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Article

# On the Existence of Neutrinos

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**Abstract:** We change the symmetry of the Weak Force from  $SU(2)$  to the quaternion group  $Q_8$ , and discuss the solution of the Dirac equation under this group. We find that spin spacetime separates into two complementary spaces: a spin polarization spacetime of even parity states, and a spin coherence space, in the  $S^3$  hypersphere, of odd parity coherent states. The former gives a 2D Dirac equation, that is a disc of polarization, and the latter gives a unit quaternion that spins the disc. Under the quaternion group, spin is a boson of spin 1 in free flight and a fermion of spin  $\frac{1}{2}$  when measured. Immediately we find that a beta electron is a boson and this obviates the need for neutrinos.

**Keywords:** neutrinos; beta decay; dirac equation; Spin; quantum theory; helicity; foundations of physics; Spin

## Introduction

The successes of the Standard Model are marred by problems with the Weak Force primarily with parity violation, and the role and properties of neutrinos, [1], [2], [3]. We suggest this questions the validity of the underlying symmetry,  $SU(2)$ , from which the Weak Force properties follow, and we propose a change to the quaternion group,  $Q_8$ .

There are many consequences, [4], from this change, and here we show neutrinos are no longer needed to conserve energy and balance spin angular momentum in beta decay. The reason is that Q-spin is a boson in free-flight, and a fermion when measured. The quaternion group brings out the details of the wave-particle duality of spin.

To understand this change, it is first necessary to describe Q-spin. For that, one must imagine spin, not as a point particle, but as oriented in a plane, which is formed from two orthogonal spin axes, we use  $e_1$  and  $e_3$ . Technically, the symmetry change is simply accomplished by multiplying one of the gamma matrices by the imaginary number.

The geometric product of two components of the Pauli spin operator includes a bivector,  $\sigma_i\sigma_j = \delta_{ij} + \varepsilon_{ijk}i\sigma_k$ . The first term is a totally symmetric contribution giving the polarization, and the second term is totally anti-symmetric giving the coherence. Spin is universally measured and accepted as a point particle of intrinsic angular momentum: a polarized property with two states of up and down from the vector operator,  $\sigma$ . There is no bivector,  $i\sigma$ , in this definition, nor in the Dirac equation. Including the bivector leads to the formulation of quaternion spin, or Q-spin, [5] [6], [7], and a formal formulation of helicity. The details of much of the following description of Q-spin can be found in these papers.

One consequence of changing symmetry by adding the bivector, is the introduction of helicity as an element of reality of spin, and clarifies its role. Spin polarization and helicity are complementary properties of spin, analogous to position and momentum. Spin polarization is defined in a 2D spacetime with two spatial components, while helicity is defined in the complementary space of quaternions, which spins the axis of linear momentum either L or R.

This changes the point particle description of spin, to a 2D spinning disc of angular momentum. The disc of angular momentum is a result of two orthogonal fermionic axis of spin on the same particle, (not two spins being a matter-antimatter pair), each with magnetic moment of  $\mu$ . In free-flight, the two axes are indistinguishable, and they couple to give a composite boson of spin 1, center upper figure of Figure (1). Upon encountering a polarizing filter, the boson decouples into a fermion. Environment

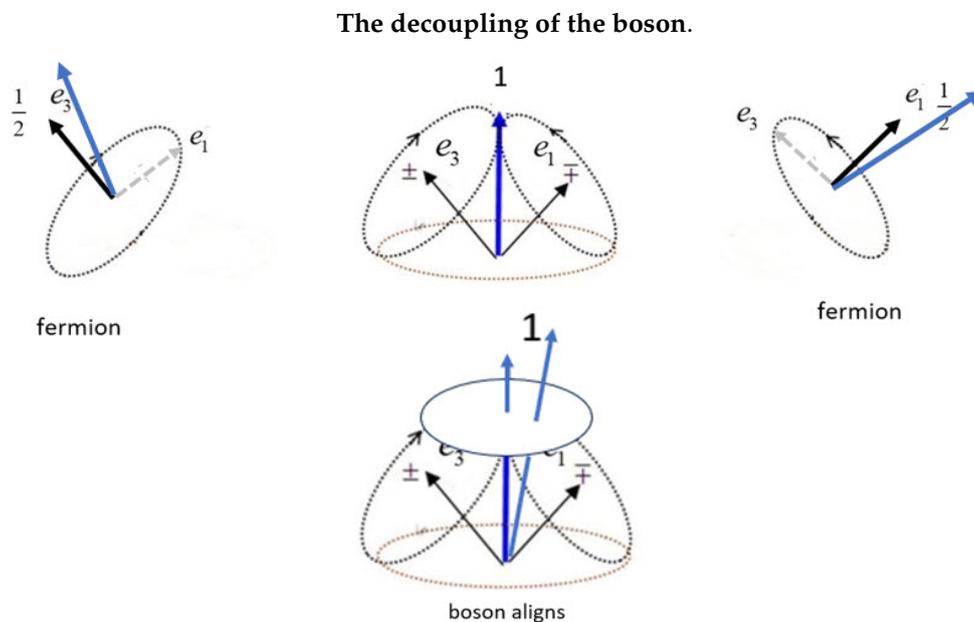
determines the spin. When in a polarizing field, an electron has the usual Dirac spin of up and down,  $e_F^-$ , while in free-flight, it is a boson,  $e_B^-$

