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The Electron and Quarks:
A "Double Solution" for 1/2 Spin Particles

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Abstract

There are a number of electron and quark models to choose from. All have their strength and weakness which restrict them. So the search for a better models goes on. Research into educational models for undergraduates and below, that were not dependent on a specific electron models, pointed out some possible ways to improve current models. It remains simple enough to serve its goal as part of an educational model while being robust enough to be used as a tool for research. It is a "double solution" for 1/2 spin particles resulting from a close examination of standing waves in several dimensions. The result is a model for 1/2 spin particles that more accurately represents the wave/particle duality.

Spherical Standing Waves

Standing waves as a model for particles has proved very useful for physics. The concept of a standing wave is also an intuitive way to grasp the concept of the wave/particle duality. It moves between and extended wave form and a point particle form. In so doing it resolves the problems of the particle modeled solely as a shell or a point.

Students are taught the model of a standing wave on a string where two liner opposing waves create the standing wave. That concept can be misleading for a spherical standing wave which can be viewed as a single wave over time instead of two opposing waves. This is interesting for those wanting an introduction to string theory, a close look at how standing waves on strings and in 3-dimensions relate when modeled.

Now the wave equation remains unchanged under rotation of the spatial coordinates. Therefore there are solutions that only depend on the radial distance from a point. This can be done for a 3-dimensional spherical wave. However it must meet the requirement that the positive and negative amplitudes cancel out as in this equation.

$$(ru)_{tt} - c^2 (ru)_{rr} = 0;$$

The quantity ru in the equation satisfies the 1-dimensional wave equation of the form

$$u(t,r) = \frac{1}{r} F(r - ct) + \frac{1}{r} G(r + ct),$$

Now the values F and G are arbitrary functions which can each represent 1/2 of the spherical standing wave over time, the expanding and contracting phases. This was the generic electron model as a standing wave in an educational model.

So in 1 and 3 dimensions a standing wave can be defined by the scalar distance from a point. However we can only do this in odd numbered dimensions.

The string example commonly used, is a two dimensional description of a standing wave, and is used in even numbered dimensions where a spherical solution to the wave equation does not work. In string theory, strings were first defined as a number of 0-dimensional harmonic oscillators.

So are particles a point, strings, waves, or combination of both across dimensions? Spherical scalar waves can be modeled as branes in string theory. These are just a few of the questions facing physicists today. These difficult questions arise even when we examine some of the most fundamental concepts in physics, like the standing wave, There are a number of approaches to try and answer these questions with, each with their strengths and weaknesses.

Point Particle Component of a Standing Wave

Just the generalized concept of a 1/2 spin particle as a standing wave has been quite successful. The generic standing wave in an educational model predicted a finite size for the point particle due to the fine-structure constant which could give a visual representation of quantum spin [1].

This is helpful as when using the Schrödinger equation, the interaction of the field with spin is not well defined and there is no explanation for the gyromagnetic ratio of 2. The 1/2 spin of the inward component of a spherical standing wave as it collapses into the point particle, which has a finite size based on the fine-structure constant, does both of these.

Of all the explanations of the fine-structure constant, the easiest example to use within this model is the way Feynman described it. In QED the fine-structure constant is seen in the "observed coupling constant", it is "the amplitude for a real electron to emit or absorb a real photon." P 129 [2].

In QED, α is the coupling constant determining the strength of the interaction between electrons and photons but QED does not predict its value so α must be determined experimentally. QED does provide a way to measure α directly using the Quantum Hall Effect or by the anomalous magnetic moment of the electron. The theory of QED predicts a relationship between the dimensionless magnetic moment of the electron (or the "Lande g-factor", g) and the fine structure constant α.

If a ½ spin particle were truly dimensionless, the observed coupling constant would have a value of 0 in a Feynman Diagram which is the halfway point between the positive and negative amplitudes of the particle, known as the node when a standing wave is plotted over time. Instead it comes out just under this point. Why not just above or some other places if it is not on the node?

Using this model, one can see the origin of observed coupling constant/fine-structure constant in QED. By graphing the standing wave with the outward-bound scalar wave as the positive amplitude, as it is increasing in scalar value, and the other as the negative amplitude for the electron in QED.

The negative amplitude scalar wave must complete a 1/2 spin to generate the elementary charge, but the positive amplitude wave does not have a 1/2 spin component. By setting a finite size for the point particle, the negative amplitude wave will be retarded in its motion traversing it, and the node of the graph will be moved down to the where the observed coupling constant predicts it to be at. Both waves move the same distance (amplitude), but the distance covered by the negative amplitude during its 1/2 spin in the point particle is not factored in by the classical method of graphing a standing wave in QED or classical models.

(The fine-structure/electron coupling constant) X -1 = (Finite Point Particle constant)

(1/2 spin particles Amplitude) X (Finite Point Particle constant) = Size of Finite Point Particle.

This gives a finite size that even in relation to the particles own standing wave, is so small it can effectively be considered a point particle. But even this finite size for the point particle is useful in a model of the electron.

