A physical explanation for why the electron spin g-factor exceeds 2

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The paper explains physically why the electron has a spin g-factor of more than 2 and what the equivalent factors are for other fermions, pi mesons and photons. The conclusion of the proposed framework is that half of the factor is due to the rotation in a loop of the six adjusted-Planck mass and charge sized pre-fermions and the other half due to the sum of the one-sixth electron charges on each pre-fermion. The sum of these fractional charges defines the identity of the fermion loop. The suggested framework does not explain the size of the anomalous magnetic moment of the electron although it does propose a possible solution.

Keywords: Electron; Spin g-factor; Magnetic moment; Anomalous magnetic moment; Pre-fermion;

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I. INTRODUCTION

This paper follows on from previous work on the structure of fermions based on a pre-fermion framework [1][2] and uses the same definitions. Double-adjusted SI (DASI) units are used here throughout in order to simplify equations, except where specific sizes are quoted in SI units.

II. SIGNIFICANCE and OBJECTIVES

The significance is in explaining simply, in terms of the physical pre-fermion framework of loops, where the spin g-factor of a loop arises from, with the main example here being the electron loop.

Mathematically, the Dirac equation predicts g = 2 [3], QED predictions agrees with the experimentally measured value exceedingly well [4] and even a classical derivation agrees [5], although the latter suggests it is due to charge being relativistically invariant whereas mass is not.

The objective is to produce values for the magnetic moments of the fermions, pi mesons and photons using the framework of stacking of loops. These are compared with observed values.

III. OUTLINE

The underlying idea is that the motional energy of the pre-fermions, called meons, drives them around in a loop so that each meon, regardless of sign of mass-type twist energy M*j or resultant fractional charge Q*j, rotates around the loop at the same frequency by adjusting its velocity and radius of rotation, in order to be the same energy size, positive or negative.

The total energy of a loop is always zero when all energies are taken into account because for each mass-type energy there is an equal and opposite charge-type energy and both are always treated with identical equations.

IV. MASS ENERGY CONSIDERATIONS

The balancing of mass energies within loops, to maintain $\pm \boldsymbol{h}$ angular momentum for each meon regardless of sign of twist energy, is produced by balancing just the mass and twist energies themselves to have the same frequency as a rest-mass electron, when considering an electron loop.

The formulae for a meon pair, one third of an electron loop, with each meon having additional $-\boldsymbol{Q_*j}$ charge, where $\boldsymbol{j} = (\boldsymbol{\alpha}/2\pi)^{½}/6$ and $\boldsymbol{Q_*j} = \boldsymbol{q}_e/6$, and $+\boldsymbol{M_*j}$ twist energy gives the set of mass energy formulae for a pair that is in a frame of reference where the loop is stationary as

$$\boldsymbol{E_m} = +(+\boldsymbol{M_*}+\boldsymbol{M_*j})(\gamma_i-1)\boldsymbol{c}^2 = -(-\boldsymbol{M_*}+\boldsymbol{M_*j})(\gamma_o-1)\boldsymbol{c}^2$$
$$= (\gamma_e-1)\boldsymbol{M_*c}^2 = m_e\boldsymbol{c}^2$$

The $\boldsymbol{X_*}$ are DASI values for meon mass and charge. The γ are for the inner velocity $\mathbf{v_i}$, the outer velocity $\mathbf{v_o}$ and the 'central' velocity $\mathbf{v_e}$ which is what each meon would have if it did not have any twist energy. The positive energy of the positive meon $(+\boldsymbol{M_*}+\boldsymbol{M_*j})$ rotating at the inner radius and velocity is equal in size to the negative energy of the negative meon $(-\boldsymbol{M_*}+\boldsymbol{M_*j})$ rotating at the outer radius and velocity. Both must have the same rotational frequency $\mathbf{w_e}$, set by the mass of the electron.

Although strictly the formulae use γ , at the velocities of our normal set of loops these are very much smaller than $\boldsymbol{c}$ and the use of $(\gamma-1) \sim (1+ ½\,\boldsymbol{v}^2/\boldsymbol{c}^2 -1) = ½\,\boldsymbol{v}^2/\boldsymbol{c}^2$ can be used thus

$$\boldsymbol{E_m} = +½\,(+\boldsymbol{M_*}+\boldsymbol{M_*j})\,\mathbf{v_i}^2 = -½\,(-\boldsymbol{M_*}+\boldsymbol{M_*j})\,\mathbf{v_o}^2$$
$$= ½\,\boldsymbol{M_*}\mathbf{v_e}^2 = m_e\boldsymbol{c}^2$$

This set of mass formulae is the same for all pairs, adjusted for sign of $\boldsymbol{M_{*}j}$ twist energy and $\boldsymbol{Q_{*}j}$ charge. So all meons rotate at $\mathbf{v_i}$ or $\mathbf{v_o}$ velocities relative to their central velocity $\mathbf{v_e}$, appropriate for the frequency of the loop. What sets the actual radii at which the meons rotate is the frequency of the loop, and so its mass.