$$e_F^- (\text{anisotropy}) \leftrightarrow e_B^- (\text{isotropy}) \quad (1)$$

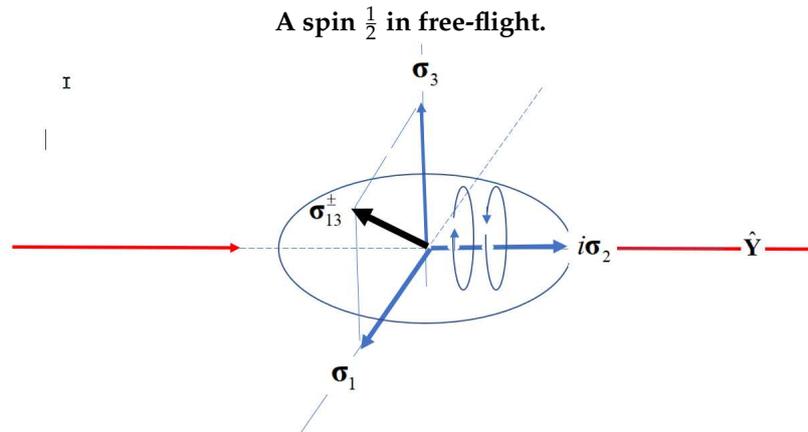
Figure (1). shows two ways the boson decouples. If the filter axis lies close to one of the fermionic axes, that axis will decouple and align. This is the least action principle. It is shown by the two figures on the left and right, depicting the transition from a boson to a fermion. However, if the filter lies close to the coupled boson, say within 22.5 degrees on either side of the boson, center lower of Figure(1), then the boson does not initially decouple, but persists as a spin 1 and precesses with Larmor frequency double that of the fermions, with magnetic moment of  $2\mu$ .

It is compelling that the structure of quaternion, or Q-spin, Figure (2) is geometrically identical to a photon in free-flight. That is, the photon's two axes, which are orthogonal to the direction of linear momentum, are the magnetic and electric components. Q-spin carries two magnetic components that are also orthogonal to the direction of motion.

To justify these changes, note first that the usual point particle spin is a Pauli vector,  $\sigma$ , and its components are in Minkowski spacetime,  $(I, \sigma_X, \sigma_Y, \sigma_Z)$ . These form the SU(2) group, and follows from the Dirac equation, [8] which is represented in the Dirac field by the gamma matrices,  $(\gamma^0, \gamma^1, \gamma^2, \gamma^3)$ . However, this is a four dimensional field and contains two particles, one with spin  $\frac{1}{2}$  and, as Dirac interpreted it, the second spin  $\frac{1}{2}$  is the antimatter twin of the first. The main problem with this, is the energies from solving the Dirac equation are equal and opposite,  $E = \pm\sqrt{m^2 + p_X^2 + p_Y^2 + p_Z^2}$ . The negative energy solutions caused Dirac problems which he resolved by creating a fermionic continuum of negative energy and filled it with electrons, leading to the sea of electron model and hole theory. This is, however, not easy to accept and is more of a rationalization than based upon sound theory. Q-spin offers an alternate explanation.



**Figure 1.** center upper, the two polarization axes form Q-spin of magnitude 1 from the coupling of two mirror states in free flight. Left and right fermions: When a filter axis is closer to one of the axes,  $e_1$  or  $e_3$  then that axis decouples into a fermion and the other precesses orthogonal to the aligned spin and averages away. Center figure, lower: when the filter is placed so it is within 22.5 degrees on either side of the boson vector, then the boson does not initially decouple, but precesses as a spin 1 with Larmor frequency which is double that of the fermions.



