# Standing (Electromagnetic) Wave Structure of the Electron- III Creation of the Electric Charge

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**Abstract**

The author shows that that just as the mass and the spin, the electric charge of the electron also could be attributed to its standing helical (electromagnetic) half wave structure [1]. It turns out that the fine structure constant is the ratio of the electromagnetic field energy of the electron to its total energy. The magnetic dipole moment of the electron also emerges in a simple manner from the standing helical half wave structure. This structure rules out the existence of the magnetic monopole. The standing helical half wave structure also allows two other states which could represent spin half particles with no electrical charge. The author suggests that they could very well represent the neutrino and the anti-neutrino.

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## 1 Introduction

We know that the plane wave which represents a particle could be formed by the confinement of the electromagnetic wave [1]**.** The standing wave formed by such a confinement was seen to generate mass. The space-dependent component of the standing wave when given a translational velocity was seen to get converted into the amplitude wave which gets compacted into the internal coordinates while the time-dependent component gets converted into the phase wave that represents the particle in the external coordinates. It was observed that the compacted amplitude accounts for the spin of the particle [2]. The idea that the EM wave forms the most basic structure of a particle like the electron is quite appealing in the light of the fact that the electron-positron collision results in only high energy photons. Besides, the electron possesses only the electromagnetic field.

We know that in the rest frame of reference, the standing EM half wave structure of the electron as represented in the equation given below describes the creation of the mass and the spin of the particle [1][2].

$$\phi_o^R \quad = \quad 2\left[\boldsymbol{\xi}_{\mathbf{yo}} \cos\left(E_o x_o'/\hbar c\right) - \boldsymbol{\xi}_{\mathbf{zo}} \sin\left(E_o x_o'/\hbar c\right)\right] e^{-i\hbar^{-1}E_o t_o} \quad . \tag{1}$$

The standing wave given here is right handed (positive helicity) and is oriented along the x-axis. We may obtain the left handed standing wave by changing the sign of vector $\boldsymbol{\xi}_{zo}$. A standing half wave formed by the confinement of a photino, which is the name given to a single EM wave, is called by the name 'staphon' which is a short form for standing photino. We know that this staphon when given translational velocity along the x-axis takes on the form of the plane wave given by [2]

$$\phi^{R} = 2\{\xi_y \cos[E(x'-vt')/\hbar c] - \xi_z \sin[E(x'-vt')/\hbar c]\} e^{-i\hbar^{-1}(Et-\text{þ}x)} . \quad (1A)$$

This can be simplified by taking $\xi_y = \xi \cos\varphi$ and $\xi_z = \xi \sin\varphi$ and we obtain

$$\phi = \xi\{e^{i[E(x'-vt')/\hbar c+\varphi]} + e^{-i[E(x'-vt')/\hbar c+\varphi]}\} e^{-i\hbar^{-1}(Et-\text{þ}x)} . \quad (1B)$$

Here $\phi$ represents the linear combination of the forward and the reverse waves which have opposite helicities although their spin is aligned in the same direction.

We saw that this standing half wave structure of the particle explains the Pauli's exclusion principle in a simple manner. If this staphon structure provides explanation for so many properties of the electron, it is but natural to expect that such a structure should also explain the creation of its electric charge. If such an explanation is possible, then it becomes quite obvious that the current approaches which treats an electron as a point particle are just approximations. We know that quantum electrodynamics has to deal with the problem of infinities regarding the self energy and the charge of the electron arising mainly from the point particle picture and these problems of infinities have been resolved using the renormalization procedure which is basically an adhoc approach [3]. Note that the standard model treats particles as point masses which can at best be an idealization. The proposed staphon structure of the electron appears to be an improvement over such a picture as it introduces definite spatial spread to the particle. We shall now attempt to extend the approach to explain the creation of the electric charge of the electron.

## 2 The Electromagnetic Field of a Charged Particle

We know that the relativistic transformation equations for the EM field of a charged particle are given by [4]

$$\boldsymbol{\xi}' = \gamma(\boldsymbol{\xi} - \boldsymbol{\beta}\times\mathbf{B}); \quad \mathbf{B}' = \gamma(\mathbf{B} + \boldsymbol{\beta}\times\boldsymbol{\xi}); \quad \boldsymbol{\xi}'^2 - \mathbf{B}'^2 = \boldsymbol{\xi}^2 - \mathbf{B}^2 . \quad (2)$$

Here $\boldsymbol{\xi}$ and $\mathbf{B}$ stand for the electric and magnetic fields of the charged particle in a given frame of reference while $\boldsymbol{\xi}'$ and $\mathbf{B}'$ represent their values when viewed from a second frame of reference which has a uniform velocity $-\mathbf{v}$ with regard to the first one. In the above equations, we have taken $\boldsymbol{\beta} = \mathbf{v}/c$ and $\gamma = 1/\sqrt{(1-\boldsymbol{\beta}^2)}$.

