from fellow amateur physicists. These remarks are encouraging but do not add any credibility to the model (on the contrary, we'd say). However, we also had discussions with some researchers on Kerr-Newman and *Zitterbewegung* models. While we speak a very different language, these discussions suggest the key ideas might make some sense.

[3] See: Ivan Todorov, *From Euler's play with infinite series to the anomalous magnetic moment*, 12 October 2018 (https://arxiv.org/pdf/1804.09553.pdf).

[4] For a more detailed account of the substance of these conversations, see: Silvan S. Schweber, *QED and the Men Who Made It: Dyson, Feynman, Schwinger, and Tomonaga* , p. 222-223.

[5] See: https://www.nobelprize.org/prizes/physics/1955/summary/ and https://www.nobelprize.org/prizes/physics/1965/summary/.

[6] See: Brian Hayes, *Computing Science: g-ology*, in: *American Scientist*, Vol. 92, No. 3, May-June 2004, pages 212-216. The subtitle says it all: it is an article 'on the long campaign to refine measurements and theoretical calculations of a physical constant called the *g* factor of the electron.' https://pdfs.semanticscholar.org/4c12/50f66fc1fb799610d58f25b9c1e1c2d9854c.pdf.

## The new quantum physics

We will *not* explain perturbation theory here.[7] We only want to give a quick overview of its results in the context of the *theoretical* explanation of the anomalous magnetic moment. Indeed, we described the methodology of its *measurement* in the above-mentioned paper and, hence, we will not repeat ourselves here. In fact, we suggest the reader directly consults the 2009 article of the Harvard University group that does these experiments.[8] We will just note that the confusion starts with the definition of the anomalous magnetic moment. It is actually *not* a magnetic moment but a *gyromagnetic ratio* (i.e. a *ratio* between a magnetic moment and an angular momentum) and it's defined as:

$$a_e = \frac{g}{2} - 1$$

The 2009 article states that the *measured* value of $g$ is equal to 2.00231930436146(56). The 56 (between brackets) is the (un)certainty: it is equal to 0.00000000000056, i.e. 56 *parts per trillion* (ppt) and it is measured as a standard deviation.[9] Hence, $a_e$ is equal to 0.00115965218073(28).

The so-called anomaly is the difference with the theoretical value for the *spin* angular momentum which came out of Dirac's equation for the free electron, which is equal to 2. The confusion starts here because there is no obvious explanation of why one would use the (theoretical) $g$-factor for the intrinsic spin of an electron ($g$ = 2). The electron in the Penning trap that is used in these experiments is *not* a spin-only electron. It follows an orbital motion – that is one of the three or four layers in its motion, at least – and, hence, if some theoretical value for the $g$-factor has to be used here, then one should also consider the $g$-factor that is associated with the orbital motion of an electron, which is that of the Bohr orbitals ($g$ = 1). In any case, one would expect to see a *classical* coupling between (1) the precession, (2) the orbital angular momentum and (3) the spin angular momentum, and the situation is further complicated because of the electric fields in the Penning trap, which add another layer of motion. We illustrate the complexity of the situation below[10].

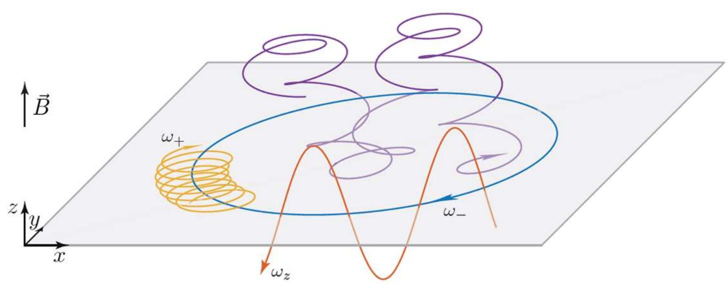


**Figure 1**: The three principal motions and frequencies in a Penning trap

[7] The interested reader may consult any standard textbook on that. See, for example, Jon Mathews and R.L. Walker, *Mathematical Methods of Physics*, 1970.

