CHAPTER 4 : PHOTON MASS AND THE B(3) FIELD.

4.1 INTRODUCTION

The B(3) field was inferred in November 1991 {1 - 10} from a consideration of the conjugate product of nonlinear optics in the inverse Faraday effect. In physics before the great paradigm shift of ECE theory the conjugate product was thought to exist in free space only in a plane of two dimensions. This was absurd dogma necessitated by the need for a massless photon and the U(1) gauge invariance of the old theory {13}. The lagrangian had to be invariant under a certain type of gauge transformation. Therefore there could be no longitudinal components of the free electromagnetic field, meaning that the vector cross product known as the conjugate product could have no longitudinal component in free space, but as soon as it interacted with matter it produced an experimentally observable longitudinal magnetization. In retrospect this is grossly absurd, it defies basic geometry, the basic definition of the vector cross product in three dimensional space, or the space part of four dimensional spacetime.

The first papers on B(3) appeared in Physica B in 1992 and 1993 and can be seen in the Omnia Opera of www.aias.us. The discovery of B(3) was not immediately realized to be linked to the mass of the photon, an idea that goes back to the corpuscular theory of Newton and earlier. It was revived by Einstein as he developed the old quantum theory and special relativity, and with the inference of wave particle duality it became part of de Broglie's school of thought in the Institut Henri Poincaré in Paris. Members of this school included Proca and Vigier, whose life work was dedicated largely to the theory of photon mass and a type of quantum mechanics that rejected the Copenhagen indeterminacy. This is usually known as causal or determinist quantum mechanics. The ECE theory has clearly refuted indeterminacy in favour of causal determinism, because ECE has shown that essentially all the valid equations of physics have their origin in geometry. Indeterminism asserts that some aspects of nature are absolutely unknowable, and that there is no cause to an effect, and that a particle for example can do anything it likes, go forward or backward in time. To the causal determinists this is absurd and anti Baconian dogma, so they have rejected it since it was proposed, about ninety years ago. This was the first great schism in physics. The second great schism follows the emergence of ECE theory, which has split physics into dogma (the standard model) and a perfectly logical development based on geometry (ECE theory). Every effect has a cause, and the wave equations of physics are derived from geometry in a rigorously logical manner. Many aspects of the standard model have been refuted with astonishing ease. This suggests that the standard model was "not even wrong" in the words of Pauli, it was a plethora of ridiculous abstraction that could never be tested experimentally and which very few could understand. This plethora of nonsense is blasted out over the media as propaganda, doing immense harm to Baconian science. This book tries to redress some of that harm.

Vigier immediately accepted the B(3) field and in late 1992 suggested in a letter to M. W. Evans, the discoverer of B(3) , that it implied photon mass because it was an experimentally observable longitudinal component of the free field and so refuted the dogma of U(1) gauge transformation. Vigier was well aware of the fact that the Proca lagrangian is not U(1) gauge invariant because of photon mass, and by 1992 had developed the subject in many directions. The subject of photon mass was as highly developed as anything in the standard physics. The two types of physics developed side by side, one being as valid as the other, but one (the standard model) being much better known. The de Broglie School of Thought was of course well known to Einstein, who invited Vigier to become his assistant, so by implication Einstein favoured the determinist school of quantum mechanics as is well known. So did Schroedinger, who worked on photon mass for many years. One of Schroedinger's last papers, with Bass, is on photon mass, from the Dublin Institute for Advanced Studies in the mid fifties. So by implication, Einstein, de Broglie and Schroedinger all rejected the standard model's U(1) gauge invariance, so they would have rejected the Higgs boson today.