Let us now express the electric and magnetic field of a charged particle moving with velocity v. For this purpose, we just have to assume that the charged particle is at rest in the unprimed frame of reference. Dropping the prime from $\boldsymbol{\xi}'$ and $\mathbf{B}'$ in those equations and replacing $\xi$ and $\mathbf{B}$ by $\boldsymbol{\xi}_o$ and $\mathbf{B}_o$ respectively, we obtain the electric and magnetic field of a uniformly moving charged particle as

$$\boldsymbol{\xi} = \gamma\,\boldsymbol{\xi}_o ; \quad \mathbf{B} = \gamma\,\boldsymbol{\beta}\times\boldsymbol{\xi}_o ; \quad \boldsymbol{\xi}^2 - \mathbf{B}^2 = \boldsymbol{\xi}_o^2 . \quad (3)$$

In obtaining these equations, we have taken into consideration that in its rest frame of reference, a charged particle possesses only electrostatic field and no magnetic field. Look at the likeness of these equations to those of energy and momentum of a particle given by

$$E = \gamma E_o ; \quad \text{þ}c = \gamma\,\boldsymbol{\beta}\,E_o ; \quad E^2 - \text{þ}^2 c^2 = E_o^2 . \quad (3A)$$

Of course, there are differences also between (3) and (3A). Although E and ξ behave similarly under relativistic transformation, we have to keep in mind that ξ is a vector while E is a scalar. In spite of the similarity in the relativistic transformations, we should keep in mind that **þ** is a true vector while **B** is an axial vector. Besides, E and **þ** are the intrinsic properties of the particle while ξ and **B** are the fields at a point near the charged particle.

Now our aim is to show that the electric and the magnetic fields of a staphon have the same form as that of a point charge and also they behave similarly under a relativistic transformation. Such similarities will confirm that the staphon indeed possesses the electric charge. With this purpose in mind let us take a staphon whose electric and magnetic vectors are $\boldsymbol{\xi}_o$ and $\mathbf{B}_o$. If we now observe the system from a frame of reference with regard to which the staphon has a translational velocity v, then we know from (2) that the electric and the magnetic field at a point on it will be contributed by the forward wave and the reverse wave which would undergo relativistic transformation as given below.

$$\xi_1 = \gamma\left(\xi_o - \boldsymbol{\beta}\times\mathbf{B}_o\right) \; ; \quad \xi_2 = \gamma\left(\xi_o + \boldsymbol{\beta}\times\mathbf{B}_o\right) \; . \tag{4}$$

$$\mathbf{B}_1 = \gamma\left(\mathbf{B}_o + \boldsymbol{\beta}\times\xi_o\right) \; ; \quad \mathbf{B}_2 = -\gamma\left(\mathbf{B}_o - \boldsymbol{\beta}\times\xi_o\right) \; . \tag{5}$$

Note that the direction of the magnetic field undergoes a reversal in a normal reflection while that of the electric field remains unchanged [5]. Using equations (4) and (5), we obtain the resultant values for the electric and the magnetic fields at a point on the staphon as

$$(i)\;\; \xi_S = \left(\xi_1 + \xi_2\right) = 2\gamma\xi_o = \gamma\xi_{So} \; ; \;\; (ii)\;\; \mathbf{B}_S = \left(\mathbf{B}_1 + \mathbf{B}_2\right) = 2\gamma\,\boldsymbol{\beta}\times\xi_o = \gamma\,\boldsymbol{\beta}\times\xi_{So} \; ;$$