[8] D. Hanneke, S. Fogwell, N. Guise, J. Dorr and G. Gabrielse, *More Accurate Measurement of the Electron Magnetic Moment and the Fine-Structure Constant*, in: Proceedings of the XXI International Conference on Atomic Physics, 2009. We prefer this article over the original 2006 article (G. Gabrielse, D. Hanneke, T. Kinoshita, M. Nio, and B. Odom, *New Determination of the Fine Structure Constant from the Electron g Value and QED*, Phys. Rev. Lett. 97, 030802, 2006) because it can be freely consulted online: http://gabrielse.physics.harvard.edu/gabrielse/papers/2009/PushingTheFrontiersOfAtomicPhysics.pdf.

[9] To be precise, the article gives the *measured* value for $g$/2, which is equal to 1.00115965218073(28).

[10] We took this illustration from an excellent article on the complexities of a Penning trap: *Cylotron frequency in a Penning trap*, Blaum Group, 28 September 2015, https://www.physi.uni-heidelberg.de/Einrichtungen/FP/anleitungen/F47.pdf. The motions are complicated because the Penning trap traps the electron using both electric as well as magnetic fields (the electric field is *not* shown in the illustration, but it is there). One should note the illustration does *not* show the intrinsic spin of the electron, which we should also consider. See our above-mentioned paper for a more detailed description of the various layers of motion.

The point we are trying to make is the following: the theoretical value for $a_e$ (*zero*) would seem to need a better explanation. However, let us roll for a moment with the idea that – through the magic of classical coupling – that its theoretical value should be zero and that we, therefore, do have some anomaly here of the measured order of magnitude, i.e. $a_e$ = 0.00115965218073(28). How is it being explained? The new quantum physicists write it as (the sum of) a series of first-, second-, third-,…, $n^{th}$-order *corrections*:

$$a_e = \sum_n a_n \left(\frac{\alpha}{\pi}\right)^n$$

The first coefficient ($a_1$) is equal to 1/2 and the associated first-order correction is, therefore, equal to:

$$\alpha/2\pi \approx 0.00116141$$

Using "his renormalized QED theory", Julian Schwinger had already obtained this value back in 1947. He got it from calculating the "one loop electron vertex function in an external magnetic field." I am just quoting here from the above-mentioned article (Todorov, 2018). Julian Schwinger is, of course, one of the most prominent representatives of the second generation of quantum physicists, and he has this number on this tombstone. Hence, we surely do not want to question the depth of his understanding of this phenomenon. However, the difference that needs to be explained by the 2nd, 3rd, etc. corrections is only 0.15%, and Todorov's work shows all of these corrections can be written in terms of a sort of exponential series of α/2π and a *phi*-function ϕ(*n*) which had intrigued Euler for all of his life. We copy the formula for (the sum of) the first-, second- and third-order term of the theoretical value of $a_e$ as calculated in 1995-1996 (*th* : 1996).[11]

$$\begin{aligned} a_e(th:1996) &= \frac{1}{2}\frac{\alpha}{\pi} + \left[\phi(3) - 6\,\phi(1)\,\phi(2) + \phi(2) + \frac{197}{2^4\,3^2}\right]\left(\frac{\alpha}{\pi}\right)^2 \\ &+ \left[\frac{2}{3^2}\left(83\,\phi(2)\,\phi(3) - 43\,\phi(5)\right) - \frac{50}{3}\,\phi(1,3) + \frac{13}{5}\,\phi(2)^2 \right. \qquad (19) \\ &+ \left. \frac{278}{3}\left(\frac{\phi(3)}{3^2} - 12\,\phi(1)\,\phi(2)\right) + \frac{34202}{3^3\,5}\,\phi(2) + \frac{28259}{2^5\,3^4}\right]\left(\frac{\alpha}{\pi}\right)^3 + \ldots \\ &= 1.159652201(27)\times 10^{-3} \end{aligned}$$

We also quote Todorov's succinct summary of how this result was obtained: "Toichiro Kinoshita of Cornell University evaluated the 72 [third-order loop Feynman] diagrams numerically, comparing and combining his results with analytic values that were then known for 67 of the diagrams. A year later, the last few diagrams were calculated analytically by Stefano Laporta and Ettore Remiddi of the University of Bologna."