**Figure 2.** Two properties of Q-spin in free-flight: its polarization axes,  $\sigma_3$  and  $\sigma_1$ , are perpendicular to its axis of linear momentum  $e_2 = Y$ . These two fermionic axes couple to give a composite boson of spin 1. The helicity is in the direction of propagation and averages out the polarizations. Q-spin is geometrically identical to a photon in free-flight.

Under the quaternion group, the matter-antimatter interpretation is replaced by one particle with two axes, rather than two particles each with one axis. To see this, we create the symmetry change by multiplying one of the gamma matrices by the imaginary number. This changes the Dirac field to  $(\gamma_s^0, \gamma_s^1, i\gamma_s^2, \gamma_s^3)$ . We include the subscript  $s$  because now the spin has structure and can be oriented in any direction, so the spacetime coordinates of Minkowski spacetime,  $(\beta, X, Y, Z)$ , are different from the body fixed coordinates of the spin spacetime, denoted by  $(\beta_s, e_1, e_2, e_3)$ . We choose the direction of linear momentum to be  $Y = e_2$  so the plane formed from the two fermionic axes,  $e_1$  and  $e_3$ , is coplanar to the  $X, Z$  plane where the filter is oriented. We can express each axis by coordinates,  $(\sigma_s^1, \tilde{\sigma}_s^2)$  and  $(\sigma_s^3, \tilde{\sigma}_s^2)$ , and define the Hermitian gamma matrix by,

$$\tilde{\gamma}_s^2 \equiv i\gamma_s^2 = \begin{pmatrix} 0 & i\sigma_s^2 \\ -i\sigma_s^2 & 0 \end{pmatrix} = \begin{pmatrix} 0 & \tilde{\sigma}_s^2 \\ -\tilde{\sigma}_s^2 & 0 \end{pmatrix} \quad (2)$$

The consequences of this change are depicted in the upper center figure in Figure (1). We assert the coupling and forming of this resonance spin of 1 lowers the energy of the structure and stabilizes it. Notice in Figure (1), center upper, that the two axes have opposite spin, and they are precessing with equal and opposite energy and in phase: they are mirror states. From the solution to the Q-spin Dirac equation the energy is given by  $E = \pm\sqrt{m^2 + p_1^2 + p_3^2}$  where the  $p_1$  and  $p_3$  are energies from the two axes and express internal energy of Q-spin in free flight. Since the two axes are precessing oppositely, they therefore balance each other. Q-spin resolves the negative energy problem that Dirac encountered.

In free flight, in summary, Q-spin is one particle in the four dimensional Q-spin field of  $(\gamma_s^0, \gamma_s^1, \pm\tilde{\gamma}_s^2, \gamma_s^3)$  which describes the coupling of two fermionic axes to give a boson, which is spun by the quaternion giving L or R helicity. Notice that in free flight, the axis,  $Y$  which is the direction of linear momentum, is spinning, and this averages the polarization axis to zero. In free flight, only helicity is present, and the polarization is zero from our frame of reference. This is the wave nature of a spin.

The decoupling of the boson is governed by two properties: first the spin-spin coupling strength relative to the applied field strength; and second the orientation of the filter relative to the spin orientation.

Before the boson spin decouples, the spin-spin coupling is stronger than the filter strength. Eventually, however, the boson must decouple as it approaches closer to the filter, and it then breaks up into a fermion. We assert the fermionic axis closer to the filter will align: in the case shown in Figure

(1), center lower, the  $e_1$  axis eventually aligns. It is important to know which axis aligns since they have opposite spin polarization.

Another change from the two state Dirac spin is when spin is in free-flight and when measured, it is always perpendicular to the axis of linear momentum, analogous to the photon magnetic component. This is seen from Figure (1). In contrast, fermion spin is usually defined as parallel to the axis of linear momentum. Q-spin distinguish between spin and helicity. In particle physics, helicity is the projection of spin along the axis of linear momentum, whereas for Q-spin this measure is always zero. Two experiments are needed: one to measure the spin polarization, like a Stern-Gerlach filter; a complementary experiment that measures the circular coherence of electrons. The four states of Q-spin are: L or R spinning of the  $e_2$  axis, which is helicity; and spin states of up or down, which is spin polarization: helicity and polarization are complementary properties.

