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:

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

The electromagnetic energy density in joules per metres cubed is:

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

and the Poynting vector is:

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

Eq. (76) defines the electromagnetic energy density available from the vacuum. more accurately spacetime. This process is governed by the Poynting Theorem (75) and therefore there is conservation of total energy, there being electromagnetic energy density in the vacuum. The relevant electromagnetic field tensor is:

$$F^a_{\mu\nu} = \partial_\mu A^a_\nu \quad -(78)$$

so either:

$$\underline{E} = -\underline{\nabla} \phi \quad -(79)$$

or:

$$\underline{E} = -\frac{\partial \underline{A}}{\partial t}. \quad -(80)$$

The antisymmetry of the Cartan torsion means that the complete non-linear field of Eq. (30) is antisymmetric:

$$F^{a}_{\mu\nu} = -F^{a}_{\nu\mu} = \int^{a}_{\mu\nu} - \int^{a}_{\nu\mu} + \omega^{a}_{\mu\nu} - \omega^{a}_{\nu\mu}. \quad -(81)$$

The Cartan torsion is defined by:

$$T^{a}_{\mu\nu} = q^{a}_{\lambda} T^{\lambda}_{\mu\nu} \quad -(82)$$

where the antisymmetric torsion tensor $T^{\lambda}_{\mu\nu}$ is defined by the commutator of covariant derivatives:

$$[D_\mu, D_\nu] V^\rho = -T^{\lambda}_{\mu\nu} D_\lambda V^\rho + R^{\rho}{}_{\sigma\mu\nu} V^\sigma \quad -(83).$$

The torsion tensor is defined by the difference of antisymmetric connections:

$$T^{\lambda}_{\mu\nu} = \Gamma^{\lambda}_{\mu\nu} - \Gamma^{\lambda}_{\nu\mu} \quad -(84)$$

and the tetrad postulate means that:

$$\Gamma^{a}_{\mu\nu} = -\Gamma^{a}_{\nu\mu} = \partial_\mu q^{a}_{\nu} + \omega^{a}_{\mu\nu}. \quad -(85)$$

It follows that the antisymmetry in Eq. (30) is defined by:

$$\int^{a}_{\mu\nu} + \omega^{a}_{\mu b} A^{b}_{\nu} = -\left(\int^{a}_{\nu\mu} + \omega^{a}_{\nu b} A^{b}_{\mu}\right). \quad -(86)$$

If Eq. (79) is used for the sake of argument then the Poynting Theorem becomes:

$$\frac{\partial W}{\partial t} + \underline{\nabla} \cdot \underline{S} = -\frac{1}{2}\frac{R}{\mu_0}\frac{\partial}{\partial t}\left(A^2(vac)\right). \quad -(87)$$

From Eq. (45):

$$\underline{A}(vac) = -\frac{\mu_0}{R}\underline{J}(vac) \quad -(88)$$

so we arrive at:

$$\frac{\partial W}{\partial t} + \underline{\nabla}\cdot\underline{S} = -\frac{1}{2}\mu_0 R\frac{\partial}{\partial t}\left(\frac{J^2(vac)}{R}\right) \quad -(89)$$

which shows that the vacuum energy density and vacuum Poynting vector are derived from the time derivative of the vacuum current density squared divided by R.

In practical applications we are interested in transferring the electromagnetic energy density of the vacuum to a circuit which can use the energy density. In an isolated circuit consider the equation:

$$\Box A^a_\mu = \mu_0 j^a_\mu. \quad -(90)$$

When the circuit interacts with the vacuum:

$$j^a_\mu \rightarrow j^a_\mu + j^a_\mu(vac) \quad -(91)$$

so the Proca equation becomes:

$$\Box A^a_\mu = \mu_0\left(j^a_\mu + j^a_\mu(vac)\right) \quad -(92)$$

and

$$\partial^\mu F^a_{\mu\nu} = \mu_0\left(j^a_\mu + j^a_\mu(vac)\right). \quad -(93)$$

The Coulomb law is modified to:

$$\underline{\nabla}\cdot\underline{E} = \frac{1}{\epsilon_0}\left(\rho(circuit) + \rho(vac)\right) \quad -(94)$$

and the equation governing the scalar potential is:

$$(\Box + R)\phi = \frac{\rho(vac)}{\epsilon_0}. \quad -(95)$$

The d'Alembertian operator is defined by:

$$\Box = \frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \nabla^2 \quad -(96)$$