Apparently, the calculations are even more detailed now: the mentioned Laporta claims to have calculated 891 *four*-loop contributions to the anomalous magnetic moment.[12] One gets an uncanny feeling here: if one has to calculate a zillion integrals all over space using 72 third-order diagrams to calculate the 12th digit in the anomalous magnetic moment, or 891 fourth-order diagrams to get the

[11] It is worth quoting Todorov's succinct summary of how this result was obtained: Toichiro Kinoshita of Cornell University evaluated the 72 [Feynman] diagrams [corresponding to the third-order loop] numerically, comparing and combining his results with analytic values that were then known for 67 of the diagrams. later the last few diagrams were calculated analytically by Stefano Laporta and Ettore Remiddi of the University of Bologna.

[12] See: Stefano Laporta, *High-precision calculation of the 4-loop contribution to the electron g-2 in QED*, as reported in: https://www.sciencedirect.com/science/article/pii/S0370269317305324.

next level of precision, then there might something wrong with the theory. Is there an alternative? We think there is, and the idea is surprisingly simple.

## Classical electron models

Mr. Burinskii would probably *not* wish to describe his Dirac-Kerr-Newman model of an electron as a classical electron model – and neither would he want to be considered as a classical physicist[13] – but that is what it is for us: a charge with a geometry in three-dimensional space. To be precise, it is a disk-like structure, and its *form factor* – read: the ratio between the radius and thickness of the disk – depends on various assumptions (as illustrated below) but reduces to the ratio between the Compton and Thomson radius of an electron when assuming classical (non-perturbative) theory applies. We quote from Mr. Burinskii's 2016 paper: "It turns out that the flat Compton zone free from gravity may be achieved without modification of the Einstein-Maxwell equations."

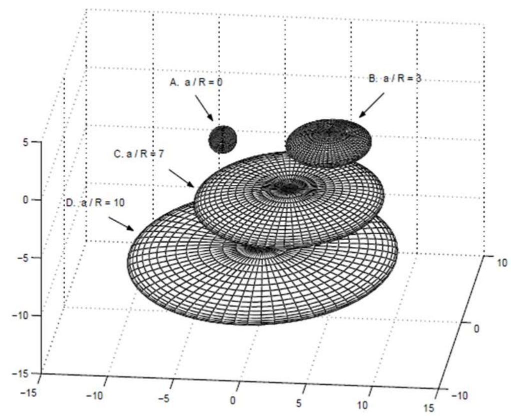


**Figure 2**: Alexander Burinskii's electron model

Hence, it would seem we get the fine-structure constant as the ratio of the Compton radius – i.e. the radius of the disk $R$ – and the classical electron radius – i.e. the thickness of the disk $r$ – out of a smart model based on Maxwell's and Einstein's equations, i.e. classical electromagnetism and general relativity theory:

$$\alpha = \frac{r}{R} = \frac{r_e}{r_C} = \frac{\mathrm{e}^2/\mathrm{m}c^2}{\hbar c/\mathrm{m}c^2} = \frac{\mathrm{e}^2}{\hbar c}$$

There is no need for smart quantum mechanics here! These results, therefore, confirm the intuitive but, admittedly, rather primitive *Zitterbewegung* model we introduced in our own papers. To illustrate the point, we would like to summarize one of the many possible interpretations of the fine-structure constant as a dimensional scaling constant here.[14]

[13] See: Alexander Burinskii, *The Dirac–Kerr–Newman electron*, 19 March 2008, https://arxiv.org/abs/hep-th/0507109. A more recent article of Mr. Burinskii (*New Path to Unification of Gravity with Particle Physics*, 2016, https://arxiv.org/abs/1701.01025, relates the model to more recent theories – most notably the "supersymmetric Higgs field" and the "Nielsen-Olesen model of dual string based on the Landau-Ginzburg (LG) field model." We admit we do not understand a word of this. As for Mr. Burinskii's general expertise (which is *quantum* physics, mainly), see his profile: https://www.researchgate.net/profile/Alexander_Burinskii.