From the formulae, simplifying the results, can be found

$$\mathbf{v_i}^2 = \mathbf{v_e}^2 /(1+\boldsymbol{j}) \quad \text{and} \quad \mathbf{v_o}^2 = \mathbf{v_e}^2/(1-\boldsymbol{j})$$

This mass set formulae show that the velocity changes are not exactly equal inwards versus outwards.

The actual changes depend on the loop frequencies. For the electron at rest with mass 9.10938 $\times10^{-31}$ kg [6], frequency 2.47112 $\times10^{20}$ Hz , it can be shown that the velocity changes are +5.76635 $\times10^{-12}$ ms^{-1} outwards and -5.71744 $\times10^{-12}$ m s^{-1} inwards, leading to radius changes of +2.33349$\times10^{-32}$ m outwards and -2.31370 $\times10^{-32}$ m inwards relative to central velocity and rotational radius of 1.73246 $\times10^{-3}$ ms^{-1} and 7.01064 $\times10^{-24}$ m respectively. However, since they are very close to being equal, it will usually be simpler to use the same size change, equal to ± ½ $\boldsymbol{j}\, v_e$,or ± ½ $\boldsymbol{j}\, r_e$, since the outer is 0.50214 $\boldsymbol{j}$, when related to the central velocity $\mathbf{v_e}$ or radius $\boldsymbol{r_e}$, and the inner 0.49788 $\boldsymbol{j}$. The same ratios will apply to all sized loops.

V. CHARGE ENERGY CONSIDERATIONS

The radii at which each meon is mass-angular momentum balanced means, in the case of the electron, that the larger size mass ($+\boldsymbol{M_*}+\boldsymbol{M_*j}$) positive meon will rotate at a smaller radius than the negative meon with its smaller size mass ($-\boldsymbol{M_*}+\boldsymbol{M_*j}$). The result is that the larger size negative charge ($-\boldsymbol{Q_*}-\boldsymbol{Q_*j}$) of the negative meon rotates further out than the smaller positive charge ($+\boldsymbol{Q_*}-\boldsymbol{Q_*j}$) of the positive meon. The net effect is overall negative charge energy. The total charge energy thus generated by the pair in an electron will be

$$\boldsymbol{E_Q} = Q_p\, \boldsymbol{c}^3 = +(-\boldsymbol{Q_*}-\boldsymbol{Q_*j})\, \gamma_o \boldsymbol{c}^3 + (+\boldsymbol{Q_*}-\boldsymbol{Q_*j})\, \gamma_i \boldsymbol{c}^3$$

Or, in simplified form

$$\boldsymbol{E_Q} = +\tfrac{1}{2}(-\boldsymbol{Q_*}-\boldsymbol{Q_*j})\, \boldsymbol{c}\, \mathbf{v_o}^2 + \tfrac{1}{2}(+\boldsymbol{Q_*}-\boldsymbol{Q_*j})\, \boldsymbol{c}\, \mathbf{v_i}^2$$

$$= -\tfrac{1}{2}\, \boldsymbol{Q_*c}\, [(1+\boldsymbol{j})\, \mathbf{v_o}^2 - (1-\boldsymbol{j})\, \mathbf{v_i}^2]$$

Which can be adjusted using the mass set of formulae relating $\mathbf{v_i}$ and $\mathbf{v_o}$ to $\mathbf{v_e}$ as

$$\boldsymbol{E_Q} = -\tfrac{1}{2}\, \boldsymbol{Q_*c}\, \mathbf{v_e}^2\, [(1+\boldsymbol{j})/(1-\boldsymbol{j}) - (1-\boldsymbol{j})/(1+\boldsymbol{j})]$$

$$= -\tfrac{1}{2}\, \boldsymbol{Q_*c}\, \mathbf{v_e}^2\, (4\boldsymbol{j}/(1-\boldsymbol{j}^2))$$