and

$$(iii)\; \xi_S^2 - \mathbf{B}_S^2 = 4\xi_o^2 = \xi_{So}^2 \; . \tag{6}$$

Here $\xi_S$ and $\mathbf{B}_S$ stand for the electric and the magnetic fields of the staphon while $\xi_{SO}$ represents its electric field in its rest frame. Note that in the rest frame of reference of the staphon, v = 0 and therefore, from (6.ii) we obtain, $\mathbf{B}_\mathbf{S} = 0$. The reason for taking the direction of $\mathbf{B}_2$ opposite to that of $\mathbf{B}_1$ is that in a normal reflection, the direction of the magnetic vector gets reversed [5]. We can also understand this difference in the behavior of the electric and the magnetic fields based on the fact that the magnetic field is represented by an axial vector while the electric field is represented by a proper vector. Therefore, in the stationary reference frame of the staphon, the magnetic field gets canceled. However, once the staphon gains translational velocity, the magnetic field makes its appearance and is given by (6.ii). Recall the analogous behavior of momentum in the case of the standing wave when the momentum of the forward and the reverse waves gets canceled in the rest frame as they are equal but in the opposite directions.

A comparison of the transformation equations for the point charge given in (3) with those given in (6) shows that they are identical. This means that the electric and the magnetic fields of a staphon transform exactly the same way as those of charged point particle. We already know that in a relativistic transformation, the energy and the momentum of a staphon behave exactly the same way as those of a particle [1]. This reinforces our conviction that a charged particle like an electron has the inner structure of a confined photino.

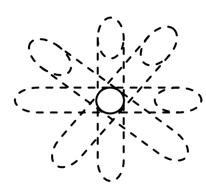
Here one question that may be raised will be regarding the electric field component $\boldsymbol{\xi}_\mathbf{x}$ of the charged particle moving along the x-axis. A photino confined along the x-axis, does not possess any component of the electric vector along the x-axis. Therefore, it may seem that the staphon structure may not give a proper explanation for the existence of the electric field in the direction of the translational motion. Actually, the picture would become clear if we keep in mind that a particle is represented by infinite number of staphons occupying all possible directions at a given point by the process of quantum superposition. These staphons exist in a virtual state producing the electrical field symmetrically in all directions. In other words, the symmetric field experienced around a charged particle can be understood as caused by the virtual interactions undergone by the staphons uniformly in all directions.

Here it should be noted that the picture of a wave progressing along a straight line is not the correct representation of the process. We have to think in terms of the wave front. Therefore, when we confine a wave to form the staphon, the entire wave front would be split into the forward and the reverse waves resulting in the formation of the "wave front" of the standing waves. When we consider the fact that due to the process of quantum superposition, the staphon would occupy all possible orientations, it is possible to imagine the "standing wave front" creating a spherically symmetrical electrical field around the staphon. We shall discuss about the field due to the EM wave in detail in section 4.

## 3 The Staphon and the Electric Charge

From (6) we observe that in its rest frame of reference a staphon can possess only the electric field as its magnetic field gets destroyed by the reflected wave. This is exactly how a point charge behaves. Further, we saw from section 2 that the transformation equations for the electric and the magnetic fields of the staphon are exactly same as that of a point charge. These properties force us to conclude that the confinement of the electromagnetic wave not only creates mass, but also creates the electric charge. Here it should be noted that the EM wave is not to be pictured in the conventional manner. It has been observed that the EM wave can be attributed a helical structure in the physical space with a radius of $\lambda/2\pi$ [6]. In fact, the Maxwell's equations admit such a solution which seems to have been overlooked till now. A staphon structure formed by the confinement of such a wave may allow us to avoid the pitfalls of treating a particle like electron as a point mass or a point charge.

Let us now examine how the field of the EM wave would appear when confined to form the staphon. We know that although a single staphon is a standing helical half wave, due to the process of quantum superposition, the resultant structure will be spherically symmetric and



*The figure shows a large number of staphons centered at a point aligned in all possible directions by the process of quantum superposition and the resultant spherical structure would represent a particle. If the spatial amplitude of the staphon becomes zero, the sphere would shrink to a point.*

Figure. 1

will form a sphere with radius $\lambda/2\pi$ (see figure 1). We know from (6) that if $\xi_o$ is the field of the EM wave, then, $\xi_{so}$ ($\xi_{so}= 2\xi_o$) will be the field on the staphon which possesses a spherical structure. Note that in the rest frame of reference, the electric field $\xi_{So}$ can be taken as the electrostatic field. Therefore, as per the Coulomb's law we should have

$$\xi_{SO} \quad = \quad 2\xi_o \quad = \quad e/4\pi\varepsilon_o R^2 \quad , \tag{7}$$