[14] See the above-mentioned paper: Jean Louis Van Belle, *Layered Motions: The Meaning of the Fine-Structure Constant*, 23 December 2018, http://vixra.org/pdf/1812.0273v3.pdf.

First, we need to think about the meaning of $e^2$. There is something interesting here: the elementary charge $e^2$ has the same physical dimension – the *joule-meter* (J·m) – as the *hc* = Eλ product.

$$[\mathrm{e}^2] = \left[\frac{\mathrm{q_e}^2}{4\pi\epsilon_0}\right] = \frac{\mathrm{Nm^2C^2}}{\mathrm{C^2}} = \mathrm{Nm^2} = \mathrm{Jm}$$

Now, what was that *hc* = Eλ product again? We get it in the context of the description of a photon. To be precise, we get it by applying one of the two *de Broglie* equations to a photon:

$$h = \mathrm{p}\lambda = \frac{\mathrm{E}}{c}\lambda = \Longleftrightarrow \lambda = \frac{hc}{\mathrm{E}}$$

The energy (E) and wavelength (λ) are, of course, the energy and the wavelength of our photon. However, it turns out it makes sense to apply these equations to any particle that moves at the speed of light. The reader will wonder: what other particle? Our electron has a rest mass, right? It does, but our *Zitterbewegung* model assumes this rest mass is the equivalent mass of the *rest matter oscillation*. This rest matter oscillation is a two-dimensional oscillation: a local circulatory motion, in fact. It is illustrated below.

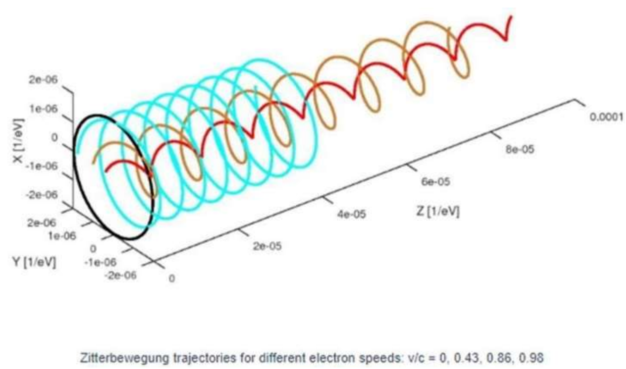


**Figure 3**: The *Zitterbewegung* model of an electron

The illustration above does not only show the *Zitterbewegung* itself but also another aspect of the theory. As the electron starts moving along some trajectory at a relativistic velocity (i.e. a velocity that is a substantial fraction of *c*), then the radius of the oscillation will have to diminish. Why? Because the tangential velocity remains what it is: *c*. Hence, the geometry of the situation shows that the radius of the oscillation becomes a wavelength in the process.[15] As Dirac noted in his Nobel Prize speech[16], the idea of the Zitterbewegung is very intuitive – and, therefore, very attractive – because it seems to give us a geometric (or, we might say, physical) explanation of the (reduced) Compton wavelength as the Compton scattering radius of an electron (a = ħ/mc).15 However, if we think of an actual physical interpretation, then it is quite obvious that the suggested plane of circulatory motion is not consistent with the measured direction of the magnetic moment – which, as the Stern-Gerlach experiment has shown us, is either up or down. Hence, we may want to think the plane of oscillation might be parallel to the direction of propagation, as drawn below.

[15] We refer to the mentioned paper for a more elaborate *exposé* of the geometry.
[16] Paul A.M. Dirac, 12 December 1933, Nobel Lecture, *Theory of Electrons and Positrons*, https://www.nobelprize.org/uploads/2018/06/dirac-lecture.pdf.

