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► **To cite this version:**

Ramiro A Montalvo. The Bound Photon Model -A New Source for the Unification of Forces and Particles. 2021. ⟨hal-03321633⟩

**HAL Id: hal-03321633**

**<https://hal.science/hal-03321633v1>**

Preprint submitted on 17 Aug 2021

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# The Bound Photon Model – A New Source for the Unification of Forces and Particles

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July 11, 2021

## ABSTRACT

Recent experimental evidence reveals the binding of photon pairs into quantized states of orbital angular momentum forming bosons and other experiments that form fermions as electron-positron pairs. This and other evidence suggest a bound photon model that postulates all massive elementary particles are composed of photon pairs with opposite momentum bound by an interaction that reflects the photons over a distance near their wavelength. Close examination of how the Dirac equation was solved in 1928 reveals that Bound Photon model is actually required to comply with the quantum and relativistic constraints in QED. The use of photons allow compliance with the more powerful conformal symmetry for unifying gravity with quantum mechanics. The bound photon (BP) model unifies the four forces into a single attractive force between photons, and unifies the number of elementary particles to one particle, the photon. This report explores the extent to which the BP model agrees with the experimental data and how it compares with the Dirac theory in QED, the weak theory, the strong theory in QCD and general relativity. The bound photon model is found to be in good agreement with the experimental evidence in non-relativistic quantum mechanics and EM. With relativistic quantum mechanics the model's solutions from the wave equation are closely related to those of the Dirac and Klein Gordon equations, the difference being that the Dirac theory's solutions use massive particle waves that result in having massive propagators while BP model's solutions use massless waves and propagators. In the area of generating the masses of the leptons, mesons and baryons the bound photon model offers a fairly accurate two parameter solution that is much simpler and in better agreement with the experimental mass data when compared with the results from lattice theory for QCD. An initial quantum gravity theory is described which generates the curvature of space-time using photon pairs and is different from general relativity as expected because of the known incompatibility of general relativity with quantum mechanics. The report contains the foundation of a unified bound photon theory but additional theoretical and experimental research is needed to complete the theory for the weak force, the strong force and quantum gravity.

## 1 INTRODUCTION

The current standard model of particle physics, while accounting for a vast amount the experimental data, has a number of problems including: infinities that require renormalization<sup>1</sup>, a large number of elementary particles, fields and constants to fit the experimental results that are

not generated by the basic theory, the inability to generate the particle masses adequately<sup>2</sup>, and a well-known fundamental incompatibility between gravity and quantum mechanics.

Some of the difficulties suggest the Bound Photon model as a possible solution, for example the requirement for massless gluons with the strong theory. Other areas where a requirement for massless particles shows up are with the Goldstone theorem<sup>3</sup> and the gauge invariant theories. In QED, the Dirac theory solutions for the electron contain an unexpected oscillation in the position of the particle at a frequency that is twice the Compton frequency and is known as Zitterbewegung<sup>4-6</sup>. This oscillation can only be adequately explained by a pair of massless photons interacting so as to reflect off each other's field to form a massive particle.

When the Compton frequency or the corresponding Compton wavelength was first analyzed by A. Compton and P. Debye, it revealed that the Compton scattered radiation was intimately related to a proper QED theory<sup>7</sup>. Later the solution was worked out by Klein and Nishina with an equation that carries their name.

The main reason why the standard model failed after decades of efforts to find a solution is that it is forced to be much more complex than it needs to be<sup>3</sup> Hartle p. 791. Numerous field theories had to be developed over decades of time in the attempt to fit the experimental evidence with piece meal success only. No single field theory that would solve the problems was found. The bound photon theory is by design much simpler therefore it requires much simpler physics and quantum mechanics.

The bound photon model has extensive support from the experimental evidence. An important result from the research of the known particle masses in section 7, revealed the discovery of two extremely accurate values for the proton and muon masses. They appear to be quantized values for the proton and muon masses accurate to a few parts per billion.

## 1.1 Experimental evidence for photons to bind into a massive particle

Recent work since the early 1990's has shown various forms of photon-photon interactions that reveal photons can bind and show evidence for generating a massive particle with the characteristic that the photons in the pair retain their identity. This means that a description of the particle, experimental or analytical, can manifest a massive particle or pairs of massless particles. The clearest experimental evidence comes from the observation of photons binding into quantum states of orbital angular momentum with integer values of  $\hbar$ .<sup>8</sup> A photon beam from a laser in the Laguerre-Gaussian mode is modified by polarization filters to produce pairs of orbiting photons that travel in spiral paths around the beam center making their collective forward motion along the beam less than the speed of light, while the individual photons travel in a spiral the at the speed of light. Changing the reference frame of the observer to that of the forward motion, results in a stationary pair of photons orbiting each other allowing the calculation of their mass as a new type of massive particle. In another example<sup>9</sup> the authors

couple a laser beam in a single electromagnetic mode to strongly interacting cold Rubidium atoms in highly excited Rydberg states. The authors comment on the behavior of the photon in the abstract as: “Here we demonstrate a quantum non-linear medium inside which individual photons travel as massive particles with strong mutual attraction and the propagation of photon pairs is dominated by a two photon state. In a third example<sup>10</sup> the authors use a different method to produce the orbital states by passing the beam through a prism that is physically rotated. The results reveal quantized orbital states from  $-4\hbar$  to  $-1\hbar$  for left handed beams and  $+1\hbar$  to  $+4\hbar$  for right handed beams.

The behavior of photons in a Bose-Einstein condensate reveals that, in addition to the heavy atoms in a dilute gas changing into a single quantum state, the photons also fall into a single state and acquire a mass<sup>11</sup>.

It is widely accepted theoretically that all quantum transitions from a set of particles A to a set B as  $A \rightarrow B$ , will also occur in the opposite direction as  $B \rightarrow A$ . The decay interactions of  $e^+ e^- \rightarrow \gamma \gamma$  and  $\pi^0 \rightarrow \gamma \gamma$  should also occur in the opposite direction. The process  $\gamma \gamma \rightarrow \pi^0$  has never been observed in the laboratory. What has been observed<sup>12,13</sup>, is pair production using high intensity laser beams that used 6.4 laser photons on average produce an  $e^+ e^-$  pair. (A clean pair production experiment using just two photons has been proposed<sup>14</sup>.) The reverse of a positron electron annihilation shows that photons can also bind to form a pair of fermions which complements Padgett’s experiment that creates bosons.

Strong experimental evidence cannot be ignored requiring any new theory to be compatible with the evidence otherwise it will be invalidated by it. The BP model has the characteristics required by the experimental evidence and it resolves a large number of problems with the standard model therefore it should be considered as a high priority alternative new theory by the physics community.

## 1.2 Basic Bound Photon Model

A summary of the general characteristics of the bound photon (BP) model will be introduced here so that the reader, who is immediately confronted with many questions, can gain a quick perspective on how some of the properties of the photon can generate the characteristics of the currently known massive elementary particles. The model was built so that the resulting massive particle’s characteristics such as mass, spin, and charge agree with the experimental evidence. Most of the massive particles are the quarks and leptons which carry a charge with the neutrinos uncharged. The BP model description of a charged particle consists of a spin 1/2 core and an electric field composed of a finite series of quantized photon pair states with zero spin, each of which is occupied with probability of  $\alpha$ , the fine structure constant. The series starts with the Compton wavelength for the photon which doubles for subsequent pairs in the series.

Uncharged particles (the neutrinos) consist of a fully occupied core pair only. The BP model description of the weak force works out to be the core to core interaction between the leptons to first order, and much smaller contributions from the core to electric field interaction.

In Section 6, it will be shown that an interaction between photons is required to explain the existence of an electric field around a charged particle. The discussion leads to the conclusion that right handed circularly polarized photons bind to form particles and left handed circularly polarized photons bind to form antiparticles and, unlike chirality photons do not bind and may repel. The value of  $\alpha$  for the occupation levels of the field were assigned so as to agree with the known radial energy density of the electric field of a single charge. Right handed cloud photon pair states form the electric field of a negative charge and left handed cloud photon pair states form the field of a positive charge. The mass of a charged particle at rest equals the energy of a  $m(1 - \alpha)$  core pair plus the energy of a finite number of  $m\alpha$  occupied field states, both divided by  $c^2$ . The magnetic field, as it is well known, is just the description tool to account for the interactions when the charges are in motion so it would be described by bound photon pairs in motion.

The masses of the particles heavier than the electron are determined by further refinements to a pattern that has already been seen<sup>15</sup> but have been largely ignored by the particle physics community. It was observed that the mass of the leptons, mesons, and baryons with masses greater than 100 Mev have a tendency to be integer or half integer multiples of a basic mass equal to the mass of the electron divided by the fine structure constant and is equal to 70.025 Mev. The generation of mass for these heavier particles will be described in Section 7.

## 2 The relation Between Massive and Massless Particles

Before special relativity there were no particles with zero mass and the photon was not known as it was considered to be EM radiation until Einstein introduced it. With the advent of special relativity the photon was designated to have zero mass as a result of requiring both massive and massless particles to have a Lorentz invariant mass. This designation of zero mass created a special situation which should be examined. In relativistic mechanics, massless and massive particles occupy different domains in the phase space of velocity, energy and mass. Massive particles can only move at speeds between zero and less than  $c$  and require infinite energy if forced to reach  $c$ , while massless particles can only travel at  $c$  and do so with any amount of energy in sharp contrast with massive particles. Clearly they occupy separate domains for velocity. The relativistic relation  $E^2 = p^2c^2 + (mc^2)^2$  looks simple enough when the mass is reduced to very small values so in the limit it goes to zero. The outcome of limits in physics has been questioned by Michel Berry<sup>16</sup> with the possibility that limits may be, either as expected, or quite different as “singular limits”. He cautions: “Limits in physics can be singular too – indeed they usually are reflecting deep aspects of our scientific description of the world”. In Section 5 a

singular limit appears to play a part. In section 8 massless photons allowed a quantum gravity to be developed while general relativity which uses massive particles failed to be compatible with quantum mechanics.