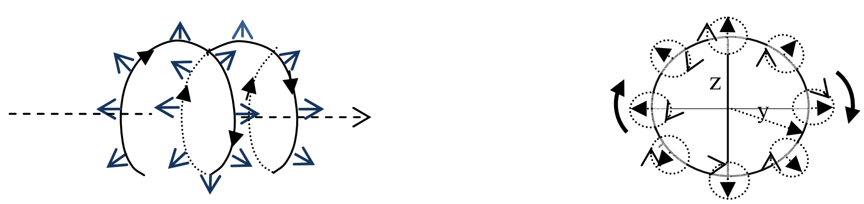
where R = λ/2π. Here e is the charge of the staphon. The fact that the spherical structure is formed by a very large number of staphons existing at a point in a virtual way due to quantum superposition does not mean that the charge present on the surface of the sphere will be infinite. This is because, in any interaction at an instant, the effect is attributed to one staphon state just as the rest energy of the particle is represented by the energy of a single staphon. Note that the field around a charged particle is created by the virtual interactions and in that sense the representation of a particle as formed by a large number of virtual staphon states is consistent with the quantum mechanical approach.

Needless to say, the Coulomb's law sets a definite value for the electric field of the EM wave. In (7), Taking R = λ/2π = 1/k, we have

$$\xi_o \quad = \quad k^2 e/8\pi\varepsilon_o \quad . \tag{7A}$$

According to the classical electrodynamics, ω and k of the EM wave are related to each other by a simple relation. But there is no such relation connecting its amplitude with k. This lack of clarity on the amplitude has been quite intriguing. The relation given in (21A) closes that gap.

When a charged particle is represented by a standing EM half wave, certain important issues needs to be understood clearly. The most basic one is regarding the fact that for the EM wave $\nabla.\xi$ **= 0,** while for the standing wave $\nabla.\xi \neq 0$. We have to explain how the process of confinement brings out this change in the divergence. Let us take the helical EM wave which




(a) (b)

*(a)shows the helical wave in the real space representing the EM wave. In the special case shown here the electric field of the EM wave located at each point on the helical path is aligned in the direction of the radius vector. In (b) the projection of the helical wave on a plane transverse to it is shown. Note that the electrical field always remains directed outward on the circumference of the circle.*

Figure 2

represents a solution to the Maxwell's equations in vacuum [6]. We shall take up the case where the electrical vector is aligned in the direction of the radius vector. We know that this involves the following conditions.

$$\xi_y \quad = \quad \alpha\, y \qquad and \qquad \xi_z \quad = \quad -\alpha\, z \quad , \tag{8}$$

$$where \quad y \quad = \quad R\cos\left[\omega t - kx\right] \quad and \quad z \quad = \quad -R\sin\left[\omega t - kx\right] \quad . \tag{8A}$$

The electrical vector of such a wave will be tracing a helical path as shown in figure 2(a). Here we should keep in mind that the test charge by which we measure the field is not a point charge, but an electron having the same spatial spread. Therefore, when we treat the test charge as a point particle, we are implicitly taking R = 0. This allows us to use the conventional solutions of the Maxwell's equation to understand the situation. In other words we can imagine that the electric field is created in the transverse directions by the waves moving parallel to each other forming the wave front.

Note that although the wave equation represents the propagation of a single EM wave, actually the propagation of the energy of the EM wave could be understood only in terms of the wave front. However, once we confine the wave in a small region, the situation changes. This is because a standing wave can be understood in terms of a forward wave and a reverse wave. This would mean that the wave front also has to represent the corresponding forward waves and the reverse waves. In other words, the moment we confine a wave, the progressive wave front will have to be replaced by the wave front constituted by the standing waves. Now let us introduce the spherical symmetry of the staphon arising from by the quantum superposition. This would be possible only if we have a system of standing waves enclosing the original staphon in all directions. In figure 2(b) the projection of the propagating helical wave on to a transverse plane is given. Note that the projection of the standing helical half wave also will have the appearance. Remember that even when the wave gets reflected, the direction of the rotation of the helical wave will remain the same in the projection. The electrical vector will be directed outwards at every point on the circle. Taking into consideration the spherical symmetry, we can easily imagine that the electrical field due to the system of standing waves constituting the front around the staphon also will have the electrical vector pointing in the outward direction. As discussed already, to understand the situation in the wave front constituted by the standing waves, we may fall back on the conventional picture of the wave front.