The fine-structure constant has been described and measured in a number of ways, often related to charge and particles. It has been defined as the ratio of elementary charge to Planck charge, the ratio of two energies needed to overcome electrostatic repulsion between charged particles, the ratio of the velocity of the Bohr electron in the atom to the speed of light, the ratio between the classical radius of the electron to the Bohr radius and the electron's Compton wavelength. Robert Stone Jr. defined the fine-structure the ratio of Charge to Spin [3].

Mark Aaron Simpson said this about particles having a finite size in the String Theory Development group [5]. *"What others may not understand, from the conditionals on our model, is that the field equation must reflect the condition that we placed on the singularity. In our model, the quantum singularity is finite (not like a wormhole) so assuming it is 1/2 axial parsed for both "sides" is an adequate and appropriate assumption. Other symmetry assumptions are also fine....The reason I posed the long question is, the entire mechanism will be in 2 "states" like the Janus coin. It will take 2 similar equations that are conditional to the Brane being open state and closed state."*

The list goes on and demonstrates the need for the fine-structure constant to be included in a model of the electron and 1/2 spin particles. Mark's statement also suggests the need for a double solution for spin particles and that this concept is not opposed to string theory models.

Visualizing Quantum Spin and Charge

Draw a circle and divide it in half top to bottom. At the top we have no charge, 180 degrees around it at the bottom we have a charge of 1 electron volt. Think of half of this circle as being a generator. As you travel around the circle, the electron generates a charge during its ½ spin. An arrow at the top on the circumference can be used to show the direction of the quantum spin.

It is easy to see how a 0-spin particle does not generate any charge, as it does not travel around the circle. If the other half of the circle were modeled as a motor that uses this charge, a 1-spin particle would have 0 net charge after completing a full revolution.

Anti-particles can be represented with a mirror image of this circle where the generator and motor sides are reversed. A 0-spin anti-particle still develops no charge and a 1-spin anti-particle still has a 0 net charge. For positive 1/2 spin lets assign a clockwise or positive direction for our arrow which generates a positive charge. The negative 1/2 spin would then spin counter clockwise, in a negative direction, to generate a negative charge.

A← vector would be a negatively charged particle.
A → vector would be a positively charged particle.
A ↔ vector would be a neutral Spin 1 particle
A 0-spin particle does not need a quantum spin vector and is simply a circle, O.

If you overlay the circles of a particle and it’s anti-particle, the two spins cancel out, and the two sides, generator and motor, cancel each other out. So both circles cancel each other out just like they are supposed too.

This simple representation of quantum spin is more powerful than it appears at first. Standing waves can also be modeled in 2 dimensions as a circular membrane. A single standing wave, much like a drum skin, will show a positive and negative displacement over time. If the membrane is divided into two nodes with a standing wave on each side of the circle will have opposing amplitudes on each side, one positive and one negative, just like in the example for spin in this paper.

There are also advantages to using a vector notation for quantum spin, one of those is that it can be used in QED, and later it will be used in the Dirac equation.

This model of quantum spin can easily be used in Feynman Diagrams as well. The point for a particle or anti-particle would just be enlarged to a small circle with a vector to denote which it is. Pair production or annihilation would be a small circle with two vector arrows in opposite directions. One could use as little or as much detail as needed. A 1-spin particle would be as we just described. A 0-spin particle would be a circle with no vector arrow, and a 1/2 spin particle would have a line dividing it in half with a vector arrow showing the direction of spin.

This works well, but particles with a fractional charge must be included as well. Dividing the circle into six segments. Starting at the top and going in the direction of the vector arrow will be the starting point.

When you have traveled 1/6 of a circle, which is 1/3 of the way around the generator side, you have 1/3 of an electron volt. The divided circle representing 1/2 spin particles would have a line for this point to the center to denote a 1/2-spin particle with 1/3 charge. We would then denote a line at 2/3 around the generator side for a particle 1/2-spin with 2/3 charge.

Particle and anti-particles circles will still cancel each other out. Thus we can represent standing waves as a two dimensional circular membrane and a vector to denote quantum spin.

So this model can also be useful for those investigating string theory. A Brane/Membrane can model standing waves as well as a string. A Brane is just an extended string, so such an approach is compatible with string theory as well.

Using a vector to denote spin is not new, Clifford algebra has been around a long time and uses vectors. Jonathen Scott applied the use of vectors to the Dirac equation. The "Complex Four Vector Notation" Clifford algebra system he used is the equivalent of Pauli's two by two matrices.

Now the relativistic Dirac wave equation normally is done by four by four complex matrices, but his approach ca be used with the Dirac equation as well. This vector notation is symmetrical in its treatment of three-dimensional space, and fits well with the spherical standing wave developed in this paper. The variables **i**, **j**, and **k** are the x, y and z directions in 3-D space in his paper.

The axis of rotation appears explicitly in the equation, and also appears again, unexpectedly, in the interaction with an external electromagnetic potential. In section 3.1 he gives the first-order Klein-Gordon equation using vector notation.

It is in section 3.8 of his paper that is of the most interest here. In that section he gives a more generalized version of the first-order Klein-Gordon equation that does not require an arbitrary choice in the vector for the *z* direction (where the speed is 0 and the orientation is scalar to the frame of the observer). Thus it changes from a 3-dimensional to a 2-dimensional one, and it acquires an imaginary vector component.