The B(3) field was also accepted by protagonists of higher topology electrodynamics, three or four of whose books appear in this World Scientific series "Contemporary Chemical Physics". For example books by Lehnert and Roy, Barrett, Harmuth et al., and Crowell, and it was also accepted by Kielich, a pioneer of non linear optics. Other articles, notably by Reed {7} on the Beltrami fields and higher topology electrodynamics, appear in "Modern Nonlinear Optics", published in two editions and six volumes form 1992 to 2001. Piekara also worked in Paris and with Kielich, inferred the inverse Faraday effect (IFE). The latter was re inferred by Pershan at Harvard in the early sixties and first observed experimentally in the Bloembergen School at Harvard in about 1964. The first observation used a visible frequency laser, and the IFE was confirmed at microwave frequencies by Deschamps et al. {7} in Paris in 1970 in electron plasma. So it was shown to be an ubiquitous effect that depended for its description on the conjugate product. The B(3) field was widely accepted as being a natural description of the longitudinal magnetization of the IFE.

Following upon the suggestion by Vigier that B(3) implied the existence of photon mass, the first attempts were made to develop O(3) electrodynamics {1 - 10}, in which the indices of the complex circular basis, (1), (2) and (3), were incorporated into electrodynamics as described in earlier chapters of this book. Many aspects of U(1) gauge invariance were rejected, as described in the Omnia Opera on www.aias.us from 1993 to 2003, a decade of development. During this time, five volumes were produced by Evans and Vigier {1- 10} in the famous van der Merwe series of "The Enigmatic Photon", a title suggested by van der Merwe himself. These are available in the Omnia Opera of www.aias.us. In the mid nineties van der Merwe had published a review article on the implications of B(3) at Vigier's suggestion, in "Foundations of Physics". This was a famous journal of avant garde physics, one of the very few to allow publication of ideas that were not those of the standard physics.

The O(3) electrodynamics was a higher topology electrodynamics that was transitional between early B(3) theory and ECE theory, in which the photon mass and B(3) were both derived from Cartan geometry.

4.2 DERIVATION OF THE PROCA EQUATIONS FROM ECE THEORY.

The Proca equation as discussed briefly in Chapter Three is the fundamental equation of photon mass theory and in this section it is derived from the tetrad postulate. The latter always gives finite photon mass in ECE theory and consider it in the format:

$$D_\mu q^a_\nu = \partial_\mu q^a_\nu + \omega^a_{\mu b} q^b_\nu - \Gamma^\lambda_{\mu\nu} q^a_\lambda = 0 \quad -(1)$$

where q^a_ν is the Cartan tetrad, where $\omega^a_{\mu b}$ is the spin connection and $\Gamma^\lambda_{\mu\nu}$ is the gamma connection. Define:

$$\omega^a_{\mu\nu} = \omega^a_{\mu b} q^b_\nu , \quad -(2)$$

$$\Gamma^a_{\mu\nu} = \Gamma^\lambda_{\mu\nu} q^a_\lambda , \quad -(3)$$

then:

$$\partial_\mu q^a_\nu = \Gamma^a_{\mu\nu} - \omega^a_{\mu\nu} := \Omega^a_{\mu\nu} . \quad -(4)$$

Differentiate both sides:

$$\partial^\mu \partial_\mu q^a_\nu = \Box q^a_\nu = \partial^\mu \Omega^a_{\mu\nu} \quad - (5)$$

and define:

$$\partial^\mu \Omega^a_{\mu\nu} := -R q^a_\nu \quad - (6)$$

to find the ECE wave equation:

$$(\Box + R) q^a_\nu = 0 \quad - (7)$$

and the equation:

$$\partial^\mu \Omega^a_{\mu\nu} + R q^a_\nu = 0, \quad - (8)$$

where the curvature is:

$$R = - q^\nu_a \partial^\mu \Omega^a_{\mu\nu}. \quad - (9)$$

Now use the ECE postulate and define an electromagnetic field:

$$F^a_{\mu\nu} := A^{(0)} \Omega^a_{\mu\nu} \quad - (10)$$

to find:

$$(\Box + R) A^a_\mu = 0 \quad - (11)$$

and

$$\partial^\mu F^a_{\mu\nu} + R A^a_\nu = 0. \quad - (12)$$

These are the Proca wave and field equations, Q. E. D.