### 3 Relativistic Mechanics of Bound Photon Pairs

The relativistic relations for the momentum, energy and mass of a massive particle composed of two photons moving in opposite directions with an interaction force that allows them to reflect off each other can be simply derived. Each of the photons will be treated as an individual particle that still acts as a photon when bound. For a change of reference frame, the photon's frequency obeys the relativistic Doppler relation as:  $\omega = \omega_0 \gamma(1 + v/c)$  where  $\gamma = 1/(1 - v^2/c^2)^{1/2}$ . A massive particle has a rest energy  $E_0 = mc^2$  therefore each of the photons is assigned an energy of  $E_0/2$  corresponding to a frequency  $\omega_0/2$  at rest. Applying the Doppler relation for a boost with velocity  $v$  gives the energy relations for photon 1 and photon 2 as:

$$E_1 = (\gamma E_0/2)(1 + v/c) \quad (3-1)$$

$$E_2 = (\gamma E_0/2)(1 - v/c) \quad (3-2)$$

when the boost is in the direction of photon 1. The usual relativistic relations for the energy  $E$  and momentum  $P$  for a massive particle follow from those of the photon pair as:

$$E = E_1 + E_2 = (\gamma E_0/2) [(1 + v/c) + (1 - v/c)] = \gamma E_0 \quad (3-3)$$

$$P = (E_1 - E_2)/c = (\gamma E_0/2c) [(1 + v/c) - (1 - v/c)] = \gamma E_0 v/c^2 \quad (3-4)$$

$$P = \gamma m v \quad (3-5)$$

The constraint on the energy of each of the two photons that are bound as a massive particle of mass  $m$  that is valid for any momentum of the massive particle is easily obtained with the substitution for  $E$  and  $p$  from equations (3-3) and (3-4) in the relation  $E^2 = (pc)^2 + (mc^2)^2$  yielding:

$$m = (4/c^2) (E_1 E_2)^{1/2} \quad (3-6)$$

This relation between  $E_1$  and  $E_2$  assures that  $m$  is the invariant mass of the particle. Equation (3-6) will be a required constraint with the Feynman diagram solutions when two photons are used to represent a massive particle which uses a single line in the diagram.

Two other relations, derived from equations (3-3) and (3-6), were found to be relevant in comparisons with current theories.

$$E = E_1 + (mc^2)^2 / (4E_1) \text{ and } E = E_2 + (mc^2)^2 / (4E_2) \quad (3-7)$$

To avoid confusion, the subscripts have been chosen to make  $E_1 \geq E_2$  for a massive particle with positive momentum.

In conclusion the relations developed in this section show that, as far as the laws of relativistic mechanics are concerned, a pair of bound massless photons behaves the same way as a massive particle.

#### 4 Non Relativistic Quantum Mechanics of a Bound Photon Pair

An important outcome of the bound photon model (BP model) is how the non-relativistic quantum wavelength for a massive particle relates to the wavelengths of the two photons that make up a massive particle. For a clear description, the one-dimensional case will be treated here with the 3-dimensional case not expected to create any conceptual problems because of rotational invariance. The energy and momentum for a photon is the same variable except for units therefore the wave function for two photons moving in opposite directions with energies  $E_1$  and  $E_2$  using plane waves can be written as:

$$\Phi(x,t) = \cos\left(\frac{E_1}{\hbar c}x - \frac{E_1}{\hbar}t\right) + \cos\left(\frac{E_2}{\hbar c}x + \frac{E_2}{\hbar}t\right) \quad (4-1)$$

The positive sign in the time coefficient of photon 2 generates a wave moving in the opposite direction of photon 1. Using the trigonometric identity for the sum of two cosines yields:

$$\Phi(x,t) = 2\cos\left[\frac{(E_1 + E_2)}{2\hbar c}x - \frac{(E_1 - E_2)}{2\hbar}t\right] \cos\left[\frac{(E_1 - E_2)}{2\hbar c}x - \frac{(E_1 + E_2)}{2\hbar}t\right] \quad (4-2)$$

At  $t = 0$ :

$$\Phi(x,0) = 2\cos\left[\frac{(E_1 + E_2)}{2\hbar c}x\right] \cos\left[\frac{(E_1 - E_2)}{2\hbar c}x\right] \quad (4-3)$$

The de Broglie wavelength in a diffraction measurement uses  $\Phi^2$ , thus with the identity  $2\cos^2 A = \cos 2A + 1$ ,  $\Phi^2$  becomes:

$$\Phi^2(x,0) = \left(\cos\left[\frac{(E_1 + E_2)}{\hbar c}x\right] + 1\right) \left(\cos\left[\frac{(E_1 - E_2)}{\hbar c}x\right] + 1\right) \quad (4-4)$$

For low energies compared to the rest mass, the second factor in equation (4-4) is a wave that modulates the wave in the first factor at a much lower rate producing beats. The coefficient of  $x$  in the second factor gives the relation for the beat wavelength  $\lambda_b$  as:

$$(E_1 - E_2)/\hbar c = P/\hbar = 2\pi/\lambda_b \quad (4-5)$$

The beat wavelength is the same as the quantum or de Broglie wavelength given by  $P = 2\pi\hbar/\lambda_q$  making  $\lambda_b = \lambda_q$ . This remarkable result of the BP model, shows that the quantum wavelength originates from the beat of two waves corresponding to the waves of the two photons that form a

massive particle. It is made possible because the momentum of a bound pair of massless photons has to be the difference of the two photon's momenta which becomes the difference in the photon's energies due to the relation  $p = E/c$  for photons. In addition, this result shows that the Schroedinger equation is correct in the non relativistic domain due to the serendipitous outcome of a trigonometric identity. The wavelength of the first factor in equation (4-4) corresponding to the average photon wavelength, should be measurable by a high resolution electron diffraction experiment unless the charge of the electron interferes in some way. This shorter wavelength has probably not been seen experimentally because of either: the higher resolution required, or the dismissal of the oscillations as interference from some other source. What has been noticed in relativistic quantum mechanics is the enigmatic oscillatory motion known as Zitterbewegung<sup>4-6</sup> that shows up in the solutions of the Dirac and Klein Gordon equations. This and other anomalies will be discussed in Section 5.

In this section it has been shown how the bound photon model solution relates to the non-relativistic solutions of the Schroedinger equation with equation (4-2). Equations (4-1) and (4-2) describe two formats for the same wave. The second factor of equation (4-3) reveals the wavelength of a massive particle according to the Schroedinger equation while the first factor reveals the mean of the two photon waves from the BP model. This characteristic of the BP model, to be able to manifest either the quantum waves of the photons or the quantum wave of the massive particle the photons represent, turns out to be an important feature in the comparison of the BP model with Dirac theory. It also shows an unexpected characteristic. Even though the Schroedinger equation is non-relativistic it contains a relativistic characteristic revealed by a trigonometric identity.

## **5 Relativistic Quantum Mechanics of a Bound Photon Pair and Its Relation to Dirac Theory**

Historically the transition from non-relativistic quantum mechanics to the relativistic case has had a number of problems as described in the introduction. The foundation of the bound photon model will be further explored in this section by examining how the current Dirac theory uses the Klein Gordon and the Dirac equations to obtain solutions for the relativistic formulation of quantum mechanics for massive particles, and then for a comparison, how the bound photon (BP) model arrives at its solutions. The BP model first uses the wave equation to obtain solutions that are free non-interacting massless photons then adds an interaction between photons, which is supported by the experimental evidence described in section 1.1. The photon-photon interaction can be seen as each photon binding due to the field of the other photon.

## 5.1 The Klein Gordon and Dirac Equations

The Klein Gordon equation, in natural units, is usually presented as:

$$(\nabla^2 - \partial^2/\partial t^2 - m^2)\phi = 0 \quad (5-1)$$

It treats the space and time derivatives equally, as required for relativistic invariance, and it is a second order operator. For  $m = 0$ , it becomes the wave equation. With the mass term the Hamiltonian becomes:

$$\mathbf{H} = \sqrt{p^2 c^2 + m^2 c^4} \quad (5-2)$$

which is quite different from the Hamiltonian for  $m = 0$  as  $\mathbf{H} = pc$ . For the Klein Gordon equation, applying equation (5.2) as an operator creates the problem of interpreting what a half derivative is. Using  $\mathbf{H}^2$  avoids that problem and the solutions are Lorentz invariant. However the Klein Gordon solutions led to two difficulties: negative energy solutions and negative probabilities. The negative energy solutions could be ignored but they are required to explain the experimental evidence. To interpret the wave function as a probability it must obey the continuity equation which contains a first order time derivative. Paul Dirac tried to avoid these problems by using a first order equation on both space and time as:

$$c\alpha \nabla \Phi - \partial \Phi/\partial t + \beta mc^2 \Phi = 0 \quad (5-3)$$

with  $\alpha$  and  $\beta$  to be determined by the constraints of Lorentz invariance and equations (5-1) and (5-3). The constraints require the product  $\alpha\beta$  to be zero and both  $\alpha^2$  and  $\beta^2$  to be one<sup>4</sup> (Gingrich p. 75) which is mathematically impossible if they are plain variables. It is possible only if  $\alpha$  and  $\beta$  are matrices and  $\Phi$  is a column vector. The introduction of column vectors, commonly known as spinors, opens the possibility that the set of components actually describe more than one particle not the single particle that was intended because each component could describe the wave function of a different particle. The Dirac equation solutions also have negative energy components which mathematically result in momentum in the opposite direction to the momentum of the positive energy components. This odd result (odd in the sense of trying to describe the interactions of a single particle) shows up in the Dirac theory and field theories for relativistic QM with the rules for Feynman diagrams. Having components moving in opposite directions strongly suggests a different particle for each such component which will be validated in several different ways. It will be shown in section 5.2 that the energy dependence of the components of the Dirac solutions in the chiral representation is the same as the energy dependence of the two photons in the BP model. The current interpretation with field theory is that the components are not particles but together the components are part of a multiple particle theory that includes particle-antiparticle pairs even at non-relativistic speeds. This is vague and

confusing because to describe a single electron for example, you need a set of 4 components and to describe a positron you need a different set of 4 related components and yet, no single component or pair of components describes an electron or a positron, see Griffiths<sup>17</sup> p. 234. As far as the negative energy solutions field theory changes them to positive energy which does make sense but interprets them as moving backwards in time in the Feynman diagrams, also a confusing concept. The BP model also has positive energies for all components and by definition the photons in the pair move in opposite directions removing the oddities that have been described above. At higher energies field theory appears more sensible when it describes with operators the creation and annihilation of particles in which case it is justified as there are multiple particles involved.