#### The Dirac Equation under the Quaternion Group

Most of what is described above for Q-spin follows from the Dirac equation but with the change in symmetry using Eq.(2). This gives a non-Hermitian Dirac equation,

$$\left( i\gamma_s^0\partial_0 - i\gamma_s^1\partial_1 \pm i\tilde{\gamma}_s^2\partial_2 - i\gamma_s^3\partial_3 - m \right) \psi^\pm = 0 \quad (3)$$

and we suppress the subscript  $s$  on the derivatives. We call this the quaternion Dirac or Q-Dirac equation. The anti-commutation of the  $\gamma_s^\mu$  matrices ensures that energy and mass are conserved and the Klein-Gordon equation is recovered, [9]. Note that the symmetry change also changes the signature of the Dirac field with diagonal elements in Minkowski spacetime of  $\eta^{\mu\nu} = (1, -1, -1, -1)$  to  $\tilde{\eta}_s^{\mu\nu} = (1, -1, +1, -1)$  in spin spacetime.

The term  $\tilde{\gamma}_s^2$  is not a spatial component, but rather a time being the frequency. This dimension is the origin of quantum coherence that leads to the formulation of helicity. Helicity is the complementary element of reality to spin polarization, and the two have complementary spaces: polarization spacetime and a coherence space.

In free-flight, as mentioned above, a spin is in an isotropic environment, rendering the two axes (1,3) indistinguishable. Therefore, permutation with the parity operator,  $P_{13}$  does not change the (1,3) spatial dependence in Eq.(3), but the bivector,  $i\sigma_2 = \sigma_3\sigma_1$  is anti-symmetric to 13 permutation. Therefore the above equation admits two solutions in left and right handed coordinate frames, which are mirror states, Figure (3),

$$P_{13}\psi^\pm = \psi^\mp \quad (4)$$

Figure (3) shows the mirror images of  $\psi^\pm$  with  $\psi^+$  in a right handed frame and  $\psi^-$  in a left handed frame. Note that summing the two states cancels the bivector and subtracting them cancels the (1,3) polarizations, leading to separate states that are odd and even with respect to parity,

$$P_{13}\Psi^\pm = \pm\Psi^\pm = \pm\frac{1}{\sqrt{2}}(\psi^+ \pm \psi^-) \quad (5)$$

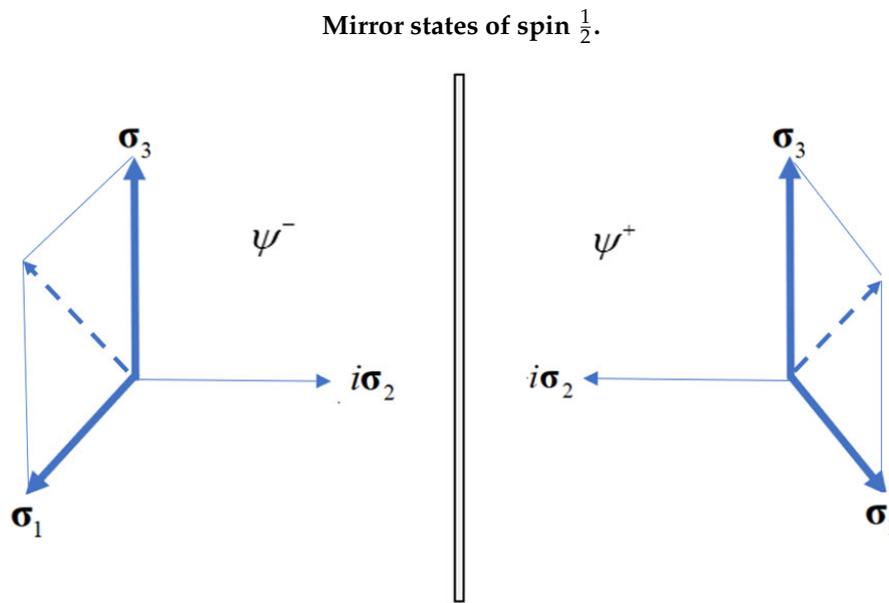
This separates the Dirac equation into two distinct equations which describe complementary attributes of Q-spin: the first is a 2D Dirac equation in the (1,3) plane, and the second is the Weyl equation for a massless spinor,

$$\left( i\gamma_s^0\partial_0 + i\gamma_s^1\partial_1 + i\gamma_s^3\partial_3 - m \right) \Psi^+ = 0 \quad (6)$$

$$\tilde{\gamma}_s^2\partial_2\Psi^- = 0 \quad (7)$$

Concomitantly the quaternion spin spacetime separates into two distinct complementary spaces: polarization spacetime, (0,1,3), for Eq.(6); and coherent space (not spacetime) (2), for Eq.(7). The

Hermitian part, Eq.(6), is the same as the usual Dirac equation, but in two dimensions rather than three.