The photon mass is defined by the curvature:

$$R = \left(\frac{mc}{\hbar}\right)^2. \qquad -(13)$$

Therefore:

$$\left(\Box + \left(\frac{mc}{\hbar}\right)^2\right) A^a_\mu = 0 \qquad -(14)$$

and

$$\partial^\mu F^a_{\mu\nu} + \left(\frac{mc}{\hbar}\right)^2 A^a_\nu = 0. \qquad -(15)$$

For each state of polarization a these are the Proca equations of the mid thirties. They are not U(1) gauge invariant and refute Higgs boson theory immediately, because Higgs boson theory is U(1) gauge invariant. Eq. (10) can be regarded as a postulate of ECE theory in which the electromagnetic field is defined by the connection $\Omega^a_{\mu\nu}$. By antisymmetry:

$$F^a_{\mu\nu} = - F^a_{\mu\nu} \qquad -(16)$$

and from the first Cartan structure equation:

$$T^a_{\mu\nu} = \partial_\mu q^a_\nu - \partial_\nu q^a_\mu + \omega^a_{\mu\nu} - \omega^a_{\nu\mu}. \qquad -(17)$$

The fundamental postulates of ECE theory are:

$$A^a_\mu = A^{(0)} q^a_\mu, \qquad -(18)$$

$$F^a_{\mu\nu} = A^{(0)} T^a_{\mu\nu}, \qquad -(19)$$

so:

$$F^a_{\mu\nu} = \partial_\mu A^a_\nu - \partial_\nu A^a_\mu + A^{(0)}\left(\omega^a_{\mu\nu} - \omega^a_{\nu\mu}\right)$$
$$= A^{(0)}\left(\Gamma^a_{\mu\nu} - \Gamma^a_{\nu\mu}\right). \quad -(20)$$

By antisymmetry:

$$F^a_{\mu\nu} = 2\left(\partial_\mu A^a_\nu + A^{(0)}\omega^a_{\mu\nu}\right) \quad -(21)$$

so:

$$F^a_{\mu\nu}(\text{original}) = 2\left(F^a_{\mu\nu}(\text{new}) + A^{(0)}\omega^a_{\mu\nu}\right). \quad -(22)$$

The postulate (10) is a convenient way of deriving the two Proca equations from the tetrad postulate. In so doing:

$$R_0 = \left(\frac{m_0 c}{\hbar}\right)^2 \quad -(23)$$

where m_0 is the rest mass of the photon. More generally define:

$$R = \left(\frac{mc}{\hbar}\right)^2 \quad -(24)$$

where:

$$m = \gamma m_0 \quad -(25)$$

then the de Broglie equation is generalized to:

$$E = \hbar\omega = mc^2 = \hbar c R^{1/2} \quad -(26)$$

and the square of the mass of the moving photon is defined by the curvature:

$$m^2 = \left(\frac{\hbar}{c}\right)^2 R = \left(\frac{\hbar}{c}\right)^2 q^\nu_a \partial^\mu\left(\omega^a_{\mu\nu} - \Gamma^a_{\mu\nu}\right) \quad -(27)$$

The Proca equations are discussed further in Chapter three. The dogmatic U(1) gauge transformation of the standard physics is:

$$A^\mu \rightarrow A^\mu + \partial^\mu \chi \quad -(28)$$

but the Proca Lagrangian in the usual standard model units is:

$$\mathcal{L} = -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} + \frac{1}{2} m_0^2 A_\mu A^\mu \quad -(29)$$

and this lagrangian is not U(1) gauge invariant because the transformation (28) changes it.

This fundamental problem for U(1) gauge invariance has never been resolved, and the current theory behind the Higgs boson still uses U(1) gauge invariance after many logical refutations. The result is a deep schism in physics between the scientific ECE theory and the dogmatic standard theory.