## 5.2 Comparison of the Bound Photon Model Solutions to the Dirac Solutions

The Dirac theory requires four components, two to cover spin and two to cover particles and antiparticles. The Dirac solution in the chiral representation, frequently used in QED, shows the presence of the bound photon model<sup>3</sup> (Peskin p. 46). The solution for eigen states of  $\sigma_z$ , spin up along the z direction (with  $\hbar = c = 1$ ) is:

$$\Psi_D(z,t) = \begin{pmatrix} \sqrt{E-p} \begin{pmatrix} 1 \\ 0 \end{pmatrix} \\ \sqrt{E+p} \begin{pmatrix} 1 \\ 0 \end{pmatrix} \end{pmatrix} e^{-i(pz-Et)} \quad (5-4)$$

where E is the total energy of the particle and p is the momentum along the z direction and they obey the relation  $E^2 = p^2 + m^2$ . The subscript "D" indicates a Dirac solution. **At this point the BP model is well hidden in the Dirac solution, but if a substitution for the variables E and P is made from the bound photon's equations (3-3) and (3-4), they become obvious.** It just takes the replacement of E as  $E_1 + E_2$  and of p as  $E_1 - E_2$  in the column vector yielding:

$$\Psi_D(z,t) = \begin{pmatrix} \sqrt{2E_2} \begin{pmatrix} 1 \\ 0 \end{pmatrix} \\ \sqrt{2E_1} \begin{pmatrix} 1 \\ 0 \end{pmatrix} \end{pmatrix} e^{-i(pz-Et)} \quad (5-5)$$

The two components in the coefficient have the same energy dependence as the two photons in the bound photon model. This supports the statement made earlier that the components may describe individual particles and now more generally equation(5-5) shows that the energy dependence of the Dirac components in the chiral representation is the same as that of the two photons of the bound photon model.

Using the same format as was used in equation (5.4), the BP model can describe a generic massive particle with no spin or charge with only two components as:

$$\Psi_p(z,t) = \begin{pmatrix} e^{-i(E_1 z - E_1 t)} \\ e^{i(E_2 z + E_2 t)} \end{pmatrix} \quad (5-6)$$

The important difference between the bound photon solution and the Dirac solution is that the wave portion in the exponent for the BP model is for a massless particle while the exponent of the Dirac solutions is for a massive particle. A weakness in the use of a massive wave is that it does not treat the space and time dimensions equally. It also means that the Dirac solutions will have massive propagators while the BP model solutions have massless propagators. Applying the rules for Feynman diagrams to the bound photon case, can be accomplished by using two external photon lines to replace each massive particle's external line and the use of the energy constraint from equation (3-6). Since the BP model's parameters for mass and electric field have well defined and finite energy content, the model eliminates the infinities of the standard model.

### 5.3 Additional evidence for the presence of the BP Model in the Dirac theory

Walter Greiner<sup>5</sup>, has made a comprehensive study of the Dirac theory solutions for plane waves (pp. 99-121 and wave packets pp. 183-188), to illustrate the difficulties, problems, inconsistencies and often paradoxes that show up in the transition from a non-relativistic quantum mechanics theory to a relativistic one. Greiner used plane waves and wave packets to calculate the velocity and position of a single particle assuming that he can use the Ehrenfest theorem. Greiner found that using an operator according to the Ehrenfest theorem for plane waves results in having velocity eigen values are  $\pm c$ , the speed of light (p118). Greiner interprets this paradoxical result as showing that relativistic quantum mechanical operators may require changes when applying the Ehrenfest theorem. He finds that the operators may not always be as valid as they are with non-relativistic quantum mechanics. He then attempts to find the correct velocity operator by what he calls the even part of the operator for  $dx/dt$ . The even part gives the correct velocity as  $v$  ( $cp/E_p$ ) for positive energy solutions but  $-v$  ( $-cp/E_p$ ) for negative energy solutions. Here again he encounters the paradoxical result that the negative energy solutions have velocity directed against their momentum. Using wave packets, Greiner (p 183-187) finds that with the restriction of only positive energies for the plane waves of the packet, the expectation value of the velocity is the classical velocity  $v$  but when using both positive and negative energies the eigen values are  $\pm c$  (Greiner p 187). He also shows (Greiner p188) that with a complete set of solutions including positive and negative energies the expectation value of the solution has a time-independent group velocity and superimposed, a rapid oscillation known as Zitterbewegung. In view of these problems Greiner comes to the same conclusion as other observers of these effects that a single particle quantum description may not always be valid with Dirac theory and restricts the operators that can be used. As a result, the conclusion is that Dirac theory cannot describe a single particle. With the BP model a relativistic single particle can be described by equation (5-6). This set of problems encountered

by Greiner also illustrate that the present standard model is more complicated and carries a flaw that has not been solved as described in the introduction.

### The VRV characteristic of the BP model

The Dirac solutions in the Dirac-Pauli representation do not explicitly show the energy dependence of the bound photons in the components but they do show a characteristic of the BP model as an expression that contains the sum of a variable and the reciprocal of the variable (VRV) which can be derived from equation (3-7) in section 3 as:

$$E = \frac{mc^2}{2} \left( \frac{2E_1}{mc^2} + \frac{mc^2}{2E_1} \right) \quad (5-8)$$

The VRV characteristic shows up in the coefficients of the components of the Dirac solutions in the Dirac-Pauli representation and in some of the cross sections derived from the Dirac solutions. For example, in this representation, Griffiths<sup>17</sup> p 233, and Gingrich<sup>4</sup> p 89, upon choosing the  $u^{(1)}$  solution for particles with  $p$  in the  $z$  direction can be put into the form:

$$\Psi(z,t) = u^{(1)} e^{-i(pz-Et)} = \sqrt{E+mc^2} \begin{pmatrix} \sqrt{\frac{E+mc^2}{1}} \binom{1}{0} e^{-i(pz-Et)} \\ \sqrt{\frac{cp}{E+mc^2}} \binom{0}{1} e^{-i(pz-Et)} \end{pmatrix} \quad (5-9)$$

showing the VRV characteristic for the variable  $E + mc^2$  in the components of the column vector. All 4 solutions show the VRV characteristic with just sign changes in  $p$  and in the exponent.

The scattering cross sections that show the VRV characteristic are the ones that involve the photon. The first example is Compton scattering which uses the photon as a probe of the electron. For the case of the initial electron at rest the cross section is:

$$\frac{d\sigma}{d\cos\theta} = \frac{\pi\alpha^2}{m^2} \left(\frac{\omega'}{\omega}\right)^2 \left[\frac{\omega'}{\omega} + \frac{\omega}{\omega'} - \sin^2\theta\right] \quad (5-10)$$

where  $\omega$  is the energy of the incoming photon and  $\omega'$  the energy of the outgoing photon. The first two terms clearly show the VRV characteristic in the photons's energy ratio. The Compton scattering cross section in the center of mass frame for high energy is:

$$\frac{d\sigma}{d\Omega} = \frac{\alpha^2}{8E_{cm}^2} \left( \frac{1+\cos\theta}{2} + \frac{2}{1+\cos\theta} \right) \quad (5-11)$$

This cross section shows the VRV characteristic in the scattering angle. A second example is electron-positron annihilation<sup>4</sup> (Gingrich, Practical Quantum Electrodynamics", equation (8.261), p. 272) which shows the VRV characteristic in the photon's energy ratio.

## 5.4 The weak force “seesaw” relation

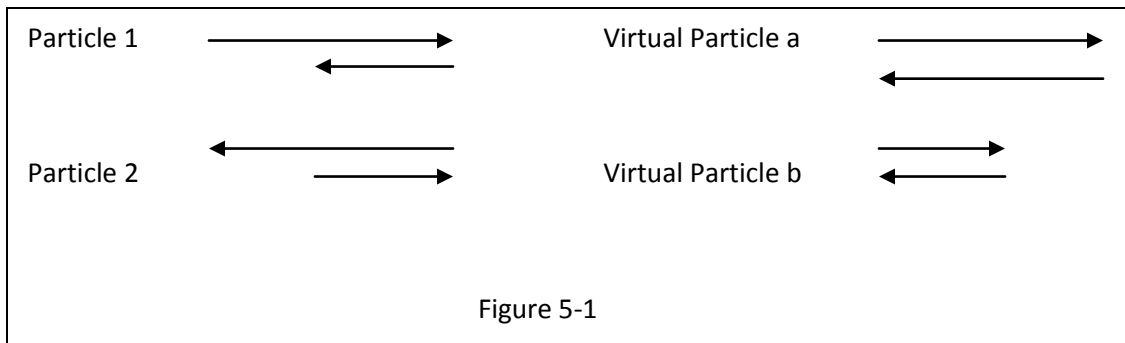
There is a characteristic identified as “seesaw” seen in weak force models beyond the standard model, that attempt to explain the smallness of the neutrino masses compared to the quark and charged lepton masses. A solution derived by Rabindra Mohapatra<sup>19</sup>, makes an estimate that roughly agrees with the experimental data after a number of approximations and simplifications. The mass of the electron neutrino is given by  $m_\nu = m_e^2 / gm_w$  where  $m_e$  is the mass of the electron and  $m_w$  the mass of the W boson. It is called seesaw because it allows one mass to become small when another mass is large. Equation (3-6) of the BP model:

$$E_1 E_2 = (mc^2/2)^2 \quad (3-6)$$

produces a seesaw relation for the energies of the two photons that constitute a massive particle which could apply to scattering relations. The weak force solution sets a relation between the masses of three different massive particles involved in the weak interaction: the neutrino, the electron and the W boson. Equation (3-6) of the BP model is a dynamic expression for the energies of the two photons that form a generic massive particle of mass  $m$ . The BP model provides a justification for Mohapatra’s solution and suggests that BP model plays a part in the development of the weak theory and may also be important in the interpretation of all experimental scattering results. The possible impact on the scattering process will be explored below and is described as back photon scattering.

## 5.5 Back Photon Scattering

Consider the scattering of two identical massive particles in the center of mass frame. The energies of the pair of photons in each of the massive particles will be constrained by equation (3-6). At rest the two photons have equal energy equal to  $\frac{1}{2}mc^2$ . When in motion the forward photon will gain energy while the back photon energy will decrease. Figure (5-1) illustrates the magnitude of the momentum or energy for the four photons involved in the scattering.



The forward photons of the two electrons will be of higher energy while the two back photons will have lower energy. In the left side of the figure, massive particle 1 comes from the left with net momentum to the right and particle 2 comes from the right with net momentum to the left. When the particles meet the two high momentum photons, which have equal energy, can form a particle at rest that can be considered to be a virtual particle identified as “a”. The two low momentum photons form virtual particle “b”. Next consider the scattering of two electrons at very high energy well beyond the rest mass of an electron. When the low energy (back photons) reach the rest mass of a neutrino, a resonance condition is realized and given the high energy available in excess over the rest mass energy of the two electrons, the excess energy of virtual particle ‘a’ can decay by the available channels which can very well be identified as short lived resonance particle. The resonance particle currently identified as the  $W^-$  boson is actually a resonance that originates from the high energy scattering between a neutrino and an electron in the BP model interpretation, and the  $W^+$  as the corresponding resonance for the neutrino and the positron. The masses of the neutrino and the electron determine the mass of the W by the VRV (see-saw) relation. This example with the scattering of two electrons reveals an important result.