The time dependent part of ϕ of the circuit is therefore defined by:

$$\frac{1}{c^2}\frac{\partial^2 \phi}{\partial t^2} + R\phi = \frac{\rho(vac)}{\epsilon_0}. \quad -(97)$$

The most fundamental unit of mass of the circuit is the electron mass m_e , whose rest angular frequency is defined by the de Broglie wave particle dualism:

$$R_e = \left(\frac{m_e c}{\hbar}\right)^2 = \frac{\omega_e^2}{c^2} = q^{\sim}_{a}\, \partial^\mu \left(\omega^a_{\mu\nu} - \Gamma^a_{\mu\nu}\right). \quad -(98)$$

So Eq. (97) becomes:

$$\frac{\partial^2 \phi}{\partial t^2} + \omega_e^2 \phi = \frac{c^2 \rho(vac)}{\epsilon_0} \quad -(99)$$

which is an Euler Bernoulli resonance equation provided that:

$$\frac{c^2 \rho(vac)}{\epsilon_0} = A\cos\omega t. \quad -(100)$$

The solution of the Euler Bernoulli equation

$$\frac{\partial^2 \phi}{\partial t^2} + \omega_e^2 \phi = A\cos\omega t \quad -(101)$$

is well known to be:

$$\phi(t) = \frac{A \cos \omega t}{(\omega_e^2 - \omega^2)^{1/2}} \quad -(102)$$

At resonance:

$$\omega_e = \omega \quad -(103)$$

and the circuit's scalar potential becomes infinite for all A, however tiny in magnitude. This allows the circuit design of a device to pick up practical quantities of electromagnetic radiation density from the vacuum by resonance amplification. The condenser plates used to observe the well known Casimir effect can be incorporated in the circuit design as in previous work by Eckardt, Lindstrom and others.

From Eqs. (41) and (44)

$$\frac{c^2 \rho(vac)}{\epsilon_0} = -c^2 R \phi(vac) \quad -(104)$$

and if we consider the space part of the scalar potential ϕ then:

$$\Box \rightarrow -\nabla^2 \quad -(105)$$

and for each polarization index a the Proca equation reduces to:

$$\nabla^2 \phi = \left(\frac{mc}{\hbar}\right)^2 \phi. \quad -(106)$$

The Laplacian in polar coordinates is defined by:

$$\nabla^2 \phi = \frac{\partial^2 \phi}{\partial r^2} + \frac{2}{r} \frac{\partial \phi}{\partial r} \quad -(107)$$

so there is a solution to Eq. (106) known as the Yukawa potential:

$$\phi = \frac{B}{r} \exp\left(-\left(\frac{mc}{\hbar}\right) r\right) \quad -(108)$$

This solution was used in early particle physics but was discarded as unphysical. The early experiments to detect photon mass {1- 10} all assume the validity of the Yukawa potential. However the basic equation:

$$\square A_\mu = \mu_0 j_\mu \quad -(109)$$

also has the solution:

$$\phi = \frac{e}{4\pi\epsilon_0}\left(\left(1 - \frac{\underline{n}\cdot\underline{v}}{c}\right)|\underline{r} - \underline{r}'|\right)^{-1}_{tr} \quad -(110)$$

and

$$\underline{A} = \frac{\mu_0 e \underline{v}}{4\pi}\left(\left(1 - \frac{\underline{n}\cdot\underline{v}}{c}\right)|\underline{r} - \underline{r}'|\right)^{-1}_{tr} \quad -(111)$$

which are the well known Liénard Wiechert solutions. Here t_r is the retarded time defined by:

$$t_r = t - \frac{1}{c}|\underline{r} - \underline{r}'|, \quad c = \frac{|\underline{r} - \underline{r}'|}{t - t_r}. \quad -(112)$$

Therefore the static potential of the Proca equation is given by Eq. (110) with:

$$\underline{v} = \underline{0} \quad -(113)$$

and the static vacuum charge density in coulombs per cubic metre is given by:

$$\rho(\text{vac}) = -\left(\frac{mc}{\hbar}\right)^2 \frac{1}{4\pi}\left(\frac{e}{|\underline{r} - \underline{r}'|}\right)_{tr} \quad -(113)a)$$

which is the Coulomb law for any photon mass.