4.3 LINK BETWEEN PHOTON MASS AND B(3).

The complete electromagnetic field tensor of ECE theory can be defined by:

$$F^a_{\mu\nu} = f^a_{\mu\nu} - f^a_{\nu\mu} + \omega^a_{\mu b} A^b_\nu - \omega^a_{\nu b} A^b_\mu \quad -(30)$$

where:

$$A^a_\mu = A^{(0)} q^a_\mu , \quad f^a_{\mu\nu} = \partial_\mu A^a_\nu . \quad -(31)$$

Consider now the tetrad postulate in the format:

$$\partial_\mu q^a_\nu = \Gamma^a_{\mu\nu} - \omega^a_{\mu\nu} := \Omega^a_{\mu\nu} . \quad -(32)$$

Eq. (31) follows directly from the subsidiary postulate:

$$f^{a}_{\mu\nu} = A^{(0)} \Omega^{a}_{\mu\nu} \quad -(33)$$

and as shown already in this chapter gives the Proca wave and field equations in generally covariant format. It is seen that the Proca equations are subsidiary structures of the more general nonlinear structure (30).

The B(3) field that is the basis of unified field theory is defined by:

$$B^{a}_{\mu\nu} = -ig\left(A^{c}_{\mu}A^{b}_{\nu} - A^{c}_{\nu}A^{b}_{\mu}\right) = \omega^{a}_{\mu b}A^{b}_{\nu} - \omega^{a}_{\nu b}A^{b}_{\mu} \quad -(34)$$

and is derived from the non linear part of the complete field tensor (30). In the B(3) theory:

$$\omega^{a}_{\mu b} = -ig A^{c}_{\mu} \epsilon^{a}{}_{bc}. \quad -(35)$$

Now define for each polarization index a:

$$g^{\mu\nu} = \partial^{\mu}A^{\nu} - \partial^{\nu}A^{\mu}. \quad -(36)$$

It follows that:

$$\partial^{\rho}g^{\mu\nu} + \partial^{\nu}g^{\rho\mu} + \partial^{\mu}g^{\nu\rho} = 0. \quad -(37)$$

This equation is the same as:

$$\partial^{\mu}\tilde{g}_{\mu\nu} = 0 \quad -(38)$$

where the tilde denotes the Hodge dual. It follows that:

$$\partial^{\mu}\tilde{f}_{\mu\nu} = 0 \quad -(39)$$

which is the homogenous field equation of the Proca structure. Eq. (32) allows the description of the Aharonov Bohm effects {1 - 10} with the assumption:

$$\Gamma^a_{\mu\nu} = \omega^a_{\mu\nu} . \quad -(40)$$

With this assumption the potential is non zero when the field is zero. In UFT 157 on www.aias.us the following relation was derived for each polarization index a:

$$j^\mu = -\frac{R}{\mu_0} A^\mu \quad -(41)$$

where the charge current density is:

$$j^\mu = (c\rho, \underline{J}) \quad -(42)$$

and where:

$$A^\mu = \left(\frac{\phi}{c}, \underline{A}\right) . \quad -(43)$$

Here μ_0 is the vacuum permeability and ϵ_0 is the vacuum permittivity. So:

$$\rho = -\epsilon_0 R \phi \quad -(44)$$

and:

$$\underline{J} = -\frac{R}{\mu_0} \underline{A} \quad -(45)$$

where ρ is the charge density, ϕ is the scalar potential, $\underline{J}$ is the current density and $\underline{A}$ is the vector potential. A list of S. I. Units was given earlier in this book, and the units of the vacuum permeability are:

$$\mu_0 = J s^2 C^{-2} m^{-1} . \quad -(46)$$

The complete set of equations of the Proca structure is therefore:

$$f^a_{\mu\nu} = A^{(0)}\left(\Gamma^a_{\mu\nu} - \omega^a_{\mu\nu}\right) \quad -(47)$$