**All scattering experiments involving two identical leptons or quarks can create a resonance when the energy of one of the virtual particles reaches the rest energy of another known massive particle.**

The similarity between the scattering process based on the BP model and the parameters used in Mohapatra’s model<sup>19</sup> for the weak force provides direction for the development of a weak theory based on the BP model. Considering all characteristics shown by the BP model, the appropriate source for the weak force is the core to core interaction between leptons and quarks in weak decay. When compared with the standard model, the W and Z particles become the result of back photon resonances. A practical result from the BP model in this area is that the mass of the electron neutrino can be calculated from the mass of the W boson and in addition, the result becomes more accurate compared with current estimates because the masses of the electron and the W boson are very well known and the BP model calculation does not have any approximations. The BP model calculation using equation (3-6) gives a mass of 3.2479 eV for the electron neutrino.

The architecture and method of Fig. 5-1 can be used for the scattering of two electrons moving in opposite directions to describe metals and their Fermi surfaces in condensed matter physics. The slight mass difference between virtual particles “a” and “b” produces the energy gap which fits the superconductivity theory. Yoichiro Nambu<sup>14</sup> noted that the symmetry of a superconductor in the normal state is broken when in the superconducting state generating the BCS energy gap in the process. Another consequence of the process is that the particles involved are massless.

## 5.6 Summary of Key Characteristics, Discussion and Conclusions of Section 5

In this section it was found that the constraints from being a solution of a wave type equation and Lorentz invariance has introduced the use the column vector format (spinors) and Lie algebra to both the Dirac theory and the BP model. Their solutions to describe a massive particle are very similar. The important difference in the solutions is in the exponent where the wave part (propagator) is defined, one being massive the other massless. There is an important consequence of using a massive propagator in that it does not treat the space and time dimensions equally making Dirac theory flawed and more complicated. The wave portion of a Dirac solution contains the usual relation for the energy, momentum and mass  $E^2 = p^2 + m^2$  in the exponent as:  $-(pz - Et)$  in equation (5-4). Writing the exponent in terms of just E makes it:  $-(\sqrt{E^2 - m^2}z - Et)$  where the energy dependence for the space dimension is more complex than the time dimension as just E. Writing it in terms of p still makes one more complex than the other. For the BP model the exponent of equation (5-6) is just  $-i(E_1z - E_1t)$ . The relations for space and time dimensions are both linear and of the same magnitude.

A summary of the important characteristics of the BP model are given below.

1. There is compelling experimental evidence that supports the BP model. The evidence shows that pairs of photons can bind into quantum states of orbital angular momentum with integer values of  $\hbar$  requiring the photons to have an interaction or force strong enough to bind them.
2. The BP model is embedded in the in the chiral representation of the Dirac solution. The energy dependence of the two column vector components of the Dirac solution is the same as the energy dependence of the two photons of the BP model components.
3. The Dirac theory for QED as well as the weak and strong theories of the Standard Model use massive propagators which have the flaw of not treating the space and time dimensions equally. That flaw together with other problems eventually contribute to the failure of the standard model as described below.
4. Both the Dirac theory and the BP model solutions are composite descriptions which are able to describe either a composite particle or the individual component particles. For the Dirac theory the components are massive particles. For the BP model they are massless. The Dirac theory solution has velocity eigen values of  $\pm c$ , the speed of light, when the full velocity operator is used, and eigen values of  $\pm v$ , the speed of the massive particle, when the even part of the operator is used. For the Dirac theory to be consistent with these characteristics, it requires the theory to abandon the claim that it describes the quarks and leptons as elementary particles.
5. The theoretical evidence for solving the Dirac equation shows that massive particles can only be created by combining a pair of massless photons into a composite particle. The details for this conclusion are the fact that the mathematics/nature rejects the introduction of a mass term to the

wave equation if constrained to using a single wave function and accepts it if multiple components are used together with the fact that those components are actually wave functions representing massless particles.

6. The BP model is much simpler than the standard model because it uses a single elementary particle and the more powerful conformal symmetry allowing it to use simpler physics and quantum mechanics.

The reality of the evidence listed in 1. to 5. requires the re-evaluation of the current standard model for both its successes and failures including the direction of future particle physics theories beyond the standard model that should include the BP model.

#### Problems associated with the Higgs mechanism used by the Standard Model

The Higgs mechanism assumes the existence of a Higgs field from cosmological considerations to generate the mass of a particle. The Higgs mechanism of the standard model has serious problems to the point of invalidating the model as a theory that gives masses to the particles. It is successful in generating the particle masses because it uses the experimental masses as input. Three of the important problems will be mentioned below.

1. The high energy density of the Higgs field is too high by 120 orders of magnitude and in another version by 50 orders of magnitude when compared with the astronomical evidence. This is the highest mismatch known in physics.
2. The hierarchy problem arises from two conflicting requirements. In the standard model (SM) all fundamental particle masses must be less than the electroweak mass of a few hundred  $\text{Gev}/c^2$  as required by the physics of the Higgs boson. When the effects of gravity are considered, the SM electroweak scale acquires quantum contributions of the order of the Plank mass with a value of  $10^{18} \text{ Gev}/c^2$ . This very large mass difference by a factor of  $10^{16}$  is the hierarchy problem.
3. The claim that the Higgs mechanism generates the masses of the 29 elementary particles is untenable because it uses 29 coupling constants from the experimental data for the masses<sup>2</sup>. It just shifts the lack of knowledge of how they acquire their masses to the coupling constants. The mathematics are correct but they are more complex than necessary when compared to the simpler BP model.

## 6. Description of a Charge and Its Electric Field as Bound Photon Pairs

The concepts that form the foundation of electrodynamics, charge, electric field and magnetic field are examined to see if it is possible to formulate an equivalent description based on the bound photon model. The transition appears to be possible if the connecting parameter is energy density. The electric field which is an energy density in space can be equated to the energy density of standing waves of photon pairs. From the quantum side the problem is finding the series of photon pairs or photon quantum states of varying wavelengths that reproduce the energy density of the electric field of a single charge in the space around it. From the electromagnetic side, the answer is given by Coulomb's law and the definition of the electric field. The electric field, although very well known, has problems with the infinite energy of a point charge and inconsistencies with calculations for the electron's radiation and self-reaction when accelerated that have not been fully resolved D. Griffiths 1999<sup>20</sup> p. 95 and 460. The problems continue with relativistic quantum mechanics making Griffiths notice its persistent nature with the comment "perhaps they are telling us that there can be no such thing as a point charge in classical electrodynamics, or maybe they presage the onset of quantum mechanics" Griffiths 1999<sup>20</sup> p. 467.

### 6.1 Characteristics of Charges and the Electric Field Relevant to the Bound Photon Model

The electric field from a single charge such as from an electron or positron is given by:

$$E(r) = q / 4\pi\epsilon_0 r^2 \quad (6-1)$$

Consider the case of uniform charges on the surface of a sphere of radius  $r_0$ . Its field is given by Equation (6-1) for  $r$  greater than  $r_0$  and it is zero for  $r$  less than  $r_0$ . The energy required to produce such a field is easily calculated by either, 1) finding the energy to generate a charge  $q$  by integrating the force times distance of a differential charge  $dq$  from infinity to  $r_0$  and then integrating  $dq$  from zero to  $q$ , or 2) integrating the energy density of the electric field from a charge  $q$  given by  $(\epsilon_0/2)E^2(r)$  from infinity to  $r_0$ . The answer is the same for both cases and it is given by:

$$U_{em}(r_0) = q^2 / 8\pi\epsilon_0 r_0 \quad (6-2)$$

It is seen that the energy cost of confining a charge to a radius  $r$  varies as  $1/r$  and is the same as the energy of the field that the charge creates to the same radius. There is an interesting similarity between the quantum expression for the energy of a photon,  $U_p = hc/\lambda$  and the energy to confine a single charge  $e$ , with both energies being a constant divided by a distance.

Even though it does not necessarily follow for the case of a photon, the relation could be thought of as confining the energy to its wavelength, the characteristic scale of a photon. It is instructive to compare the two energies by taking their ratio as:

$$\frac{U_{em}}{U_p} = \frac{e^2}{8\pi\epsilon_0 hc} \frac{\lambda}{r_0} = \frac{\alpha}{4\pi} \frac{\lambda}{r_0} \quad (6-3)$$

where  $\alpha$  is the fine structure constant. Using the diameter of the charge confinement sphere,  $2r_0$ , as equal to the photon wavelength, the ratio is  $\alpha/2\pi$ . This suggests that the coupling constant of photons is on the order of one when compared to the electromagnetic coupling constant of  $\alpha$ . Another way to compare the magnitude of the two interactions that follows from the momentum that a photon carries, is to calculate the ratio of the two forces. The force between two electrons is:

$$F_{em} = e^2/4\pi\epsilon_0 r^2 \quad (6-4)$$

The force that a single photon produces when confined to a distance  $L$  by two mirrors can be calculated from the change of momentum upon reflection  $\Delta p = 2h/\lambda$  and the time between reflections as  $\Delta t = 2L/c$  giving:

$$F_p = \frac{\Delta p}{\Delta t} = \frac{2h}{\lambda} \frac{c}{2L} = \frac{hc}{\lambda L} \quad (6-5)$$

The force to contain two photons would be double the above value or:

$$F_p = \frac{2hc}{\lambda L} \quad (6-6)$$

For  $\lambda = L$

$$F_p = \frac{2hc}{L^2} \quad (6-7)$$

The form of the distance dependence of the force is the same for both the EM and the photon forces as a constant divided by the distance squared. Using equation (6-4) for the electromagnetic force with  $2r = L$ , and equation (6-7) for the photon force, the ratio of the two forces is:

$$F_{em} / F_p = \alpha/\pi \quad (6-8)$$

The ratio of forces differs from the ratio of energies by a factor of 2 but they remain close to the value of  $\alpha$  considering that the distance photons bind is yet to be determined but expected to be close to the wavelength. These force relations show that the force necessary to contain one or two photons at a distance equal their wavelength is repulsive and its magnitude corresponds to a coupling constant of the order of one which is about the same magnitude as that of the strong force or color force. This force is usually identified as the radiation force or radiation pressure.