So for a loop of three identical pairs, and using $v_e = r_e\, w_e$, this energy will be

$$\boldsymbol{E_{Q3}} = Q_t\, \boldsymbol{c}^3 = -\tfrac{1}{2}\, \boldsymbol{Q_*c}\, \mathbf{v_e}\, \mathbf{r_e}\, \mathbf{w_e}\, (12\boldsymbol{j}/(1-\boldsymbol{j}^2))$$

$$= -6\, \boldsymbol{Q_*j}\, \boldsymbol{c}\, (\boldsymbol{M_*}\mathbf{v_e}\, \mathbf{r_e})\, \mathbf{w_e}/(\boldsymbol{M_*}(1-\boldsymbol{j}^2))$$

$$= -\boldsymbol{q}_e\, \boldsymbol{c}\, \boldsymbol{h}\, \mathbf{w_e}/(\boldsymbol{M_*}(1-\boldsymbol{\alpha}/(72\,\pi)))$$

So, using $\boldsymbol{M_*c}^2 = \boldsymbol{h}\, \boldsymbol{w_*}$, the effective charge Q_t in the loop will be

$$Q_t = -\, \boldsymbol{q}_e\, \mathbf{w_e}/(\boldsymbol{w_*}\,(1-\boldsymbol{\alpha}/(72\,\pi)))$$

$$= -\, \boldsymbol{q}_e\, (\mathbf{w_e}/\boldsymbol{w_*})/\, (1-\boldsymbol{\alpha}/(72\,\pi))$$

VI. MAGNETIC MOMENT OF CIRCULATING MEONS

To turn the charge energy for an electron into a magnetic moment, due to the rotation of the meons around the loop, excluding any contribution due to the moving of the electric fields between opposing meons, uses $\mu_t = \tfrac{1}{2}\, Q_t\, \boldsymbol{h}/m_e$ to give

$$\mu_t = -\tfrac{1}{2}\, \boldsymbol{q}_e\, (\mathbf{w_e}/\boldsymbol{w_*})\, \boldsymbol{h}/(m_e\, (1-\boldsymbol{\alpha}/(72\,\pi)))$$

And since $m_e\boldsymbol{c}^2 = \tfrac{1}{2}\, \boldsymbol{h}\, \mathbf{w_e}$ and the standard definition of the electron magnetic moment is $\mu_e = \tfrac{1}{2}\, \boldsymbol{q}_e\, \boldsymbol{h}/m_e$

$$\mu_t = (-\tfrac{1}{2}\, \boldsymbol{q}_e\, \boldsymbol{h}/m_e)\, (\mathbf{w_e}/\boldsymbol{w_*})/\, (1-\boldsymbol{\alpha}/(72\,\pi))$$

$$= \mu_e\, (\mathbf{w_e}/\boldsymbol{w_*})/\, (1-\boldsymbol{\alpha}/(72\,\pi))$$

which appears much smaller than could provide any measurable anomalous moment to the electron loop. The issue is that the mass of the electron loop m_e is used here as the basis for its magnetic moment, whereas each meon has a mass of $\boldsymbol{M_*}(\boldsymbol{1} \pm \boldsymbol{j})$. So it is the definition of the magnetic moment using the loop size which confuses here.

To arrive at the correct total magnetic moment requires using the meon masses, but as their frequency equivalent $\boldsymbol{w_*}$ to replace the loop frequency $\boldsymbol{w_e}$. The result is

$$\mu_t = \mu_e /(1-\boldsymbol{\alpha}/(72\,\pi))$$

$$= \mu_e\, 1.000032262$$

This is still not close to the observed value of the anomalous magnetic moment factor 1.00115965211[7], but is better than the charge energy calculation.

THE g-FACTOR

To avoid the loop mass issue and arrive at the g-factor requires looking instead at angular momentum equations which do not require the explicit assumption of the mass of the loop.

For each meon in the loop, its mass angular moment is described as

$$\boldsymbol{h} = \boldsymbol{M_*}\mathbf{v_e r_e} = \boldsymbol{M_*}(1+\boldsymbol{j})\,\mathbf{v_i r_i} = -\boldsymbol{M_*}(-1+\boldsymbol{j})\,\mathbf{v_o r_o}$$

and so the charge angular momentum of a ‘plain’ meon, a positive meon and a negative meon respectively can be described as

$$\boldsymbol{\mu_p} = \boldsymbol{Q_*}\mathbf{v_e r_e}$$

$$\boldsymbol{\mu_+} = \boldsymbol{Q_*}(1-\boldsymbol{j})\,\mathbf{v_i r_i}$$

$$\boldsymbol{\mu_-} = \boldsymbol{Q_*}(-1-\boldsymbol{j})\,\mathbf{v_o r_o}$$

Now substituting a slightly different description for the velocities and radii as

