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Spin, Charge and the Fine-Structure Constant As Related to The Semi-Classical Model Presented in my Book For Undergraduate Education

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In my book I struggled with a way to explain spin and charge in particles where the average reader could grasp it using a semi-classical model. I came up with a way to do so that I would like to expand on. As the scalar wave of the electron can also be modeled as a string in string theory and it can be used in QED if one wanted, it can be used in more than just a semi-classical manner.

Visualizing Spin

In the scalar wave of the 3-D semi-classical electron I used, when the wave collapses to form the point particle aspect, the scalar wave must complete a 180-degree spin, ½ a revolution, before it starts to expand again p 129 [1]. Thus the scalar wave is "facing" the same direction as its direction of travel.

In string theory, strings were first defined as a number of 0-dimensional harmonic oscillators. So from that perspective, the string collapses to a single 0-dimensional harmonic oscillator that completes a 180-degree spin before expanding again in the 3-dimensional world.

Hopefully this allowed the reader to separate the quantum spin of the point particle component, as distinct from any rotational spin of the electron in its extended form of a standing wave.

The point particle aspect of the electron is where the vacuum and source field combine. The quantum ½ spin of the point particle can now be used in a visual way to explain how charge is created at this point.

Visualizing 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 rotation.

Semi-classically I modeled this “Generator/Motor” as a homopolar motor with the scalar wave as the armature and its interaction with the vacuum and the electromagnetic field p 129 [1]

This was as far as I went in my book, but it can also represent more than this. 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 ½ spin lets assign a clockwise or positive direction for our arrow which generates a positive charge. The negative ½ spin would then spin counter clockwise, in a negative direction, to generate a negative charge.

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.

Modeled Used as Introduction to Feynman Diagrams

This circle model could also be used with Feynman Diagrams in QED if one wanted. 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 ½ spin particle would have a line dividing it in half with a vector arrow.

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 ½ spin particles would have a line for this point to the center to denote a 1/3-spin particle with 1/3 charge. We would then denote a line at 2/3 around the generator side for a particle with 2/3 charge.

Particle and anti-particles circles will still cancel each other out. This model worked well for particles in the semi-classical model where the Up quark was the electron waveform at reduced amplitude, this predicted a mass of 1.533 MeV and a charge of 2/3 p. 149 [1]. By modeling the Down quark as the Up quark at reduced amplitude it gave a mass 4.599 MeV and a 1/3 charge.

This suggests that all ½ spin particles were the same basic waveform that was stable with the energy level of its surrounding. So we should expect to find more ½ spin particles as we reach higher energy levels, which is consistent with current observations p 149 [1].

Since String theory tries to model all ½ spin particles using strings, some basics of string theory can be introduced. It also shows some of the problems of the classical model.

The Gyro-Magnetic Ratio

This ratio is normally given by the symbol, gamma y, in Greek. It is the ratio of a magnetic dipole moment to its angular momentum. But this classical approach gave the wrong answer, and was about half the value measured in observations for the g-factor. When the Bohr Magnetron is used to calculate the g-factor, it gave a value close to 1 when the observed value is close to 2.

The semi-classical approach used in this model show the problem of the Bohr Magnetron because it failed to separate the quantum spin from the angular momentum. Bohr's model was based on 360 degrees of spin, not the 180 degrees of quantum spin represented in this model.

A semi-classical approximation would be to double the value given by the Bohr models, as the g-factor would have to be twice as strong to generate 1 electron volt in half a spin.

A better approach is to use the one taken in relativistic quantum mechanics, which relies on the Fine-Structure Constant. This will serve as a good spot to introduce this equation as well as the fine-structure constant used in it, which is a fascinating aspect of physics.

Fine-Structure Constant

G. Gabriel paper on the subject use a Dirac point particle with QED corrections p 264-269 [2], this works well with our as does the work of Robert Stone Jr. which defined the fine-structure the ratio of Charge to Spin [3]. Likewise it has been shown for decades that the Quantum Hall Effect can also be used to obtain the fine-structure constant. Another way it can be defined related to charge is the ratio of Elementary charge to Planck charge.

The name itself suggests the implications, that there is some finite structure to all the matter in the universe, but just barely. Max Born said that if the value were much different, we would not be able to distinguish matter from the vacuum itself p 253 [4].

Of all the explanations of the fine-structure constant, the best 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 [5]

If a ½ spin particle were truly dimensionless, the observed coupling constant would be at 0, 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 the semi-classical model, a student can see the origin of observed coupling constant/fine-structure constant in QED. We can graph 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 ½ spin to generate the elementary charge, but the positive amplitude wave does not have a ½ spin component. By setting the size of the finite point equal to the fine-structure constant, the negative amplitude wave will be retarded in its motion, 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, but the distance covered by the negative amplitude is not factored in by the classical method of graphing a standing wave.

The nearly 100 year old classical approximation of a dimensionless point particle has served physics well, and will continue to do so. The finite size of a particle is so small, even in relation to its standing wave, that it can effectively be treated as a dimensionless point. The point particle model works well in graphs and equations derived from classical physics that we still use today, we need only apply the fine-structure constant when needed.

There are times when the particle as a finite point rather than a dimensionless one can prove useful, as pointed out in courses on quantum gravity p 4 [6] and for those searching for an exact equation [7] to a specific problem. Yet for the most part the old classical approximation of a point particle works fine, it need only a little explanation for the student to understand why the fine-structure constant must be taken into account.

So this approach gives us a semi-classical model of spin and charge that can be used at the undergraduate level that can also be related to other fields of physics and serve as a good introduction to other fields of physics. It also provides an intuitive grasp of the fine-structure constant for the student and the average reader interested in physics. The fine-structure constant is so far ranging crossing many disciplines of physics, so it give the instructor a convenient spot to introduce a number of concepts to the student.

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