The photon force description of equation (6-6) is useful because it reveals exactly the magnitude of the force necessary to bind two free photons between two mirrors and the force is repulsive. For a pair of photons to bind an attractive interaction of that same magnitude is necessary and needs to be attractive. An attractive force with the magnitude of equation (6-6) could describe a fully occupied quantum state of two photons and it corresponds to the core of a massive charged particle. The field portion requires partially occupied quantum states which will be described in section 6.3. The aim of the BP model is to use this concept to describe a charged particle. A case will be made in section 6.2 to show that the very existence of a static electric field from a single charge requires an attractive force between photons when quantum mechanics is introduced in its simplest form.

## 6.2 Requirement for a Binding Photon-Photon Interaction by the Electric field

A case can be made that the very existence of an energy density in the space surrounding a single charge requires the photons to be the source of this energy density since they are the carriers of the electromagnetic force. Given that the energy density is time independent for the electric field of a charged particle at rest, the photons require an attractive interaction to form standing wave quantum states, without it, they will dissipate immediately. Another feature that points to the spatial dependence of the interaction comes from the fact that the energy density of a single charge has a radial gradient requiring an opposite pressure of  $\partial U(r)/\partial r$  for the gradient to be maintained. The gradient will be considered in determining the radial space dependence of a set of photon pair states of different wavelengths.

The fact that the experimental evidence supports the binding of photons into massive particles as discussed in Section 1.1 makes the case for the existence of the electric fields.

## 6.3 Description of a Charge in Terms of Bound Photon Standing Waves

The electron has a core where most its mass and energy resides and a field that corresponds to the electric field around the electron. The energy density  $U(r)$  of an electric field is:  $(\epsilon_0/2)E^2(r)$ , and for a single electron:

$$U(r) = e^2 / 32\pi^2 \epsilon_0 r^4 \quad (6-9)$$

The radial dependence of the energy density of equation (6-9) has to be replicated by the set of photon pair states that interact so as to form of standing waves. In addition, the integrated energy of equation (6-2) to a radius  $r_0$  has to equal the integrated energy of equation (6-9) to the same radius. Based on the experimental data in section 7, the sum of the energy of all the field

states should equal  $\alpha m_e c^2$ . To make the sum of the field and core energies equal to  $m_e c^2$  the core energy is  $(1 - \alpha) m_e c^2$ .

The details of how the photon pairs can meet the constraints can be illustrated as follows. The formation of the photon pairs has to be due to a quantum mechanical interaction therefore the photons will have a probability for reflection as well as for transmission. For this reason a configuration in space where the longer wavelength pair aids in the reflection of a shorter wavelength pair will add to the stability of all the pair states's configuration. This intuitive approach is based partly on the experimental evidence from the analysis of the experimental masses in sections 7-1 and 7-2. The maximum contribution to binding between a large number of pairs with different wavelengths appears to be a series of pairs centered at the center of the particle where the longer wavelength pair has twice the wavelength of the previous shorter one. This configuration is illustrated in Figure 6-1. With this configuration the reflection point of a shorter wave has the same phase and location as all of those with longer wavelengths. A series of these pairs with geometrically decreasing energy and geometrically increasing wavelength by factors of two with their center at the center of the charge can generate the energy density of the electric field of a single charge.

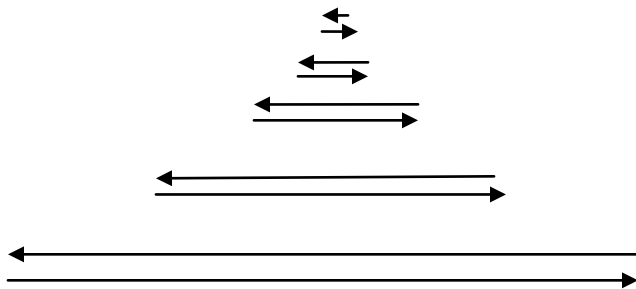


Figure 6-1

Series of photon pair states that form a single charge

illustrating their wavelength or momentum.

Figure 6-1 depicts the photon energy or momentum decreasing by factors of two illustrated vertically from the bottom up on the figure for clarity since all pairs overlap and have their center at the center of the particle. The same figure can also show the wavelength increasing by factors of two vertically down. The quantum pair states are in “s” type states thus spherically symmetric. The wavelength lines indicate the diameter of the concentric spheres giving a visual aid of what a charge would look like when composed of photon pair states.

The series of photon pair quantum states that can reproduce the electric field energy of equation (6-9) for its radial energy density dependence and equation (6-2) for its total energy down to a radius  $r_0$  is given by:

$$\epsilon_n = \frac{2hc\alpha}{2^{n-1}(\lambda_1)} \quad (6-10)$$

where  $\lambda_1$  is the photon pair state with the smallest wavelength and the 2 in the numerator accounts for the pair. The discrete radial energy density of equation (6-10) is equivalent to a continuous  $1/r^4$  dependence. That can be seen because the energy of each subsequent photon pair drops to  $1/2$  and it extends to twice the distance covering a volume that  $2^3$  times greater. For  $n = 1$  this is the expression for the energy of the quantum state of two photons of wavelength  $\lambda_1$  with an occupation level of  $1 - \alpha$ . If  $\lambda_1$  were to be chosen as the classical electron radius then all the energy will be used up to describe the electric field with none left to describe the massive core of the electron. Based on the experimental data in section 7, the wavelength  $\lambda_1$  needs to be set at a level that allows the sum of the energy of all the field states to equal  $\alpha m_e c^2$ . Summing equation (6-10) gives:

$$\sum_2^{\infty} \epsilon_n = \sum_1^{\infty} \frac{2hc\alpha}{2^{n-1}\lambda_1} = \frac{4\alpha hc}{\lambda_1} = \alpha m_e c^2 \quad (6-11)$$

The energy of all the photon pairs that represent the electric field of the electron is:

$$\epsilon_f = \alpha m_e c^2 \quad (6-12)$$

To make the sum of the field and core energies equal to  $m_e c^2$  the core energy is:

$$\epsilon_c = (1 - \alpha) m_e c^2 \quad (6-13)$$

As far as which component, the core or the field, will carry the spin of  $1/2$ , the overall evidence for the electron/positron characteristics and interactions including the findings in Section 7, point to the core pairs as the best choice. The field states will then carry zero spin each and range in space from about its Compton wavelength to infinite wavelength for the free charged particle case.

At this point the distance at which the photons bind has been assumed to be one wavelength. The possibility that they could bind at half the wavelength needs further experimental research and theoretical development. For binding at half the wavelength the description in section 6.3 will still apply with changes by factors of two only.

It is usually assumed that the electric field extends to infinity. **As a result of using a discrete sum in equation (6-11) the infinity problems that plagued EM and quantum mechanics are eliminated.** If the limit in the sum is changed from infinity to the visible size of the universe the value of  $n$  for the upper limit of equation (6-11) becomes 137, the reciprocal of  $\alpha$ . **This finding has possible cosmological implications.**

## 6.4 Introduction of the sign of a particle's charge and its particle-antiparticle nature

Equation (6-2) describes the total energy of all the volume outside a radius  $r_0$  from a single charge which has now been attributed to a cloud of photon pair states in their lowest quantum state. So far the energy has been used as the guide to generate a model that applies to a single charged or uncharged particle. Considering the space dependence of the electric field and its total energy when two like charges are moved apart or closer together clarifies what the effect should be on the number and occupation levels of photon pair states in the surrounding space of the two charges. A pair of like charges when moved closer requires the introduction of energy to the field thus an increase in the number and occupation levels for photon pair states, and if already fully occupied, an increase in the number of photon pair states. For unlike charges the same motion does the opposite, it generates energy decreasing the field and the occupation levels or number of photon pair states. This behavior is related to the fact that a pair of opposite charges one positive and the other negative create their electric fields in opposite directions so that they can cancel each other's field. When a positive and a negative charge are moved closer together so that the particle centers almost overlap, the field in all the space around them decreases to a near to zero value. When the cores meet both particles are annihilated and two free photons are emitted carrying the energy of the two cores. This indicates that a negatively charged lepton is a particle and a positively charged lepton is an antiparticle. The question as to what makes a set of photon pair states generate a positive or negative charge can be answered by assuming that right handed circularly polarized photon pair states form negative charges and are particle-like, and left-handed circularly polarized photon pair states form positive charges and are antiparticle-like. This definition is adequate for the leptons.

The quarks should also be included in this definition to be consistent but currently they are not included because the quarks were discovered much later. The nomenclature should be that positively charged quarks are antiparticles and negatively charged quarks are particles. Quarks exist only in mesons and baryons which generally have charges of both signs within. Identification of mesons as to whether they are particles or antiparticles has been inconsistent in the field. What is suggested here is that a consistent definition for both mesons and baryons is possible with a nomenclature change with the identification made as to particle or antiparticle first, by the sign of its charge if it is a single particle (a lepton); second if composed of two or three particles (mesons and baryons) by its decay products. For annihilation, all that is required of the mesons and baryons is that each of their constituent quarks meets its own antiparticle.

## 7 Particle Masses

Historically, the development of theories for the observed particle mass spectrum has been slow and not able to generate accurate mass values. The current theory of QCD with the quark and gluon particles has been hampered by mainly two reasons: 1) the fact that quarks and gluons do

not exist in isolation denying guidance to alternative theories by comparisons with accurately known experimental mass values, and 2) the fact that at the present time theorists have not been able to solve the complex QCD equations forcing the use of lattice theory with its extreme computational burden and extensive use of approximations to generate mass values with accuracies currently in the 5 to 10% range. The constituent quark model provides slightly greater accuracy than the current QCD solutions but it uses parameters that are adjusted to best fit from the experimental data which should actually come from the theory. As was done in the previous sections in developing the bound photon model, the experimental mass data was examined for additional patterns beyond those found by Malcom MacGregor<sup>15</sup>. Historically, looking for patterns in the experimental data has been a useful guide to viable theories as it happened with non-relativistic quantum mechanics with the rich radiation spectrum of the elements.