$\boldsymbol{v_i} = \boldsymbol{v_e}\,(1-\boldsymbol{s_i})$ and $\boldsymbol{v_o} = \boldsymbol{v_e}\,(1+\boldsymbol{s_o})$

$\boldsymbol{r_i} = \boldsymbol{r_e}\,(1-\boldsymbol{d_i})$ and $\boldsymbol{r_o} = \boldsymbol{r_e}\,(1+\boldsymbol{d_o})$

it is the case through $\boldsymbol{v_e}\,\boldsymbol{r_e} = \boldsymbol{w_e}$ that $\boldsymbol{s_i} = \boldsymbol{d_i}$ and $\boldsymbol{s_o} = \boldsymbol{d_o}$, so that

$$\boldsymbol{\mu_+} = \boldsymbol{Q_*}\,\mathbf{v_e r_e}\,(1-\boldsymbol{j})\,(1-\boldsymbol{d_i})^2$$

$$\boldsymbol{\mu_-} = \boldsymbol{Q_*}\,\mathbf{v_e r_e}\,(-1-\boldsymbol{j})\,(1+\boldsymbol{d_o})^2$$

These are magnetic moments of the meons, which can be divided by the plain no $\boldsymbol{j}$ factor meon magnetic moment $\boldsymbol{Q_*}\,\mathbf{v_e r_e}$ to produce their relative magnetic moments (RMMs) thus

$$\boldsymbol{\mu_{+r}} = (1-\boldsymbol{j})\,(1-\boldsymbol{d_i})^2$$

$$\boldsymbol{\mu_{-r}} = (-1-\boldsymbol{j})\,(1+\boldsymbol{d_o})^2$$

These can then be summed over the number and identity of the meons in a loop to arrive at its total RMM.

Using the values for the radius changes $\boldsymbol{d_o} = 0.50214\,\boldsymbol{jr_e}$ and $\boldsymbol{d_i} = 0.49788\boldsymbol{jr_e}$, there are only two sizes and four values of these RMMs based on the four possible meon combinations of types and charges

A	$(+1 - j)(1-\boldsymbol{d_i})^2$	$\boldsymbol{\mu_A} = +0.988704336$
B	$(-1 - j)(1+\boldsymbol{d_o})^2$	$\boldsymbol{\mu_B} = -1.011424712$
C	$(-1 + j)(1-\boldsymbol{d_i})^2$	$\boldsymbol{\mu_C} = -0.988704336$
D	$(+1 + j)(1+\boldsymbol{d_o})^2$	$\boldsymbol{\mu_D} = +1.011424712$

All isolated loops have total RMMs which are composed of sums of only these four values. These RMMs are based on the centre of the loop so are in the frame of reference of the stationary loop.

VII. LOOP ISOMERS

When calculating the total RMMs for any loop, the relative positioning of each meon and its related $\boldsymbol{j}$ charge need to be considered. There will thus be isomers of some fermion loops, but remarkably all the isomers have the same total RMM for that loop identity.

Although the listing of the contributions of A, B, C and D below have some mixes that appear more than once, that is due to the consideration of whether the starting point is on either a positive or negative meon and their relative positions within the loop, so they are actually different isomers. This is of greater concern when considering the symmetry or asymmetry of loops for balance when stacking, although not pursued here.

There are no isomers for the electron loop, which is always (3A + 3B) meons. Total RMM of -0.068161123 or, in terms of electron size $\boldsymbol{q}$, -2.00006452|q|.

For the up quark, there are two isomers, (1A +3C + 2D) and (1B + 2C + 3D). Total RMM of +0.045440749 or, in terms of electron size $\boldsymbol{q}$, +1.33337635|q|.

For the down quark, there are four isomers, (2A + 2B + 1C +1D) (3A +1B + 2C) (1A + 3B + 2D) and (2A + 2B + 1C + 1D). Total RMM of -0.022720374 or, in terms of electron size $\boldsymbol{q}$, -0.666688175|q|.

For the neutrino, there are eight isomers, (1A + 2B + 1C + 2D) (2A + 1B +2C + 1D) (1A + 2B + 1C + 2D) (2A + 1B + 2C + 1D) (2A + 1B + 2C + 1D) (1A + 2B + 1C + 2D) (3b + 3D) and (3A + 3C). All have total RMM of zero.