This means that photon mass does not affect the Coulomb law, known to be one of the most precise laws in physics. Similarly the photon mass does not affect the Ampère Maxwell law or Ampère law. This is observed experimentally {1 – 10} with high precision, so it is concluded that the usual Liénard Wiechert solution is the physical solution, and that the Yukawa solution is mathematically correct but not physical. On the other hand the standard physics ignores the Liénard Wiechert solution, and other solutions, and asserts arbitrarily that the Yukawa solution must be used in photon mass theory. The use of the Yukawa potential means that there are deviations from the Coulomb and Ampère laws. These have never been observed so the standard physics concludes that the photon mass is zero for all practical purposes. This is an entirely arbitrary conclusion based on the anthropomorphic claim of zero photon mass, a circular argument that is invalid. The theory of this chapter shows that the Coulomb and Ampère laws are true for any photon mass, and the latter cannot be determined from these laws. In other words these laws are not affected by photon mass in the sense that their form remains the same. For example the inverse square dependence of the Coulomb law is the same for any photon mass. The concept of photon mass is not nearly as straightforward as it seems, for example UFT244 on www.aias.us shows that Compton scattering when correctly developed gives a photon mass much different from Eq. (67). These are unresolved questions in particle physics because UFT244 has shown violation of conservation of energy in the basic theory of particle scattering.

Before proceeding to the description of determination of photon mass by Compton scattering a mention is made of the origin of the idea of photon mass. This was by Henri Poincaré in his Palermo memoir submitted on July 23rd 1905, (Henri Poincare, "Sur la Dynamique de l'Electron" Rendiconti del Circolo Matematico di Palermo, 21, 127 - 175

(1905)). This paper suggested that the photon velocity v could be less than c, which is the constant of the Lorentz transformation. Typically for Poincaré he introduced several new ideas in relativity, including new four vectors usually attributed to later papers of Einstein. So Poincaré can be regarded as a co pioneer of special relativity with many others. Einstein himself suggested a zero photon mass as a first tentative idea, simply because an object moving at c must have zero mass, otherwise the equations of special relativity become singular. Later, Einstein may have been persuaded by the de Broglie School in the Institut Henri Poincaré in Paris to consider finite photon mass, but this is not clear. It was therefore de Broglie who took up the idea of finite photon mass from Poincaré. He was influenced by the works of Henri Poincaré before inferring wave particle duality in 1923, when he suggested that particles such as the electron could be wave like. Confusion arises sometimes when it is asserted that the vacuum speed of light is c. This is not the meaning of c in special and general relativity, c is the constant in the Lorentz transform. Lorentz and Poincaré had inferred the tensorial equations of electromagnetism much earlier than Einstein as is well known. They had shown that the Maxwell Heaviside equations obey the Lorentz transform. ECE has developed equations of electromagnetism that are generally covariant, and therefore also Lorentz covariant in a well defined limit. It is well known that Einstein and others were impressed by the work of de Broglie, Einstein described him famously as having lifted a corner of the veil.

Louis de Broglie proceeded to develop the theory of photon mass and causal quantum mechanics until the 1927 Solvay Conference, when indeterminism was proposed, mainly by Bohr, Heisenberg and Pauli. It was rejected by Einstein, Schroedinger, de Broglie and others. Later de Broglie returned to deterministic quantum mechanics at the suggestion of Vigier. A minority of physicists have continued to develop finite photon mass theory, setting upper limits on the magnitude of the photon mass. There are multiple problems with the idea of zero photon mass, as is well known {13}. These are discussed in comprehensive detail in the five volumes of "The Enigmatic Photon" (Kluwer, 1994 - 2002) by M. W. Evans and J.-P. Vigier. Wigner {13} for example showed that special relativity can be developed in terms of the Poincaré group, or extended Lorentz group. In this analysis the little group of the Poincaré group for a massless particle is the Euclidean E(2), the group of rotations and translations in a two dimensional plane. This is obviously incompatible with the four dimensions of spacetime or the three dimensions of space. The little group for a massive particle is three dimensional and physical, no longer two dimensional.