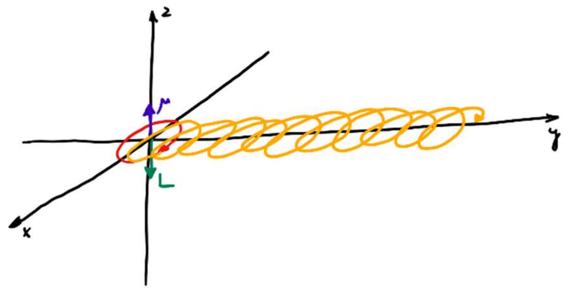


**Figure 4**: An alternative orientation of the *zbw* plane of rotation

We like the alternative picture of the *zbw* electron above not only because it is more consistent with the idea of the up-or-down orientation of the magnetic moment (cf. the Stern-Gerlach experiment) but also because it might provide us with a *physical* explanation of relativistic length contraction: as velocities increase, the radius of the circular motion becomes smaller (as illustrated above) which, in this model, may be interpreted as a contraction of the size of the *zbw* electron.

However, these remarks are not the point here. Let us return to our discussion of the anomalous magnetic moment.

## How to test the classical electron models

Mr. Burinskii's model is very flexible. If one limits the assumptions  - combining gravity and electromagnetism, we get the *Zitterbewegung* electron – a simple disk-like structure whose *form factor* is given by the fine-structure constant:

$$\alpha = \frac{r}{R} = \frac{r_e}{r_C} = \frac{\mathrm{e}^2/\mathrm{m}c^2}{\hbar c/\mathrm{m}c^2} = \frac{\mathrm{e}^2}{\hbar c}$$

When calculating the angular momentum, this form factor translates into a simple ½ factor when calculating the moment of inertia. We write $I = \mathrm{m}r^2/2$ – as opposed to the $I = \mathrm{m}r^2$ formula we would use for a pure orbital moment. This effectively gives us Dirac's theoretical value for the gyromagnetic ratio (*g*-factor) of the *spin-only* electron: g = 2. The table below summarizes the difference between the spin and orbital angular momentum.

**Table 1:** Intrinsic spin versus orbital angular momentum

| **Spin-only electron (*Zitterbewegung*)** | **Orbital electron (Bohr orbitals)** |
|---|---|
| $\mathrm{S} = \mathrm{h}$ | $\mathrm{S}_n = n\mathrm{h}$ for $n = 1, 2, \ldots$ |
| $\mathrm{E} = \mathrm{m}c^2$ | $\mathrm{E}_n = -\frac{1}{2}\frac{\alpha^2}{n^2}\mathrm{m}c^2 = -\frac{1}{n^2}\mathrm{E}_R$ |
| $r = r_\mathrm{C} = \frac{\hbar}{\mathrm{m}c}$ | $r_n = n^2 r_\mathrm{B} = \frac{n^2 r_\mathrm{C}}{\alpha} = \frac{n^2}{\alpha}\frac{\hbar}{\mathrm{m}c}$ |
| $v = c$ | $v_n = \frac{1}{n}\alpha c$ |
| $\omega = \frac{v}{r} = c \cdot \frac{\mathrm{m}c}{\hbar} = \frac{\mathrm{E}}{\hbar}$ | $\omega_n = \frac{v_n}{r_n} = \frac{\alpha^2}{n^3\hbar}\mathrm{m}c^2 = \frac{\frac{1}{n^2}\alpha^2\mathrm{m}c^2}{n\hbar}$ |

| | |
|---|---|
| $\mathrm{L} = I \cdot \omega = \mathrm{m}\frac{\hbar^2}{\mathrm{m}^2 c^2}\frac{\mathrm{E}}{\hbar} = \frac{\hbar}{2}$ | $\mathrm{L}_n = I \cdot \omega_n = n\hbar$ |
| $\mu = \mathrm{I} \cdot \pi {r_C}^2 = \frac{\mathrm{q_e}}{2\mathrm{m}}\hbar$ | $\mu_n = \mathrm{I} \cdot \pi {r_n}^2 = \frac{\mathrm{q_e}}{2\mathrm{m}} n\hbar$ |
| $\mathrm{g} = \frac{2\mathrm{m}}{\mathrm{q_e}}\frac{\mu}{\mathrm{L}} = 2$ | $\mathrm{g}_n = \frac{2\mathrm{m}}{\mathrm{q_e}}\frac{\mu}{\mathrm{L}} = 1$ |