For the anti-loops, all the above values and contributions are mirrored symmetrically.

FROM WHERE IS THE g-FACTOR DERIVED?

As can be seen from the value of the electron RMM, it has a value of just over 2|q|. This is due to the contributions of the $\pm\boldsymbol{Q_*}$ meon charges as well as the $-\boldsymbol{j}$ charges. Given that the total of the six rotating $-\boldsymbol{j}$ charges will contribute at least -1|q|, then the remainder must be due to the main meon $\pm\boldsymbol{Q_*}$ charges rotating at different radii.

The actual calculation here of the electron RMM at -2.00006452|q| does not explain the total of the anomalous magnetic moment. It is possible that the additional anomalous moment may be due to the three rotating electric fields acting across each loop from positive to negative meons, but this calculation is beyond the scope of this paper.

VIII. NUCLEONS AS STACKS

The core of nucleons consists of fermion stacks. Mainly these are the quarks but include charged leptons and possibly asymmetric neutrinos. This is possible because it is the meons themselves which are in the stack even though the structure they are in is a loop whose size would theoretically preclude them being within the nucleus.

The core of a proton stack, with arrows representing relative rotational direction and opposite rotation causing a reversal in magnetic moment, corresponding to reverse spin orientations, will be

Up quark	>>>>	+0.045440749
Down quark	<<<<	+0.022720374
Up quark	>>>>	+0.045440749
Asymmetric neutrino	<<<<	0
Asymmetric neutrino	>>>>	0

P^+	RMM Total	+0.113601872
Spin ½		+3.333480874|q|

This result may not be the same as the observed value of +2.79285 $\boldsymbol{\mu_N}$[8], but it has been made without reference to the size of the loops, which are their masses, or to the total mass of the stack of loops, which is the proton mass.

The electron, being a loop able to exist isolated on its own, is observed with its RMM in its own state. In contrast, the quark stack needs to have the loop radii all the same size, in order to maintain stability through three-fold asymmetric balancing, and so the quarks have to adjust to match each other, implying that their RMMs will also be adjusted when stacked.

The core of a neutron stack will have an extra higher energy electron, but also requires that one of the up quarks, and the down quark, has opposite rotation orientation from the proton stack. Thus

Up quark	>>>>	+0.045440749
Up quark	<<<<	-0.045440749
Down quark	>>>>	-0.022720374
Asymmetric neutrino	<<<<	0
Energetic electron	>>>>	-0.068161123

N^0	RMM Total	-0.090881497
Spin ½		-2.666752700|q|

Once more this result is not the same as the observed value of the neutron magnetic moment at −1.91304273 $\boldsymbol{\mu_N}$ [9], but it is in the right direction and approximate size. Given the loop size changes needed to adjust from the observed mass of the neutron to that of the proton when the neutron decays, it is to be expected that there are factors beyond this simple exposition.

IX. PIONS

As an example of quark/anti-quark pairings, pions can have their possible magnetic moments calculated in the same manner as above.

The neutral pion, being a pair of either up/anti-up or down/anti-down quarks will have a magnetic moment. Although it has total spin of zero, the loops are each rotating in opposite sense so their magnetic moments add.

Up quark	>>>>	+0.045440749
Anti up quark	<<<<	+0.045440749

Π^o(u)	RMM Total	+0.090881498
Spin 0		+2.666752700|q|

A charged pion will have the same zero spin but since the two loops are of opposite sign, will have their individual magnetic moments summed. Thus

Up quark	>>>>	+0.045440749
Anti down quark	<<<<	-0.022720374

Π^+	RMM Total	+0.022720374
Spin 0		+0.666688175|q|

X. PHOTONS

Whilst neutral pions have quark and anti-quark contra-rotating, in contrast photons have their loops rotating in the same sense, producing total spin 1.

The two loops in the photon stack could be quark or lepton loop and anti-loop so that the magnetic moments will always be zero in total, for example

Positron	>>>>	+0.068161123
Electron	>>>>	-0.068161123

γ	RMM Total	0
Spin 1		0

XI. CONCLUSION

Whilst the intention here is not to overturn QED calculations, the paper shows how the physical form of pre-fermion loops in which all meons have $\pm\boldsymbol{h}$ angular momentum leads to a g-factor for the electron exceeding 2. This alternate interpretation may lead to a deeper understanding of the structure of matter.

XII. REFERENCES

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