This is the most obvious problem for a massless particle, and one of its manifestations is that the electromagnetic field in free space must be transverse and two dimensional, despite the fact that the theory of electromagnetism is built on four dimensional spacetime. The massless photon can have only two senses of polarization, labelled the transverse conjugates (1) and (2) in the complex circular basis {1 - 10} used in earlier chapters. This absurd dogma took hold because of the prestige of Einstein, but prestige is no substitute for logic. The idea of zero photon mass developed into U(1) gauge invariance, which became embedded into the standard model of physics. The electromagnetic sector of standard physics is still based on U(1) gauge invariance, refuted by the B(3) field in 1992 and in comprehensive developments since then. The idea of U(1) gauge invariance is in fact refuted by the Poincaré paper of 1905 described already, and by the work of Wigner, so it is merely dogmatic, not scientific. It is refuted by effects of nonlinear optics, notably the inverse Faraday effect, and in many other ways. It was refuted comprehensively in chapter three by the fact that the Beltrami equations of free space electromagnetism have intricate longitudinal solutions in free space. According to the U(1) dogma, these do not exist, an absurd conclusion.

Probably the most absurd idea of the U(1) dogma is the Gupta Bleuler condition, in which the time like (0) and longitudinal polarizations (3) are removed artificially {13}. There are also multiple well known problems of canonical quantization of the massless electromagnetic field. These are discussed in a standard text such as Ryder {13}, and in great detail in "The Enigmatic Photon" {1 - 10}. Finally the electroweak theory, which can be described as U(1) x SU(2), was refuted completely in UFT225.

The entire standard unified field theory depends on U(1) gauge invariance, so the entire theory is refuted as described above. Obviously there cannot be a Higgs boson.

4.4 MEASUREMENT OF PHOTON MASS BY COMPTON SCATTERING

The theory of particle scattering has been advanced greatly during the course of development of ECE theory in papers such as UFT155 to UFT171 on www.aias.us, reviewed in UFT200. It has been shown that the idea of zero photon mass is incompatible with a rigorously correct theory of scattering, for example Compton scattering. This is because of the numerous problems discussed at the end of Section 4.3 - zero photon mass is incompatible with special relativity, a theory upon which traditional Compton scattering is based. In UFT158 to UFT171 it was found that the Einstein de Broglie equations are not self consistent, a careful scholarly examination of the theory showed up wildly inconsistent results, which were also present in equal mass electron positron scattering.

The theory of Compton scattering with finite photon mass was first given in UFT158 to UFT171 and the notation of those papers is used here. The relativistic classical conservation of energy equation is:

$$\gamma m_1 c^2 + m_2 c^2 = \gamma' m_1 c^2 + \gamma'' m_2 c^2 \quad (114)$$

where m_1 is the photon mass, m_2 is the electron mass, and where the Lorentz factors are defined by the velocities as usual. The photon mass is given by the equation first derived in UFT 160:

$$m_1^2 = \left(\frac{\hbar}{c^2}\right)^2 \left[\frac{1}{2a}\left(-b \pm \left(b^2 - 4ac'\right)^{1/2}\right)\right] \quad -(115)$$

$$a = 1 - \cos^2\theta,$$
$$b = \left(\omega'^2 + \omega^2\right)\cos^2\theta - 2A$$
$$A = \omega\omega' - x_2\left(\omega - \omega'\right)$$
$$c' = A^2 - \omega^2\omega'^2\cos^2\theta$$

where ω' is the scattered gamma ray frequency, ω the incident gamma ray frequency, and where:

$$x_2 = \frac{m_2 c^2}{\hbar}. \quad -(116)$$

Here $\hbar$ is the reduced Planck constant and c is the speed of light in vacuo. The scattering angle is θ. Experimental data on Compton scattering can be used with the electron mass found in standards laboratories:

$$m_2 = 9.10953 \times 10^{-31}\ \mathrm{kg} \quad -(117)$$

so:

$$x_2 = 7.76343 \times 10^{20}\ \mathrm{rad\ s^{-1}}. \quad -(118)$$

The two solutions for photon mass are given later in this section. One solution is always real valued and this root is usually taken to be the physical value of the mass of the photon.