As we mentioned in our paper[17], we will have a classical coupling between the two moments because of the Larmor precession of the electron in the Penning trap, as illustrated below. The *effective* current and the *effective* radius of the orbital motion will, therefore, *not* be equal to the values one would get from using the formulas in the right-hand column of the table above.[18]

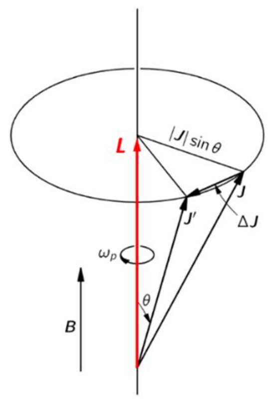


**Figure 5**: The precession of an orbital electron

Now, this classical coupling may or may not explain the bulk of what is actually being measured in these famous experiments measuring the (anomalous or not) magnetic moment of an electron in a Penning trap. However, we would suspect there will, effectively, be a small anomaly left – which is only natural because all of the formulas above assume the electron is a perfect disk (when calculating the values for the spin-only moment), or a perfect sphere (when calculating the values for the orbital moment). However, the Dirac-Kerr-Newman model of an electron tells us that is, perhaps, *not* the case. Let us copy the illustration again.

[17] Jean Louis Van Belle, *The Not-So-Anomalous Magnetic Moment*, 21 December 2018, http://vixra.org/pdf/1812.0233v3.pdf.

[18] Note that the formulas in the right column are the formulas for the properties of the Bohr orbitals. These *resemble* the cyclotron orbitals – to some extent – but one should not confuse them: the cyclotron orbitals have no nucleus at their center. In fact, the oft-quoted description of the electron in the Penning trap as an artificial atom is quite confusing and, therefore, not very useful: the radius and kinetic energy of the electron in a magnetron is of an entirely different order of magnitude! However, we would expect the formulas to be similar.

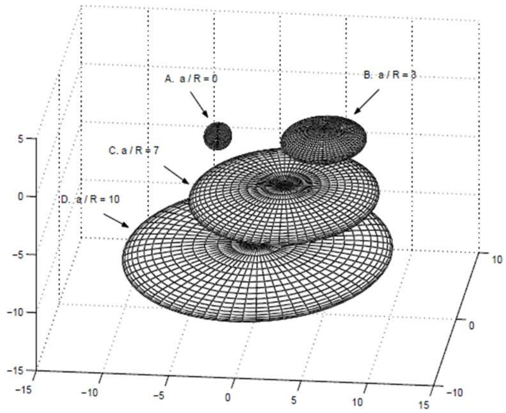


**Figure 6**: Burinskii's electron model

Despite all of the complexities of Mr. Burinskii's model, the shape of the electron can be characterized by a simple *a*/*R* ratio. Somewhat confusingly, the *R* in this formula is actually the surface area. Hence, if we re-use the *r* symbol for the radius of the disk, then *R* will be – roughly – equal to $\pi r^2$. The *a* is the ratio between the angular momentum (*J*) and the electron mass. Hence, the *a*/*R* ratio can be written as:

$$\frac{a}{R} = \frac{J}{\mathrm{m}} \frac{1}{\pi r^2}$$

We have not only the angular momentum here, but also the surface area here ($\pi r^2$) which co-determines the magnetic moment of the loop of current (I).[19] In short, all of the variables that could, potentially, explain the anomalous magnetic moment in terms of a form factor are there. Hence, the next logical step would be to validate this classical electron model by inserting it into some other model. Indeed, as Dirac noted, "the very-high frequency oscillatory motion of small amplitude superposed on the regular motion which appears to us", as a result of which "the velocity of the electron at any time equals the velocity of light" 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."[20]

However, we can, of course, *insert* this *Zitterbewegung* model – or, preferably, the more flexible model of Mr. Burinskii – into models that do *not* involve micro-motion at the speed of light. What models? Models involving the slow motion of an electron around a nucleus (atomic orbitals) or – in this particular case – the motion of an electron in a Penning trap.

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[19] The symbols in the table may be somewhat confusing: *I* (*italicized*) is a moment of inertia, but I (non-italicized) is a current. We did not want to use new symbols because the context of the formula makes clear what it what.