Here we should keep in mind that even when we confine a wave to form a staphon, the electromagnetic energy which is distributed in the wave front is not confined. Recall that the rest mass of an electron is accounted by the "intrinsic energy" of the EM wave. Only this intrinsic energy of the EM wave will be confined. We shall shortly show how the intrinsic energy of the EM wave is related to the energy of the electromagnetic field around it. The moment the EM wave is confined, the rest mass is created, at the same time the wave front and the resultant electromagnetic field gets altered. As already discussed, as the staphon can orient in any direction due to the quantum superposition, the wave fronts (note that they are standing waves) resulting from it will be spread around the staphon in a spherically symmetric manner. In fact, it may not be appropriate to treat them as the wave front since they are stripped of the "intrinsic energy" of the wave and are left with only the electric field in the rest frame of reference. In other words, the moment we confine an EM wave to form a staphon, it sets up an electric field around it and the inverse square law could be attributed to the geometry of the three dimensional space. This spread of the field from the region where the staphon is formed would result in the divergence of the field acquiring non-zero value.

As already discussed, at any point in the space the staphons could occupy all possible angles in the forward direction by the process of quantum superposition with the result that the electrical field is located on the surface of a sphere with its direction normal to it. It is quite obvious that in such a situation, the field within the sphere would be completely absent. If we now take the flux of the electrical field over the entire surface of the sphere, then by Maxwell's equation (7.i) expressed in the integral form in a region having electrical charge, we would obtain

$$\int \boldsymbol{\xi}_{so} . d\mathbf{S} \quad = \quad e / \varepsilon_o \tag{9}$$

where e is the charge contained by the sphere.

Now that we have a clear idea of how the confinement of the EM wave creates the electric charge and the field around it, we may now try to find out the energy of the electromagnetic field around the electron represented by the staphon. This is made simple by the fact that a particle like electron could now be attributed a definite radius. Here we have to keep in mind that the field lines are directed outward and therefore, the charge of the particle should be positive, and not negative as in the case of electron. Therefore, strictly speaking the particle represented by the staphon will be a positron. But we shall continue to describe the particle as electron. Towards the end of the next section we shall show how the confinement of the EM wave results in the creation of the negative electric charge. We know that the energy density of the electromagnetic field is given by [7]

$$\hat{E}_e \quad = \quad \tfrac{1}{2}\left( \varepsilon_o \xi_o^2 + \mu_o^{-1} B_o^2 c^2 \right) \quad = \quad \varepsilon_o \xi_o^2 \quad . \tag{10}$$

Note that the for the electromagnetic wave |$\boldsymbol{\xi}$| = |**B**| while $\varepsilon_o \mu_o = 1/c^2$. Since the confinement of the electromagnetic wave destroys the magnetic field, the energy in it would turn up in the electrostatic field and the total energy will be given by $\varepsilon_o \xi_o^2$. If we take into consideration the two states of polarization, the energy of the field will be twice what is given in (10). Further, if we account for the fact that in the case of the standing wave the energy density of the progressive EM wave is confined within half wave length, then the energy density will increase by a factor of 2 again. Therefore the correct value for the energy density of the standing helical half (EM) wave will be

$$\hat{E}_e \quad = \quad 4 \varepsilon_o \xi_o^2 \quad . \tag{10A}$$

Note that since the electrostatic field of the electric charge is given by $\xi_{So} = 2\xi_o$, we may express (10A) in terms of $\xi_{So}$ as

$$\hat{E}_e \quad = \quad \varepsilon_o \xi_{So}^2 \quad . \tag{10B}$$

Attributing a spherical structure, the total energy, $E_e$ of the electrostatic field of the electron will be given by

$$E_e \quad = \quad \int_R^\infty \varepsilon_o \xi_{So}^2 4\pi r^2 dr \quad = \quad \int_R^\infty \left( e^2 / 4\pi\varepsilon_o r^2 \right) dr \quad = \quad e^2 / 4\pi\varepsilon_o R \quad . \tag{11}$$

But $R = \lambda / 2\pi = \hbar c / E_o$ , where $E_o$ is the energy of the electromagnetic wave forming the staphon and can be taken as the rest energy of the electron. Therefore (10) could be written as

$$E_e \quad = \quad E_o e^2 / 4\pi\varepsilon_o \hbar c \quad = \quad \alpha E_o \quad , \tag{11A}$$

where $\alpha = e^2/4\pi\varepsilon_o\hbar c$ is the fine structure constant. If the staphon is given a translational velocity, $E_e$ will have to be replaced by $E_e'$ which represents the energy of the electromagnetic field due to the moving particle and $E_o$ will have to be replaced by E which represents the total energy of the particle. Since $E_e'$ and E behaves identically in a relativistic transformation, the ratio $E_e'$ to E will continue to be equal to α. In this approach we obtain actual significance of the fine structure constant. Thus we may state that the fine structure constant represents the ratio of the electromagnetic energy of the electron to its total energy. This picture is consistent with the generally accepted idea that the fine structure constant is a measure of the interactions of a charged particle with the electromagnetic field.