$$\partial^\mu f^a_{\mu\nu} + RA^a_\nu = 0 \quad -(48)$$

$$(\Box + R)q^a_\mu = 0 \quad -(49)$$

$$\partial^\mu F^a_{\mu\nu} = \Box A^a_\nu = -RA^a_\nu = \mu_0 j^a_\nu \quad -(50)$$

$$\partial^\mu \tilde{f}^a_{\mu\nu} = 0 \quad -(51)$$

$$j^\mu = -\frac{R}{\mu_0} A^\mu \quad -(52)$$

Now define the field tensor and its Hodge dual as:

$$f_{\mu\nu} = \begin{bmatrix} 0 & E_x/c & E_y/c & E_z/c \\ -E_x/c & 0 & -B_z & B_y \\ -E_y/c & B_z & 0 & -B_x \\ -E_z/c & -B_y & B_x & 0 \end{bmatrix}; \quad \tilde{f}_{\mu\nu} = \begin{bmatrix} 0 & B_x & B_y & B_z \\ -B_x & 0 & E_z/c & -E_y/c \\ -B_y & -E_z/c & 0 & E_x/c \\ -B_z & E_y/c & -E_x/c & 0 \end{bmatrix} \quad -(53)$$

These definitions give the inhomogeneous Proca field equation under all conditions, including the vacuum:

$$\underline{\nabla} \cdot \underline{E} = \rho/\epsilon_0 = -R\phi \quad -(54)$$

$$\underline{\nabla} \times \underline{B} - \frac{1}{c^2}\frac{\partial \underline{E}}{\partial t} = \mu_0 \underline{J} = -R\underline{A} \quad -(55)$$

and the homogenous field equations:

$$\underline{\nabla} \cdot \underline{B} = 0 \quad -(56)$$

$$\underline{\nabla} \times \underline{E} + \frac{\partial \underline{B}}{\partial t} = \underline{0} \quad -(57)$$

under all conditions.

The solution of Eq. (54) is:

$$\phi = \frac{1}{\epsilon_0}\int \frac{\rho \, d^3 \underline{x}'}{|\underline{x} - \underline{x}'|} \quad - (58)$$

and from Eqs. (54) and (58):

$$\phi = -\frac{\rho}{\epsilon_0 R} = \frac{1}{\epsilon_0}\int \frac{\rho \, d^3 \underline{x}'}{|\underline{x} - \underline{x}'|} \quad - (59)$$

so:

$$\int \frac{\rho \, d^3 \underline{x}'}{|\underline{x} - \underline{x}'|} = -\frac{\rho}{R} \quad - (60)$$

where:

$$R = -q^a_\nu \, \partial^\mu \left(\Gamma^a_{\mu\nu} - \omega^a_{\mu\nu} \right) \quad - (61)$$

Therefore:

$$\int \frac{\rho(\underline{x}') \, d^3 \underline{x}'}{|\underline{x} - \underline{x}'|} = \frac{\rho}{q^\nu_a \, \partial^\mu \left(\omega^a_{\mu\nu} - \Gamma^a_{\mu\nu} \right)} \quad - (62)$$

The original Proca equation of the thirties assumed that:

$$q^\nu_a \, \partial^\mu \left(\omega^a_{\mu\nu} - \Gamma^a_{\mu\nu} \right) = \left(\frac{m_0 c}{\hbar} \right)^2 \quad - (63)$$

where m_0 is the rest mass. For electromagnetic fields in the vacuum this was assumed to be the photon rest mass, so the Proca equations were assumed to be equations of a boson with finite mass. More generally in particle physics this can be any boson. In Proca theory therefore the electromagnetic field is associated with a massive boson (i.e. a photon that has mass). Therefore the original Proca equations of the thirties assumed:

$$\phi = \frac{1}{\epsilon_0}\left(\frac{\hbar}{m_0 c}\right)^2 \rho \quad -(64)$$

It follows that: $$\int \frac{\rho \, d^3 \underline{x}'}{|\underline{x} - \underline{x}'|} = \left(\frac{\hbar}{m_0 c}\right)^2 \rho \quad -(65)$$