### 7.1 Exploration of the Experimental Particle Mass Spectrum

Examination of the mass particle spectrum in terms of the traditional leptons, mesons and baryons shows a well populated region above 100 Mev that is about three orders of magnitude wide and includes the mesons, baryons and two of the charged leptons which will be identified as the “upper spectrum”. The “lower spectrum” contains only the electron and three neutrinos and is about seven orders of magnitude wide. The pattern, first observed by Yoichiro Nambu<sup>22</sup> and further explored by Malcom MacGregor<sup>15</sup>, suggests quantization of some form as the masses are close to multiples of what appears to be a basic mass value, the mass of the electron divided by the fine structure constant, or  $m_b = m_e/\alpha$  with a value of 70.025 Mev. The upper spectrum particle masses can be written as:

$$M = N m_b \quad (7-1)$$

where N is an integer or half integer. For example the mass of the pion is 139.57 Mev or  $N = 2$ , the K meson 493.68 Mev or  $N = 7$  and the mass of the proton 938.27 Mev or  $N = 13\frac{1}{2}$ . Quantization according to equation (7-1) implies that there is a basic length associated with the photon pair that forms the massive particle. The source of the basic length may reside in the invariant spin of the photon. Currently the spin is considered to be intrinsic but in quantum mechanics it has the same analytic description as orbital angular momentum with a circular flow of energy at the speed of light as interpreted by Hans Ohanian<sup>23</sup>. With a circularly polarized photon, the angular momentum  $p(\text{radial}) \times r$  results in  $r$  being perpendicular to the photon’s motion and thus it will remain unchanged under a Lorentz transformation. The characteristic wavelength of a free photon depends on the observer frame of reference thus there is no reference frame or scale. When two photons bind their momentum is in opposite directions thus they acquire a reference frame. A resonance can be expected when the length of the longitudinal oscillating motion that generates the standing wave of the two photons equals the length of the transverse circular motion of energy<sup>23</sup> given by  $2\pi r$ . This could explain the existence of a scale parameter in the particle mass spectrum.

To experimentally evaluate the compliance to equation (7-1) a group of 12 mesons and leptons and another group of 9 baryons, whose mass has been measured to better than 0.35 Mev, was chosen and are described in Tables 7-1 and 7-2, listed in order of increasing mass.

Table 7-1

Experimental meson and lepton masses compared with integer and integer or half-integer basic masses

Particle	Measured mass m (Mev)	$m/m_b$	N	Residue from nearest integer N ( $m_b$ Units)	N	Residue from integer or half-integer N ( $m_b$ Units)	Mass Experimental uncertainty ( $m_b$ Units)
$\mu$	105.6583715 $\pm 35$	1.508861059	2	-0.49114	1½	0.008861059	5.0x10 <sup>-8</sup>
$\Pi^\pm$	139.57018 $\pm 35$	1.99314079	2	-0.00685921	2	-0.00685921	5.0x10 <sup>-6</sup>
$\Pi^0$	134.9766 $\pm 6$	1.92754188	2	-0.07235812	2	-0.07235812	8.6x10 <sup>-6</sup>
$K^\pm$	493.677 $\pm 16$	7.049986	7	0.049986	7	0.049986	2.3x10 <sup>-4</sup>
$K^0$	497.614 $\pm 24$	7.106208	7	0.106208	7	0.106208	3.4x10 <sup>-4</sup>
$\eta$	547.853 $\pm 24$	7.823649	8	-0.176351	8	-0.176351	3.4x10 <sup>-4</sup>
$\rho$	775.49 $\pm 34$	11.0744	11	0.0744	11	0.0744	4.9x10 <sup>-3</sup>
$\omega$	782.65 $\pm 12$	11.17668	11	0.17668	11	0.17668	1.7x10 <sup>-3</sup>
$K^*$	891.66 $\pm 26$	12.7334	13	-0.2666	12½	0.2334	3.7x10 <sup>-3</sup>
$\eta'$	957.78 $\pm 6$	13.6776	14	-0.32236	13½	0.17764	8.6x10 <sup>-4</sup>
$\Phi$	1019.455 $\pm 20$	14.55839	15	-0.44161	15½	0.05839	2.9x10 <sup>-4</sup>
$\tau$	1776.82 $\pm 16$	25.37399	25	0.37399	25½	-0.12601	2.3x10 <sup>-3</sup>
Mean				0.1956		0.1056	
Random				0.2500		0.1250	

The ratio of the experimental mass m over the basic mass  $m_b$ , shown in column 3 of the two tables, will be used to evaluate the tendency in two ways. First, the difference between the ratio and the nearest integer N is computed and the results shown in columns 4 and 5, and second, the difference between the ratio and the nearest integer or half-integer N is computed and shown in columns 6 and 7. To judge the tendency to integer N, the mean residue is computed as well as the mean residue corresponding to a random distribution of masses as shown in the last two lines. For the group of 12 mesons and leptons in Table 7-1, the mean residue of 0.1956 compared with 0.2500 for a random distribution shows a slight tendency for integer values. For integer or half integer values, the mean residue 0.1056, compared with 0.1250 for the random distribution yields a similar slight tendency.

Table 7-2

Experimental baryon masses compared with integer and integer or half-integer basic masses

Particle	Measured mass m (Mev)	m/m <sub>b</sub>	N	Residue from integer N ( m <sub>b</sub> units)	N	Residue from integer or half integer N ( m <sub>b</sub> units)	Experi- mental uncert. (m <sub>b</sub> units)
p	938.272046±21	13.39905338	13	0.39905338	13½	-0.10094662	3.0x10 <sup>-7</sup>
n	939.565371 ±21	13.4175227	13	0.4175227	13½	-0.08247727	3.0x10 <sup>-7</sup>
Λ	1115.683 ±6	15.932582	16	-0.0674	16	-0.0674	8.6x10 <sup>-5</sup>
Σ <sup>+</sup>	1189.33 ±7	16.98487	17	-0.01513	17	-0.0151	1.0x10 <sup>-3</sup>
Σ <sup>0</sup>	1192.642 ±24	17.03160	17	0.0316	17	0.0316	3.4x10 <sup>-4</sup>
Σ <sup>-</sup>	1197.449 ±30	17.100246	17	0.1002	17	0.1002	4.3x10 <sup>-4</sup>
Ξ <sup>0</sup>	1314.86 ±20	18.77694	19	-0.2231	19	-0.2231	2.9x10 <sup>-3</sup>
Ξ <sup>-</sup>	1321.71 ±7	18.87476	19	-0.1252	19	-0.1252	1.0x10 <sup>-3</sup>
Ω	1672.45 ±29	23.88352	24	-0.1165	24	-0.1165	4.1x10 <sup>-3</sup>
Mean				0.1662		0.0958	
Random				0.2500		0.1250	

Table 7-2 makes the comparisons with a selection of 9 baryons with a better but still slight tendency. Looking at individual particles in Table 7-1 the tendency is stronger with an accuracy of better than one percent deviation in the residues of the muon and the charged pion in column 7. Four other particles had accuracies from 5% to 7% with a mean of 5.1%. The mean of 6 out of the 12 is 4.5%. The tendency for the individual baryons of Table 7-2 is not as good as compared to the mesons and leptons of Table 7-1. Overall, the slight evidence of the first method and the stronger evidence for 6 of the 12 particles at 4.5% in Table 7-1, can be judged to be moderate and justifies continuing the exploration for patterns in the particle masses as well as possible experiments that could provide verification.

The residues for the pion and the muon of 0.00886 and 0.00686 basic masses are close to the value of the fine structure constant of 0.00729 suggesting the conversion of those residues back to electron masses since the basic mass was defined as  $m_e/\alpha$ . After conversion, the values of 1.21428414 for the muon and 0.93996 for the charged pion show a value close to one electron mass for both. To check the tendency for integer and half integer electron masses, the basic mass residues of column 7 in Tables 7-1 and 7-2 were calculated in units of electron masses for the particles that have an experimental uncertainty of less than 0.1 of the electron mass and the results are shown in tables 7-3 and 7-4. The same analysis was repeated for electron masses using the variable K.

Table 7-3

Experimental meson and lepton basic mass residues compared  
with integer, and integer or half-integer electron masses

Particle	Measured mass m (Mev)	N residue $m/m_b - N$ ( $m_b$ units)	N residue $(m/m_b - N)/\alpha$ ( $m_e$ units)	K	K residue from integer ( $m_e$ units)	K	K residue from integer or $1/2$ integer ( $m_e$ units)	Exp. Uncert. ( $m_e$ units)
$\mu$	105.6583715	0.008861067	1.214285046	1	0.214285046	1	0.214285046	$6.8 \times 10^{-6}$
$\Pi^\pm$	139.57018	-0.00685921	-0.93995919	-1	-0.060041	1	-0.060041	0.0006
$\Pi^0$	134.9766	-0.07235812	-9.92937	-10	0.07063	10	-0.07063	0.0012
$K^\pm$	493.677	0.0499856	6.84983	7	-0.15017	7	-0.15017	0.0313
$K^0$	497.614	0.1062082	14.5544	15	-0.4457	$14\frac{1}{2}$	-0.0544	0.0470
$\eta$	547.853	-0.176351	-24.1664	-24	-0.16638	24	-0.16638	0.0470
$\Phi$	1019.455	0.058392	8.00175	8	0.00176	8	0.00176	0.0391
Mean		0.1056			0.1548		0.0889	
Random		0.125			0.2500		0.1250	

Table 7-4

Experimental baryon basic mass residues compared with integer,  
and integer or half-integer electron masses.

Particle	Measured mass m (Mev)	N residue $m/m_b - N$ ( $m_b$ units)	N residue $(m/m_b - N)/\alpha$ ( $m_e$ units)	K	K residue from integer ( $m_e$ units)	K	K residue from integer or $1/2$ integer ( $m_e$ units)	Exp. Uncert. ( $m_e$ units)
P	938.272046	-0.10094662	-13.8333211	-14	0.1666789	-14	0.1666789	$41 \times 10^{-6}$
n	939.565371	0.08247727	11.302355	11	0.302355	$11\frac{1}{2}$	0.19765	$41 \times 10^{-6}$
$\Lambda$	1115.683	0.06742	9.238738	9	0.23874	9	0.23874	.0012
$\Sigma^0$	1192.642	0.03160	4.33027	4	0.33027	$4\frac{1}{2}$	0.16973	.0313
$\Sigma^-$	1197.449	0.10025	13.73734	14	0.26266	$13\frac{1}{2}$	0.23734	.0470
Mean		0.1056			0.2601		0.202	
Random		0.1250			0.2500		0.1250	

The comparison of the mean deviation with the mean of a random distribution shows a slight tendency to integers for the lepton and mesons and none for the baryons. Looking at the individual particles, three of the seven particles in Table 7-3 have accuracies between 7 and 4% with a mean value of 5.5%. These results for the electron masses, to show similar accuracies as

the basic masses, is somewhat surprising because the large value of the basic mass, by a factor of 137 over the electron mass, would mask a tendency to show integer or half integer values for the electron mass. Together, the tendency from the comparison of the mean with random distribution and the accuracy levels of 3 of the seven particles appear significant enough to introduce the K parameter to equation (7-1). The possible conclusion is that they fit the postulate that the core mass of a particle varies as multiples of a basic mass and the field mass varies as multiples of the electron mass when the particle carries a charge and it belongs in the upper spectrum. At Fermi level distances the mass of an  $\alpha$ -occupied photon pair state is  $\alpha m_b$ , the electron mass, which fits fairly well with the experimental results for K in Table 7-3. These results provide support for adding the K values for the electron masses to equation (7-1) as:

$$M = N m_b + K m_e \quad (7-2)$$

Further analysis of the experimental mass data shows two particles with high precision fractions for K described in 7.2.