## 4 Staphon and the Magnetic Dipole Moment

The fact that electron possesses the magnetic dipole moment is another pointer to the fact that it cannot be taken as a point charge. We shall now try to calculate the magnetic moment of electron. We know that the magnetic dipole moment of a circular conductor with current I is given by

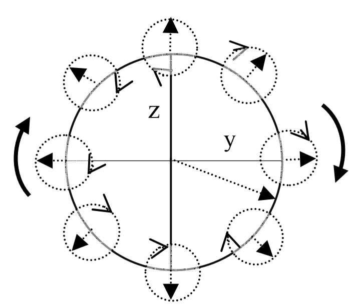
$$\mu = IA , \tag{12}$$

where $A$ is the area subtended by the conductor. Now if we take the case of the electron, we know that its magnetic dipole moment is given by [8]

$$\mu_e = e\hbar/2m , \tag{12A}$$

where m is its rest mass. The fact that the electron has the magnetic dipole moment shows that it cannot be taken as a point charge. The electron should resemble more a revolving point charge. This would mean that electron not only has a definite spatial spread but also contains within it moving charge.

We saw in the previous section that the EM wave has a helical structure in the real space and the radius of the circular cross section of the wave is λ/2π. If we view the confined EM wave in the direction of the progression of the wave, the electric vector will appear to undergo rotation as shown in figure 3. Since the electric vector is directed perpendicular to the direction




*This is the transverse view of the staphon. The electric field on the staphon undergoes rotation at the same angular frequency and in phase with the staphon and is denoted by the epicycles. As the staphon rotates, the arrow would appear to slide over the circumference with its point directed away from the centre of the circle.*

Figure.3

of the propagation, the projection of the EM wave on to a transverse plane could be represented by a circle as given in figure 3. Note that the angular velocity of the rotation of the electric field is the same as that of the rotation of the wave in the physical space in the transverse direction. In the figure the rotation of the electric field is denoted by the epicycles and its rotation is in phase with the rotation of the radius vector. Note that when the wave traverses by a wave length, the electrical vector denoted by the arrow moves laterally over the circumference of the circle once.

We saw from the previous section how we arrived at the relation

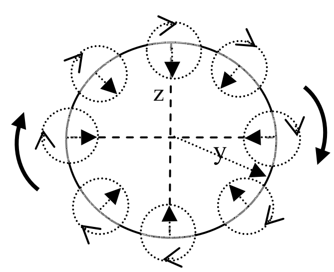
$$\int \boldsymbol{\xi}_{so}.d\mathbf{S} \quad = \quad e / \varepsilon_o \quad . \tag{13}$$

When observed from a point on the x-axis, only the staphon oriented along the same direction becomes relevant and the electrical charge e can be assumed to be moving all along its helical path dragged by the electrical vector as it moves along it. Therefore, the integration will have to be taken over the helical path. For this purpose, we shall assume that the helical path has a certain width which could be taken as small as required. In this manner, the integration represented in (13) would represent the flux of the electrical field originating from the helical path and the charge e could be taken as spread over the entire helical path. When the EM wave moves forward and gets reflected back forming the standing wave, for the observer the electrical vector of the EM wave would appear to execute circular motion as shown in figure 3. Taking the radius of the circular path as $\lambda/2\pi$ as discussed in the last section and the period of completing one full cycle by the charge as T, where T is the period of the oscillation of the EM wave, we have from (12)

$$\mu_e \quad = \quad (e/T)\pi R^2 \quad = \quad e\nu\pi\lambda^2/4\pi^2 \quad = \quad ehc^2/4\pi E \quad = \quad \hbar e/2m \quad . \tag{14}$$

Thus we obtain a simple explanation for the magnetic dipole moment of the electron. This result in a way confirms that electron has the inner structure of a standing EM half wave and this when viewed in the direction of progression appears like a circular coil with radius $\lambda/2\pi$ with a current '$e\nu$' in it where $\nu = E_o/h$.