In short the representation of spin with a vector just as described in this paper as a simple representation of spin and charge but derived from the Dirac's work instead.

A Double Solution

This has also been an examination of the fundamental concept of a standing wave. A standing wave can be modeled as a single wave spherically and as a circular membrane/brane. A standing wave can also be modeled as two waves working together on a string, or as two waves sharing a circular membrane/brane.

The concept of a standing wave has also been explored as a single spherical wave. Is there also a double wave solution in 3-dimensions?

At the start a simple standing wave consisting of one spherical scalar wave modeled over time was used. When graphed 2-dimensionally, the positive and negative amplitudes cancel each other out at 0 amplitude, the node of the standing wave, if we take into account a finite size for the point particle based on the fine-structure constant.

As a standing wave can be defined by a single vector value from a central point in 3-dimensions, we can simplify the equation at the start by comparing the amplitude of the two wave components with a single vector value.

$$\text{Amp}^{\text{Out}} + \text{Amp}^{\text{In}} = 0$$

In 3-dimensions there is a slight discrepancy with the 2-dimensional model of this approach. The wave components of In and Out waves only cancel each other out over time instead of at any moment in time as in the 2-dimensional model. Thus there is no counteracting force to prevent the spherical wave from expanding into space like a source wave, instead of reversing its direction at full amplitude as in a standing wave.

The other problem with a single spherical standing wave is that the point particle is virtually non-existent except for the brief moment the In wave completes its 1/2 quantum spin. The particle aspect has little effect in such a model, and due to this, point particle models are used, and the minor problems with them ignored for practical reasons.

This has lead to problems with models for the electron. Many have looked for the counteracting force that holds the electron standing wave together. In 2-dimensions it is the force of the second opposing wave that does this. If a "double solution" can be found that will work in 3-dimensions, it would improve our understanding of how the 1/2 spin particles might work and help solve some of the problems with other models.

If 1/2 spin particles have a finite size based on the fine structure constant, a double wave solution is possible in 3-dimensions.

Assign one standing wave to the finite point particles component of a 1/2 spin particle, and the other standing wave to the extended spherical wave.

$$\mathrm{Amp}^{Out}\,F + \mathrm{Amp}^{In}\,F = 0$$
$$\mathrm{Amp}^{Out}\,E + \mathrm{Amp}^{In}\,E = 0$$

Where :
F is the finite point particle.
E is the extended standing wave.

This however is not enough the connection between the two waves is not shown. How are they connected to form standing wave?

At this point a double solution for this model can take two forms. It can be modeled as two separate spherical waves, one contained inside the other, sharing the same energy/mass.

If the two standing waves are sharing the same mass/energy, than one will be at full amplitude at the same time the other is at minimum.

When the extended wave is at full amplitude, the point particle will be at 0 amplitude, a true point particle.

When the extended wave collapses into the particle, the finite point standing wave is approaching full amplitude. The two standing waves undergo a 1/2 quantum spin, turning themselves inside out in 3-dimensions.

$$(\mathrm{Amp}^{In}\,E - \mathrm{Amp}^{Out}\,F) + (\mathrm{Amp}^{Out}\,E - \mathrm{Amp}^{In}\,F) = 0$$

The other way a double solution can be modeled is with a visual representation of quantum 1/2 spin in 2-dimensions. If we grasp the ends of a circle, O, and give one side a 180 turn, we create a single wave with two spherical components, ∞, connected by a 180 degree, 1/2 spin.

The vector notation still needs to be added to denote quantum spin, this would be for a negatively charged particle.

$$(\mathrm{Amp}^{In\leftarrow}\,E - \mathrm{Amp}^{Out\leftarrow}\,F) + (\mathrm{Amp}^{Out}\,E - \mathrm{Amp}^{In}\,F) = 0^{\leftarrow}$$

The quantum spin vector only appears in the finite point particle component of the equation. This is because the quantum spin is confined to the particle component, the extended standing wave does not have quantum spin.

This general equation can be modified to serve as a description of 1/2 spin particles in several disciplines of physics and mathematical methods as diverse as String theory, QM, QED, and Clifford algebra, yet it still simple enough for the educational model it was intended for.

A double solution for 1/2 spin particles more accurately reflects the wave/particle duality than some other models.

It provides a method to examine the wave effects separately from the particle effects, while still maintaining the dual nature of particles and waves.

It provides a method to explore the origin of spin and charge, and the interaction of the wave with the vacuum as well as the interaction with the photon and gluon in 1/2 spin particles.

The model is still consistent with the results obtained from a single spherical wave model where the Up and Down quark masses were derived and a model for quark confinement established [6].

Like any model it raises questions as well. Spin 1 particles can be modeled with the double solution approach as well, as the charge cancels out in this model. Spin 0 particles could be modeled as a double solution with no spin as well. But both could also be modeled as the simple single spherical wave this paper started with. Are one or both of these particles a different type of standing wave? But one of the goals of any model should be to make us ask questions we have not considered before.

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