## 7.2 High Precision Potential Quantization Values Identified for the Masses of the Proton and the Muon

Further analysis of the experimental data in tables 7-3 and 7-4 data shows two particles that have very high precision fractions for K.

The mass of the proton using equation (7-2) can be written as:

$$M_p = 13\frac{1}{2} m_b - 13.8333211 m_e \quad (7-3)$$

where N is from Table 7-2, column 6 and the N residue in electron mass units is from Table 7-4 column 4. An interesting feature here is that the values of the two mass coefficients are close to each other, suggesting the form:

$$M_p = 13\frac{1}{2} m_b - 13\frac{1}{2} m_e - 0.3333211 m_e \quad (7-4)$$

An even more surprising feature is that the last term is extremely close to  $-1/3$ . The difference is 12 parts per million of an electron's mass. **In addition, the closeness of this value to  $-1/3$  for the proton acquires great significance from the fact that the quarks have charges of  $1/3$  and  $2/3$  and it fits the assumption that the K term of equation (7-2) represents the mass of the electric field of the quarks which at Fermi distances is of the order of electron masses.**

The difference between the experimental proton mass of equation (7-4) in eV and the proton mass when the last term is changed to exactly  $-1/3$  is 6.23 eV which yields a relative accuracy for the proton mass of 6.6 parts per billion. The uncertainty of the experimental mass is 21 eV which puts the residue well inside the experimental uncertainty of the proton mass.

A high precision value was also found for the muon. The muon mass in Tables 7-1 and 7-3 shows  $1\frac{1}{2}$  for N and 1 for K with a residue of 0.214285046 electron masses. The fraction  $3/14$  is 0.214285714 and differs from the residue by 0.000000668 or 0.67 parts per million of an electron mass, or 0.34 eV. The mass of the muon can then be expressed as:

$$m_{\mu} = 1\frac{1}{2} m_b + 1\frac{3}{14} m_e \quad (7-5)$$

which can be considered to be a quantized value for the mass. It differs from the experimental mass by 0.34 eV and is well within the experimental uncertainty of 3.5 eV. The difference between the indicated quantized value (IQV) of equation(7-5) and the experimental mass of the muon is 0.34 eV yields a relative accuracy of 3.2 parts per billion for the muon mass.

The mass of the proton from equation (7-4) showed that it was composed of  $13\frac{1}{2}$  basic masses and close to  $13\frac{1}{2}$  electron masses. The same feature, that the value of N is close the value of K, is also seen in the mass of the muon. Expressing the basic mass in terms of the electron mass and eliminating the small parts per million residue the proton mass becomes:

$$m_p = 13\frac{1}{2} m_e/\alpha - 13\frac{1}{2} m_e - 1/3 m_e \quad (7-6)$$

Factoring out the  $13\frac{1}{2}$  in equation (7-6) and converting all terms to electron masses gives the form:

$$m_p = \frac{27}{2} \left( \frac{1}{\alpha} - 1 \right) m_e - 1/3 m_e \quad (7-7)$$

Equation(7-5) for the muon mass shows  $1\frac{1}{2}$  basic masses and close to  $1\frac{1}{2}$  electron masses allowing the same change of the form as was done for the proton. Converting the basic mass to electron masses and factoring out the  $1\frac{1}{2}$  in equation (7-5) the muon mass becomes:

$$m_{\mu} = \frac{3}{2} \left( \frac{1}{\alpha} - 1 \right) m_e + 2\frac{5}{7} m_e \quad (7-8)$$

Equations (7-7) and (7-8) show that the first term of the proton mass is exactly 9 times the first term of the muon mass. At this point the first term of equations (7-7) and (7-8) does not exactly represent the number of basic masses as it is smaller by the factor  $(1 - \alpha)$  or about 1%. This form of the mass equation for the proton and the electron will be discussed in section 7.3.

These two high precision findings from equations (7-5) and (7-6) as well as equations (7-7) and (7-8) for the proton and muon strongly suggest that the N and K values found for these two particles are the quantized mass eigen values of a theory of particle masses that surpasses the current theory by 7 to 8 orders of magnitude which of course has yet to be developed. These indicated quantized values (IQV) are the experimental confirmation of a theory that quantizes the core and field masses together. Equation (7-2) constitutes an initial approximation for the particles in tables 7-3 and 7-4. A more accurate complete theory will include the interaction between the core pair and the field pairs which would apply to the leptons in the upper spectrum.

For the mesons the theory would add two-particle interactions that include the core-to-core and field-to-field interactions in addition to the already mentioned core-to-field interaction. For the baryons it would be a three-particle theory that includes the interactions of the 3 cores and 3 fields. It is expected that the actual values of N and K will be determined by such theories and they can become theories beyond the standard model that replace QCD.

### High Precision Values Summary Table

The analysis presented in tables 7-1 to 7-4 was done in 2013 using particle masses and constants from the 2010/2012 CO Data. The publication of this report was expected to be in 2017.

Table 7-5

#### Summary of the High Precision Indicated Quantization Data

	Parameters	2010/2012 CO DATA	2014 CO DATA
Proton	Indicated Quantization Value (IQV) or Mass Equation	$\frac{27}{2} \left( \frac{1}{\alpha} - 1 \right) m_e - \frac{1}{3} m_e$	Same
	Experimental Mass	$\text{IQV} + 12 \times 10^{-6} m_e$	$\text{IQV} - 1.9 \times 10^{-5} m_e$
	Accuracy of IQV	$12 \times 10^{-6} m_e$ or 6.2 eV	$1.9 \times 10^{-5} m_e$ or 9.7 eV
	Relative Accuracy of IQV	$6.6 \times 10^{-9}$ or 6.6 ppb	$1.0 \times 10^{-8}$ or 10 ppb
	Uncertainty of Exp. Mass	21 eV	5.8 eV
	Relative Uncertainty of Experimental Mass	$2.2 \times 10^{-8}$ or 22 ppb	$6.2 \times 10^{-9}$ or 6.2 ppb
Muon	Indicated Quantization Value (IQV) or Mass Equation	$\frac{3}{2} \left( \frac{1}{\alpha} - 1 \right) m_e + 2 \frac{5}{7} m_e$	Same
	Experimental Mass	$\text{IQV} - 6.7 \times 10^{-7} m_e$	$\text{IQV} + 1.8 \times 10^{-6} m_e$
	Accuracy of IQV	$6.7 \times 10^{-7} m_e$ or 0.34 eV	$1.8 \times 10^{-6} m_e$ or 0.93 eV
	Relative Accuracy of IQV	$3.2 \times 10^{-9}$ or 3.2 ppb	$8.8 \times 10^{-9}$ or 8.8 ppb
	Uncertainty of Exp. Mass	$6.8 \times 10^{-6} m_e$ or 3.5 eV	$4.7 \times 10^{-6} m_e$ or 2.4 eV
	Relative Uncertainty of Experimental Mass	$3.3 \times 10^{-8}$ or 33 ppb	$2.3 \times 10^{-8}$ or 23 ppb
Source Values	Proton Mass	938.272046(21) MeV	938.2720813(58) MeV
	Muon Mass	105.6583715(35) Mev	105.6583745(24) Mev
	Electron Mass	0.510998929(11) Mev	0.5109989461(31) Mev
	Fine Structure Constant	0.0072973525698(24)	0.0072973525664(17)

In view of the high precision values found for the proton and the muon, the data for those two particles was recalculated with the 2014 CO Data. For completeness and ease of comparison both sets are shown in Table 7-5.

The new data gives slightly less accurate results for the proton and slightly more accurate results for the muon in terms of the relative accuracy of the mass therefore the strength of the

conclusions can be considered to be same. It should be pointed out that the value of the fine structure constant for the 2014 CO Data changed outside the uncertainty range of the 2012 CO Data.

### 7.3 Alternative Choice for the Basic Mass

A relationship between the masses of elementary particles was noticed as far back as 1952 in a table by Y. Nambu<sup>22</sup> quoted by M. MacGregor<sup>15</sup> p. 373. The masses appear to be integers and half integer multiples of a basic mass equal to  $m_e/\alpha$  for 7 elementary particles. Recently a more comprehensive analysis was carried out by M. MacGregor<sup>15</sup> pp.399-401 for about 50 particles. Those two authors and this paper up to this point have used the same value for the basic mass as  $m_e/\alpha$ . The introduction of equation (7-2) for the masses of a charged particle to be composed of a number of basic masses and a second number of electron masses suggests the concept of using a core mass and a field mass for the particles. Another feature to consider is that the basic mass has never been measured it just appeared to fit as  $m_e/\alpha$  since 1952. Experimentally the sum of both core and field masses is measured therefore it makes sense to reduce the basic mass by a factor  $(1 - \alpha)$  so that the field mass is  $\alpha m_b$ . This fits the fact that the field contribution is electromagnetic thus it should have a coupling constant of  $\alpha$ . The alternate basic mass will be identified as the reduced basic mass or  $m_{rb}$  and it is equal to  $(1 - \alpha) m_b$  for this analysis.

Table 7-6

Particle masses from Tables 7-3 and 7-4 using a reduced basic mass  $m_{rb}$

	Mass m (Mev)	$m/m_{rb}$ ( $m_{rb}$ )	$N_r$	$N_r$ Residue ( $m_e$ )	$K_r$	$K_r$ residue ( $m_e$ )
$\mu$	105.6583715	1.519952797	1½	2.714285046	2 5/7	$0.668 \times 10^{-6}$
$\pi^\pm$	139.57018	2.00779236	2	1.060040873	1	0.0600487
$\Pi^0$	134.9766	1.94171123	2	-7.92937128	8	-0.0706287
$K^\pm$	493.677	7.10181005	7	13.8498316	14	-0.150168
$K^0$	497.614	7.15844592	7	21.5543487	21½	0.543487
$\eta$	547.853	7.88116104	8	-16.166376	-16	-0.166376
$\Phi$	1019.455	14.6654103	14½	22.501756	22½	0.001756
P	938.272046	13.49754976	13½	-0.3333211	-1/3	$12.2 \times 10^{-6}$
n	939.565371	13.51615494	13½	2.197652867	2	0.1976529
$\Lambda$	1115.683	16.0497020	16	6.7612627	7	-0.238737
$\Sigma^0$	1192.642	17.1567988	17	21.330275	21½	-0.169725
$\Sigma^-$	1197.449	17.2259500	17	30.737340	30½	0.237340

The particle masses of Tables 7-3 and 7-4 were recalculated using a reduced basic mass  $m_{rb}$  with the equation:

$$m = N_r m_{rb} + K_r m_e \quad (7-9)$$

and are shown in Table 7-6. The change to reduced masses generally leaves  $N$  the same, so  $Nr = N$ , and increases the value of  $K$  by  $N$  integers. Also, the high precision levels are preserved. For the proton, which had a  $K$  value of  $-13.8333211$  in Table 7-4, the change increased  $K$  by  $13\frac{1}{2}$  leaving a value of just  $-0.3333211$  for  $K_r$ .