[20] Erwin Schrödinger had, effectively, already derived the *Zitterbewegung* as he was exploring solutions to Dirac's wave equation for free electrons. In 1933, he shared the Nobel Prize for Physics with Paul Dirac for "the discovery of new productive forms of atomic theory", and it is worth to now quote all of Dirac's summary of Schrödinger's discovery in his 1933 Nobel Prize speech: "The variables give rise to some rather unexpected phenomena concerning the motion of the electron. These have been fully worked out by Schrödinger. It is found that an electron which seems to us to be moving slowly, must actually have a very high frequency oscillatory motion of small amplitude superposed on the regular motion which appears to us. As a result of this oscillatory motion, the velocity of the electron at any time equals the velocity of light. This is a prediction which cannot be directly verified by experiment, since the frequency of the oscillatory motion is so high and its amplitude is so small. But one must believe in this consequence of the theory, since other consequences of the theory which are inseparably bound up with this one, such as the law of scattering of light by an electron, are confirmed by experiment."

## Theoretical implications

The reader may wonder: what's the use if there is already a satisfactory theory (perturbative theory)? The answer to this question is quite obvious. First, a classical theory would be simpler, and Occam's Razor Principle, therefore, tells us we should consider it. More generally, all physicists would agree the King of Science should respect Boltzmann's adage: "Bring forth the truth. Write it so it's clear. Defend it to your last breath." Indeed, even if the results would only remotely explain the anomaly, we would still have achieved two very significant scientific breakthroughs. First, it would show that these seemingly irrelevant micro-models can be validated externally. More importantly, it would prove that an alternative (classical) explanation of the anomalous magnetic moment would be possible.

One may, of course, wonder, further down the line, if an *augmented* classical explanation of QED would upset the theoretical approach in other sectors of the Standard Model. Indeed, as Aitchison and Hey write, the new quantum electrodynamical theory (QED) provided physicists with a model – they refer to it as the 'electron-figure' but what we are talking about are gauge theories, really[21] – to analyze the forces in the nucleus – i.e. the strong and weak force. We do not think so, because these forces are *non*-linear and are also quite different in their *nature* in other respects.

Using totally non-scientific language, we may say that mass comes in one 'color' only: it is just some scalar number. Hence, Einstein's geometric approach to it makes total sense. In contrast, the electromagnetic force is based on the idea of an electric charge, which can come in two 'colors' (+ or –), so to speak. Maxwell's equation seemed to cover it all until it was discovered the nature of Nature – sorry for the wordplay – might be discrete and probabilistic.[22] Now, the strong force comes in three colors, and the rules for mixing them, so to speak, are *very* particular. It is, therefore, only natural that its analysis requires a wholly different approach. In fact, who knows? Perhaps one day some alien will show us that the application of the 'electron-figure' to these sectors was actually *not* so useful. Don't get us wrong: we think these models are all very solid, but history has shown us that one can never exclude a scientific revolution!

We will send this paper to Mr. Burinskii. If he – or others – would take up this suggestion and show that it can be done, Mr. Burinskii should probably be considered for the next Nobel Prize. As for us – amateur physicists – we would be happy to document the story. 😊

Jean Louis Van Belle, 26 December 2018

## References

All references are given in the footnotes, which have become quite bulky as a result. We will probably reorganize the paper in its next version.

[21] Ian J.R. Aitchison and Anthony J.G. Hey, *Gauge Theories in Particle Physics*, 4th edition, Volume I, p. 3.

[22] In the above-mentioned paper, we note it helps a lot to think of Planck's quantum of action as a *vector* quantity: the uncertainty may then be related to its *direction*, rather than its magnitude. We also note the theoretical framework might benefit from using the ± sign in the argument of the wavefunction to associate the wavefunction with a *non-zero* spin particle. We argue that the weird 720-degree symmetries which discouraged research into geometric (or *physical*) interpretations of the wavefunction might then disappear. See: Jean Louis Van Belle, Euler's Wavefunction: The Double Life of –1, 30 October 2018, http://vixra.org/pdf/1810.0339v2.pdf.