In the above discussion we have considered the case of the EM wave where the electric field is always aligned in the direction of the radius vector [6]. In fact, we may take the case




*The figure represents the transverse view of the staphon..Here the phase of the electric field denoted by the arrow in the epicycle differs from that of the radius vector by π. As the helical wave progresses and ges reflected back, the arrows denoting the electric field would appear to slide over the circle with the points directed to the centre of the circle.*

Figure.4

where the electric vector is aligned in a direction opposite to that of the radius vector. This pertains to the conditions

$$\xi_y = -\alpha\, y \quad and \quad \xi_z = \alpha\, z \ , \tag{15}$$

$$where \quad y = R\cos\left[\omega t - kx\right] \quad and \quad z = -R\sin\left[\omega t - kx\right] \ . \tag{15A}$$

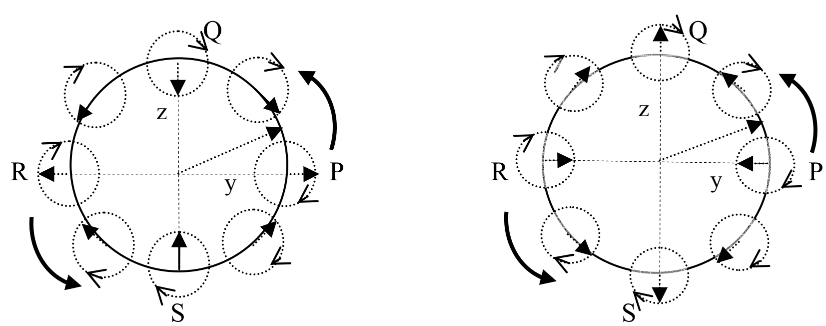
In this case, the electric vector would be having a phase difference of π with the radius vector and hence would be directed inward when the EM wave is viewed in the direction of its progression as shown in figure 4. Note that in this case the direction of the electric field is the reverse of the case represented by (8) and (8A). Therefore, the field created around the staphon would have the opposite direction. When such a wave is confined to form a staphon, it will have a charge which is opposite to that of the case discussed earlier. In other words, the first case would represent the positron having a positive electric charge while the above case would represent the electron having a negative electric charge.

Apart from these two, there are two other possibilities which we shall discuss now. The third possibility arises when we take

$$\xi_y = \alpha\, y \quad and \quad \xi_z = -\alpha\, z \ , \tag{16}$$

$$where \quad y = R\cos\left[\omega t - kx\right] \quad and \quad z = R\sin\left[\omega t - kx\right] \ . \tag{16A}$$

This represents the case where the rotation of the electric field and the radius vector are in the opposite directions. Here $\xi_y$ and $\xi_z$ are related to y and z just as in the first case. However, (16A) represents a wave which is rotating in the anti-clockwise direction (see figure 5.a ). In




(a) (b)

*(a) shows the case of the staphon where its rotation is in the anti-clockwise direction while the electric field rotates in the opposite direction. The field has positive component $\xi_y$ at P on the y-axis axis and becomes $-\xi_z$ at Q, then $-\xi_y$ at R and $\xi_z$ at S. (b) represents the case with the same direction of rotation but with the phase of of the electric vector differing with that of the radius vector by π.*

Figure 5

other words, the outward field position that exists in a single staphon state at P and R and transforms into inward fields at Q and S as shown in 5(a). This would mean that the particle represented by such a staphon would possess no electrical charge. However, it would possess half spin.

The fourth possibility arises when we take

$$\xi_y = -\alpha\ y \qquad and \qquad \xi_z = \alpha\ z \quad , \tag{17}$$

$$where \quad y = R\cos\left[\omega t - kx\right] \quad and \quad z = R\sin\left[\omega t - kx\right] \quad . \tag{17A}$$

The direction of the electrical field at any point on the helical wave is given in figure 5(b). Here also the picture is similar to the third case except that there is a phase difference of π. Therefore if a staphon is formed by such a wave, by the same logic as followed in the previous case, it would also represent a half spin particle with no electrical charge. If we now look around for leptons which have half spin with no electrical charge, then we are left with only neutrinos. We are confining ourselves to leptons because we cannot represent other particles like mesons without incorporating the strong field.

We could construct four more cases with the rotation of the helical wave reversed in each of the above four cases. Those would pertain to the states having the opposite spin states of the particle. Note that in the conventional description of the EM wave, these different structures would not show up since the radius of the helical wave in the physical space is taken to be zero. In fact, on the basis of the conventional structure of the EM wave, it would be impossible to account for the positive and negative electric charges.