To connect the results of section 7-2 involving equations (7-7) and (7-8) the following relations illustrate the process. When the calculation is made for the reduced basic mass the relation is:

$$m_{rb} = m_b (1 - \alpha) = m_b - \alpha m_b \quad (7-10)$$

for the reduced mass in terms of the electron mass:

$$m_{rb} = m_e/\alpha - m_e = \left(\frac{1}{\alpha} - 1\right) m_e \quad (7-11)$$

The last term in equation (7-11) has the same factor that appeared in the first term of equations (7-7) and (7-8) when  $N$  electron masses were factored out of the second term in equations (7-5) and (7-6).

Adjusting the core mass from the basic mass  $m_b$  to the reduced basic mass  $m_{rb}$  is equivalent to considering the first term in equations (7-7) and (7-8) to be the new core mass.

#### **7.4 Particle Masses Conclusions**

1. A fresh analysis of the particle mass spectrum in terms of the leptons, mesons and baryons and the finding of a basic mass suggest the definition of an upper spectrum with masses above 100 Mev where most of the particles are and a lower spectrum with the electron and the three generations of neutrinos.
2. The particle masses of the leptons, mesons and baryons are quantized in multiples of a basic mass accurate to about 7% for low masses in the first generation. The three generations nomenclature is not strictly obeyed. The pion and the muon are in the same first generation.
3. The experimental evidence shows that not all the mass values for the multiples of the basic mass  $N$  are realized thus a further refinement of the theory needs to be developed to predict the values seen in nature.
4. Extremely accurate experimental mass values were discovered for the proton and the muon to a level of a few parts per billion. These values experimentally confirm a mass quantization theory of extreme mass accuracy that is yet to be developed. The mass value of  $13\frac{1}{2}$  basic masses minus  $0.333321$  electron masses for the proton confirm that the masses of the quarks are in accordance with the charges of a quark of  $1/3$  or  $2/3$ .

## 8 Quantum Gravity based on the Bound Photon Model

As it is well known, Einstein's general relativity is incompatible with quantum mechanics even though it has provided a wide range of experimentally verified results. Historically, despite substantial efforts for a solution, this problem has remained unsolved for almost a century. The important theoretical reason is that Maxwell's equations in QED are linear while the Einstein equation is non-linear<sup>24</sup> Hartle p. 445. Another reason is that general relativity was developed by Einstein for massive particles with no quantum interactions. Based on the premise that the BP model uses photons for the particles, which are the solution of Maxwell's equations, allows the use of conformal symmetry for a quantum gravity theory. Among the many theoretical efforts to develop a quantum gravity theory, the use of conformal gravity is attractive because it directly solves the problem except for fact that the solution requires that all particles involved to be massless<sup>25</sup> Moffat p.150. The introduction of massive particles under the current standard model requirements destroys conformal invariance. To develop quantum gravity theories for massive particles theoreticians have tried to use symmetry breaking, various string theories and many other methods with no success to the present time. One example is Mannheim's conformal gravity<sup>26</sup> which attempts to develop a conformal gravity theory and uses symmetry breaking to allow the use of massive particles. Ironically the BP model uses a pair of massless photons so there is no need to destroy conformal symmetry.

The BP model allows simpler solutions which require simpler physics and quantum mechanics. As has been mentioned in this report, many of the problems are due to having to use the more complex quantum mechanics of the standard model. The BP model takes advantage of the following features to build a quantum gravity theory. Particles exhibit the characteristics of a wave when they travel between two points, and the characteristics of a particle when they are absorbed or reflected.

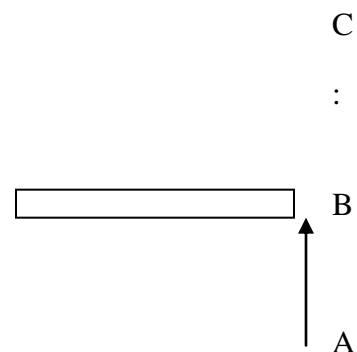


Figure 8-1

When a particle travels as a wave from point A to point B in Figure 8-1, it may be reflected at the target at B or go beyond into space shown as C. As a wave the particle explores all possible

paths including paths well beyond point B shown as C which theoretically includes all of the universe even when it is reflected at B back to A<sup>26-27</sup>. In the case of the BP model, a photon continually reflects between two points in space that are a wavelength apart. When a particle explores all possible paths in space the question can be asked: what is the effect on all that space? A tantalizing answer is that the effect on that space is gravity whose magnitude will be determined by the number of times per second that a photon is reflected into space. This is also supported by the observation that a pair of photons are entangled when they are bound. Once entangled, a measurement of spin on one affects the behavior of the other no matter how far it is. This was called “spooky action at a distance” by A. Einstein. **By uniting two mysterious properties of particles: entanglement and the exploration of all possible paths in the universe, the two difficult to understand mysteries in physics are reduced to one grander one. This could be the basis to a fully unified quantum gravity theory.**

### 8.1 Static Quantum Gravity

A quantum gravity theory can be developed using conformal invariance. The case of static gravity will be treated first. The BP model uses reflections per second to determine the magnitude of the gravity. The Newtonian gravity uses the gravitational constant G to fix the magnitude. To make the comparison between the two theories, the same amount of mass will be used for both. For quantum gravity each of the photons obey the quantum relation  $E = h\nu$  where  $\nu$  is the frequency of the photon wave which is the same as the number of reflections per second. The pair of photons that form a massive particle have an energy  $E = mc^2$  where  $m$  is the mass of the particle. The rest energy of a composite particle can be determined by adding the energies or masses of its components, for example, using the mass of one hydrogen atom for the masses of the three quarks and one electron. The reflection rate for a hydrogen atom is:

$$\nu = \frac{mc^2}{h} \quad \text{Equation (8-1)}$$

where  $m$  is the mass of a hydrogen atom and  $h$  is Planck’s constant. Using MKS units  $\nu$  becomes  $2,2688 \times 10^{23}$  reflections per second. The comparison will be made for a mass of one kilogram. Using the number of hydrogen atoms in one kilogram as  $5.9786 \times 10^{26}$ , gives a reflection rate of:  $1.3564 \times 10^{50}$  reflections per second for the quantum gravity case.

The Newtonian gravity force is defined by:

$$F_N = \frac{m_1 m_2 G}{r^2} \quad \text{Equation (8-2)}$$

Using the same format for quantum gravity the force is:

$$F_q = \frac{m_1 m_2 H}{r^2} \quad \text{Equation (8-3)}$$

where H is the new quantum gravity constant. Using the force equation for both cases simplifies the comparison. The ratio  $F_q/F_N$  gives the comparison of the constants H and G with the values:

$$H = 1.3564 \times 10^{50} \text{ and } G = 6.673 \times 10^{-11} \text{ making } H/G = 2.0327 \times 10^{60}.$$

There is an artificial case where this new quantum gravity will differ from the Newtonian one. The photons of a massive particle normally bind at a distance of their wavelength. If the pair of photons are reflected over a distance that is k times their wavelength, the gravity generated will be reduced by a factor k. This lower quantum gravity effect could potentially be verified by experiment but it will be very difficult because of the extreme weakness of the gravitational force. The effect may be observed in high gravity environments by the interaction and collapse of two massive black holes, two neutron stars or a massive black hole and a neutron star.

## 8.2 Dynamic Quantum Gravity

In going from the static case to the dynamic case a transformation to a velocity v will be applied to the pair of photons in the static case. Newtonian gravity ignores the velocity of the particles and in Einstein's general relativity theory a boost to a velocity v applied equally to a large number of massive particles can be done by using the Schwarzschild solution. In the BP model gravity, each of the photons in the pair travel at c in opposite directions and their energy and direction is changed in a boost to a velocity v according to the Doppler relations. The dynamics are quite different: first because there are two particles involved, and second because each photon in the pair has its own velocity of c or -c. The Doppler relations change the energy and direction of each photon in the pair differently. The results from general relativity (GR) are expected to disagree with the results from the BP model quantum gravity because GR does not include quantum mechanics and the fact that GR equations are non linear<sup>24</sup>. For the energies of the two photons the Doppler relations are:

$$E_1 = (\gamma E_0/2)[1 + (v/c) \cos\theta_0] \quad E_2 = (\gamma E_0/2)[1 - (v/c) \cos\theta_0]$$

Where  $E_0$  is the rest energy of the massive particle,  $E_1$  and  $E_2$  are the energies of the two photons and  $\gamma = 1/(1 - v^2/c^2)^{1/2}$ . The angular direction is modified by the Doppler relation as:

$$\cos\theta = (\cos\theta_0 + v/c) / [1 + (v/c) \cos\theta_0]$$

where  $\theta_0$  is the angle in the photon pair frame of reference when at rest and  $\theta$  is the angle after the boost to v. With the BP gravity the rate of reflections of each of the two photons will be modified by the Doppler relations. For a large collection of particles all moving with the same velocity the Schwarzschild geometry can be used. The first two terms of the Schwarzschild geometry<sup>24</sup> p. 186 are:

$$ds^2 = -\left(1 - \frac{2GM}{rc^2}\right) (cdt)^2 + \left(1 - \frac{2GM}{rc^2}\right)^{-1} dr^2 \quad \text{Equation (8-4)}$$

The Schwarzschild geometry shows a characteristic of the BP model that was described in section 5.3 for the relativistic solutions of the Dirac equation as the sum of a variable and the reciprocal of a variable (VRV). It is surprising that the VRV characteristic of the BP model shows up in the relativistic Schwarzschild geometry with equation (8-4). A closer look at the details shows that the term with the time derivative can be related to the energy in the wave of a quantum solution and the space derivative can be related to the momentum. Perhaps this is the reason for the two theories to agree in the low velocity and weak gravity regime. The two interesting relationships, VRV and the involvement of a quantum wave with the time and space derivatives provide an incentive for further foundational theoretical research.

## References

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