**Figure 3.** The mirror states of a Q-spin with  $\psi^+$  on the left and  $\psi^-$  on the right. Note that adding these states is independent of  $e_2$  and subtracting them is independent of  $e_1$  and  $e_3$ . Since we are blind to the imaginary axis, it is impossible to know which is the real object, or its reflection.

Without giving details, the solution to the Weyl equation is a unit quaternion. This is an element of reality but in the  $S^3$  hypersphere of quaternions which we are unable to observe. The only role of the quaternion is to spin the axis of linear momentum, thereby generating the helicity of L and R.

The 2D Dirac equation, Eq.(6), gives an even parity spin which is the sum of its two mirror states as seen in Figure (3). This formulation shows the two spin  $\frac{1}{2}$  axes coupled to form a spin 1 boson from the resonance, and in phase, precession of the two fermionic axes in Figure (1). When encountering a polarizing field, space becomes anisotropic and the mirror states uncouple to give one axis in Figure (1), left and right fermion figures, aligning with the field and the other averaging away.

In a polarizing field the boson undergoes a transition to a fermion, [7]. This is the particle nature of spin.

We conclude Q-spin epitomizes the wave-particle duality, being a boson in free flight and a fermion when measured. From the fact that Q-spin is a spinning disc, identifies it as an anyon [10] which can display both boson and fermion properties. This only works for a 2D system. Point particles or 3D structures do not act as anyons.

#### Beta decay

Beta decay, [1], can be expressed as a neutron in a nucleus decaying into a proton by emitting a beta particle, a fermion electron and an anti-neutrino,

$${}^1_0n \rightarrow {}^1_1p + e^- + {}^0_1\bar{\nu} \rightarrow \frac{1}{2} + \frac{1}{2} + \frac{1}{2} \quad (8)$$

The reason that Pauli, [11] with Fermi, [12] hypothesized neutrinos was because energy and angular momentum are not conserved by fermion electrons alone. The neutrino was therefore hypothesized to be a fermion, with neither mass nor charge with the fermion parallel to the axis of linear momentum.

This immediately reveals that neutrinos have no mirror image and violate parity. They carry no magnetic moment. A neutrino without a spin appears to be identical to the helicity property of Q-spin.

Moreover, neutrinos have an exceedingly small collision cross section, so neutrinos are not significantly removed by reactions. That is, once produced, neutrinos are basically of no use, yet they are postulated to keep on being produced at enormous rates. All particles have a purpose. For neutrinos, once they have balanced energy and spin in beta decay, they have no further use and simply fill up the Universe ad infinitum.

Boson beta electrons,  $e_B^-$ , in contrast, have a spin of 1 and internal structure. The latter should account for the energy distribution, and therefore not violate the conservation of energy. The spin 1 boson balances the spin without a neutrino,

$${}^1_0n \rightarrow {}^1_1p + e_B^- \frac{1}{2} \rightarrow \frac{1}{2} + 1 \quad (9)$$

If we had a neutrino without its fermion property, then all it can do is spin nothing. Moreover with almost no detection; strange parity properties; their uselessness after production; and now the boson obviating the need for a fermion anti-neutrino, we assert that neutrinos do not exist.

One detector is the water-filled Super-Kamiokande, [14] with 50,000 tons of water and 11,000 photo-multiplier tubes one km underground at a cost in 1996 of US\$600 million. Hardly any neutrino events were detected. None were direct detection of neutrinos, but were identified by their collision products based upon the usual Standard Model, with the Weak Force of SU(2) symmetry. We suggest that these are not the products of neutrino collisions. Nonetheless, over a flux of neutrinos of about  $10^{57}$  only 19 such events were detected that were attributed to neutrinos. A larger detector was built deep within the ice of the Antarctic, [15] with similar results to the Kamiokande.

We assert this puts into doubt the existence of neutrinos. Rather we suggest that neutrinos are mistaken for the complementary property of spin, it's helicity.

To determine if this description of Q-spin can replace neutrinos, the Standard Model needs to be investigated by using the quaternion group

$$SU(3)Q_8U(1) \quad (10)$$

Finally, following Noether's Theorem [13], there can be no objection in changing the symmetry to the quaternion group. The test is whether the change leads to nonsense or to sense. We believe it leads to the latter and resolves many problems in the Foundations of Physics.

#### Note

Please see the pedagogical video, [Yes, there are no neutrinos](#)

<https://youtu.be/8mGuPqGey4s?si=CLLxStcEKhSxAz4R>

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