In the above approach based on the quantum mechanical interpretation, we may assume that an electron is represented by a large number of staphons having different values for its energy and momentum. Each staphon state will be represented by the corresponding plane wave. Although, at any instant an electron may occupy a large number of plane wave states by the process of quantum fluctuations, in any measurement only one plane wave state will be realized. This way, we may explain why the staphon state could represent the electron.

## 5 Conclusion

We now observe that the treatment of a particle as a point mass or a point particle is basically a convenient approximation. We saw that a staphon structure explains all attributes of a charged particle like an electron. Such a structure implies that the particle has a definite spatial spread and could be treated as a sphere having radius λ/2π where λ is the Compton wave length of the particle. With the staphon structure we no longer have to face the problems of the infinite self energy of the electron. In fact, we now know the actual meaning of the fine structure constant as it represents the ratio of the electromagnetic energy of the electron to its total energy. A very important result from the proposed staphon structure is that it gives a clear explanation why we observe only electric monopoles in nature and why there are no magnetic monopoles. In the approach proposed here the EM wave is taken as the most basic entity. Such a wave when confined to form the standing wave (basic harmonic) destroys its magnetic field completely leaving the system with only the electrostatic field. There is no way we could create a standing wave that destroys the electric field leaving the system with only the magnetic field. In other words, the proposed staphon structure rules out the existence of the magnetic monopole completely.

The staphon structure proposed for a particle involves the confinement of only the EM wave. Therefore this kind of a structure may be appropriate only for leptons like electrons, muon and tau. But we also have two staphon states with no electric charge but possessing spin of $\frac{1}{2}\hbar$. The obvious choice for these appears to be neutrinos. But detailed studies needs to be done to confirm this. In the case of particles like quarks, strong field also should play an important role in the inner structure. Therefore, instead of the EM wave which represents only one field, a more complex wave may have to be thought of which carries the vibrations of the strong field also. It is possible that the SU(2) symmetry and SU(3) symmetry may be traced to such inner structures. The EM wave may be considered as a special case where the vibrations of the other fields are absent.

It is interesting to note that Hestenes had proposed an electronic structure based on the "zitterbewegung" motion undergone by it [9][10]. His approach is based on the assumptions

(i) the electron is a point charge moving at the speed of light in a circular motion with angular momentum $\frac{1}{2}\hbar$ observed as spin.
(ii) The phase of the Dirac wave (plane wave) is a measure of the angular displacement in the circular motion.
(iii) The circular motion generates the observed magnetic moment of the electron
(iv) The circular motion also generates an electric dipole field fluctuating with zitterbewegung frequency of $10^{21}$ Hertz.

We observe that all these properties (except that of the electric dipole field for which in any case there is no experimental evidence) are explained by the staphon structure of the electron. Hestenes presumes that electron is a point charge which travels along a helical path with its radius proportional to its Compton wave length. We observe that in the staphon approach also we obtain a similar picture. But here the charge of the electron is not taken as a point charge, but as charge spread over the helical path. But the resultant current is similar in both cases. The assumptions (ii) and (iii) given above are also satisfied by the staphon approach. But there is a difference regarding the zitterbewegung (zitter to be short) motion of the electron which is in the transverse direction in Hestenes' approach. In the staphon approach, the zitter motion takes place both in the longitudinal direction as well as in the transverse direction (note that the circular motion within the staphon takes place at the velocity of light). But the main problem arises when Hestenes assumes that the electron undergoes zitter motion at luminal velocities in the transverse direction. But motion at the luminal velocities for a point mass goes against the relativity theory. Note that in the staphon approach the zitter motion at the luminal velocity does not create any problem as it is the EM wave which is undergoing the zitter motion. We observe that in the staphon picture, the concept of the internal coordinates resolves the issue neatly. We saw that the EM wave gets compacted to the internal coordinates of the electron and it constitutes the inner structure of the electron while the electron as a whole is represented by the plane wave in the external coordinate system. This means that the staphon structure is fully consistent with the plane wave representation and consequently with the quantum electrodynamics.

The present approach is based on the assumption that the confinement of the EM wave is effected by a pair of mirrors facing each other. This is obviously an artificial construct [1] [2] and should be replaced by some field which should do the job. In the next paper, we shall examine this aspect in detail and try to find out more about this field.

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