From Eqs. (59) and (65):

$$\phi(\text{vac}) = \frac{1}{\epsilon_0}\left(\frac{\hbar}{m_0 c}\right)^2 \rho(\text{vac}) \quad -(66)$$

giving the photon rest mass as the ratio:

$$m_0^2 = \left(\frac{\hbar}{c}\right)^2 \frac{1}{\epsilon_0} \frac{\rho(\text{vac})}{\phi(\text{vac})} = 1.4 \times 10^{-74} \frac{\rho(\text{vac})}{\phi(\text{vac})}. \quad -(67)$$

Two independent experiments are needed to find $\rho(\text{vac})$ and $\phi(\text{vac})$. A list of experiments used to determine photon mass is given in ref. (1). However, in this Section the assumptions used in these determinations are examined carefully, and in the main, they are shown to be untenable. Later in this chapter a new method of determining photon mass, based on Compton scattering, will be given.

Conservation of charge current density for each polarization index a means that:

$$\partial_\mu j^\mu = 0 \quad -(68)$$

From Eqs. (68) and (52):

$$\partial_\mu A^\mu = 0 \quad -(69)$$

In the standard physics Eq. (69) is known as the Lorenz gauge, an arbitrary assumption. In the Proca photon mass theory the Lorenz gauge is derive analytically. In the Proca theory the four potential is physical, and the U(1) gauge invariance is refuted completely. In consequence, Higgs boson theory collapses.

From the well known radiative corrections {1 -10} it is known experimentally that the vacuum contains charge current density. It follows directly from Eq. (52) that the vacuum also contains a four potential associated with photon mass. Therefore there are vacuum fields which in the non linear ECE theory include the B(3) field. The latter therefore also exists in the vacuum and is linked to photon mass and Proca theory. In the standard dogma the assumption of zero photon mass means that the vacuum fields only have transverse components. This is of course geometrical nonsense, and leads to the unphysical E(2) little group {13} of the Poincaré group. The vacuum four potential is:

$$A^\mu(vac) = \left(\frac{\phi(vac)}{c}, \underline{A}(vac) \right). \quad -(70)$$

It follows that a circuit can pick up the vacuum four potential via the inhomogeneous Proca equations

$$\underline{\nabla} \cdot \underline{E} = -R\phi(vac) \quad -(71)$$

and:

$$\underline{\nabla} \times \underline{B} - \frac{1}{c^2}\frac{\partial \underline{E}}{\partial t} = -R\underline{A}(vac) \quad -(72)$$

In this process, total energy is conserved through the relevant Poynting theorem derived as follows. Multiply Eq. (72) by $\underline{E}$:

$$\underline{E} \cdot (\underline{\nabla} \times \underline{B}) - \frac{1}{c^2}\underline{E} \cdot \frac{\partial \underline{E}}{\partial t} = -R\,\underline{E} \cdot \underline{A}(vac) \quad -(73)$$

Use:

$$\underline{E} \cdot \underline{\nabla} \times \underline{B} = -\underline{\nabla} \cdot \underline{E} \times \underline{B} + \underline{B} \cdot \underline{\nabla} \times \underline{E} \quad -(74)$$

in Eq. (73) to find the Poynting theorem of conservation of total energy density:

$$\frac{\partial \overline{W}}{\partial t} + \underline{\nabla} \cdot \underline{S} = \frac{R}{\mu_0} \underline{E} \cdot \underline{A} \, (\text{vac}). \quad -(75)$$

The electromagnetic energy density in joules per metres cubed is:

$$\overline{W} = \frac{1}{2} \left(\epsilon_0 E^2 + \frac{1}{\mu_0} B^2 \right) \quad -(76)$$

and the Poynting vector is:.

$$\underline{S} = \frac{1}{\mu_0} \underline{E} \times \underline{B}. \quad -(77)$$