# 21

## Generally Covariant Electro–Weak Theory

**Summary.** A generally covariant electro-weak theory is developed by factorizing the Evans Lemma into first order differential equations and using the appropriate minimal prescription. The differential equations are written in the tangent bundle spacetime for all base manifolds so are generally covariant. The masses of the weak field bosons are understood in terms of scalar curvature. Therefore the electro-weak theory is developed without having to use the concept of spontaneous symmetry breaking and the Higgs mechanism. The latter does not occur in Einsteins general relativity and is not generally covariant nor is it a foundational concept. The electro-weak theory of Glashow, Weinberg and Salaam (GWS) is a theory of special relativity and for this reason is not generally covariant. The Evans unified field theory is foundational because it is a theory of general relativity, and so is preferred to the GWS/Higgs theory when used to describe the electro-weak field. The Evans theory has the advantage of being able to incorporate the gravitational and strong fields into electro-weak field theory. Boson masses in the Evans theory are spacetime scalar curvatures, well defined in the special relativistic limit by the Evans Principle of Least Curvature.

Key words: Generally covariant electro-weak theory, Evans unified field theory. Evans Lemma

### 21.1 Introduction

The electro-weak field theory is a theory of special relativity based directly on the concept of spontaneous symmetry breaking [1] and the Higgs mechanism. The masses of the weak field bosons are introduced through the latter mechanism, which uses an adjustable parameter to force agreement between theory and experimental data, such as data from neutrino electron scattering (weak neutral current) . This type of electro-weak theory was developed independently by Glashow, Weinberg and Salaam and is known as GWS theory. The theory is not foundational because it is not generally covariant, and because the Higgs mechanism is an ad hoc method of introducing masses in such as way that pre-conceived ideas about the neutrino and the photon are maintained intact. The GWS theory, because it is not generally covariant, can never be used to explore the effect of gravitation on electro-weak phenomena and is not a true unified field theory. The masses are introduced in GWS theory in a carefully contrived manner: it is assumed at the outset that the photon and neutrino masses are zero and must be KEPT zero by juggling parameters in the minimal prescription. These assumptions are basically in contravention of Einsteins general relativity, in which zero mass means zero energy and identically flat spacetime in which no fields or particles can exist. An everywhere Minkowski spacetime in Einsteinian general relativity means an empty universe devoid of all fields and all particles. It is now generally accepted [2] on experimental evidence that the neutrino is not a massless particle, so the basic assumption of GWS theory collapses. The weak field boson masses are introduced in GWS theory through the Higgs mechanism, in which a preconceived vacuum symmetry of special relativity is assumed to be spontaneously broken. The theory is delicately glued together in such a way that the photon and neutrino masses remain zero. So the GWS theory is a circular argument. It makes sure that the initial assumption is artificially proven. The experimentally observed weak field boson masses are not predicted foundationally in terms of the basic constants of physics, the data are FITTED with the adjustable parameter of the Higgs mechanism, the basic data in this case being scattering peaks from particle colliders, a type of spectrum of energies. The Higgs boson is postulated to exist but has not been observed experimentally in forty years of very expensive searching. The Higgs boson furthermore cannot be a foundational feature of natural philosophy because the Higgs mechanism, as we have argued, distils down to an adjustable parameter in special relativity. The Higgs boson mass must always be ill defined in general relativity, and any claim to have observed this non-existent boson will be a costly and elaborate curve fitting exercise. There will remain no experimental evidence whatsoever for a vacuum whose symmetry must be spontaneously broken - and then only in special relativity. This much serves to illustrate the mixture of ill-defined concepts known as the standard model. Added to these basic problems of GWS theory is the use of the path integral method and renormalization of the unphysical infinities introduced thereby. The GWS theory is renormalizable only if the Higgs mechanism is used [1]. Without the Higgs mechanism the path integral formalism cannot be used, so the former mechanism is a means of circumventing the fatal flaws of the path integral method by the introduction of Higgs unprovable ideas about the special relativistic vacuum. In general relativity however there is always a special relativistic vacuum by definition - the vacuum IS Minkowski (or flat) spacetime. General relativity tells us no less than this and certainly no more. So the assumed symmetric vacuum of Higgs is extraneous to the general relativity of Einstein. GWS/Higgs starts and ends by telling us that the vacuum of special relativity must have a symmetry which must be broken. GWS /Higgs, then, must always be a statement about an universe devoid of all matter and fields (Minkowski spacetme) and therefore a statement about the nature of nothing at all - primordial theism.

In Section 2 a generally covariant electro-weak theory is introduced based on differential geometry and the recently developed Evans unified field theory [3]–[27]. In sharp contrast to GWS/Higgs the Evans field theory is rigorously a theory of general relativity, and is a straightforward geometrization of all particle and field theory as fundamentally required by general relativity. The Higgs mechanism is not used, and no pre-conceptions or initial assumptions are made about the photon mass and neutrino mass. The path integral method is rigorously avoided,, and the fundamental wave equation of physics, the Evans Lemma, is derived directly from the fundamental tetrad postulate of differential geometry itself [3]–[27]. The Lemma is the subsidiary proposition which, together with Einsteins field equation in index contracted form, leads to the Evans wave equation. In so doing the Einstein field equation is interpreted in the manner originally intended [28] by Einstein, i.e. is interpreted as applying to ALL fields in nature and not only the gravitational field. A generally covariant electro-weak theory is then developed in Section 2 by factorizing the Lemma into first order differential equations in which the interaction between particles (particle scattering) is described with the appropriate covariant derivative. The latter is essentially a change in the tetrad, i.e. a change in the nature of spacetime itself, brought about by particle particle scattering, collisions, or interaction processes. The ad hoc isospinor of GWS Higgs theory [1] is given a physical interpretation in general relativity as a two component vector made up of tetrads, one for the left handed muon neutrino or left handed electron neutrino and one for the left handed electron. This procedure automatically defines a representation space of a particular, SU(2), symmetry in analogy to the SU(2) symmetry used in the original Dirac theory. (In the latter however, one component of the two vector (the Dirac spinor) is a right handed Pauli spinor and the other is a left handed Pauli spinor, both components applying to the electron.) The electro-weak two component vector is governed by its appropriate Evans Lemma, whose eigenvalue matrix is one of scalar curvatures - particle masses or energies within coefficients made up of fundamental constants. The two component vector is an object of differential geometry and not of gauge theory, and the magnitude of this two-vector is invariant under an SU(2) transformation. It is assumed on the basis of experimental data that there is no right handed neutrino in nature, but there is a right handed electron. The latter is also governed by its appropriate Evans Lemma. In the tangent bundle spacetime of the Evans field theory the Lemma can always be factorized into a Dirac equation for all base manifold geometries. Any observed elementary particle spectrum (particle particle scattering process) may be built up directly by appropriate choice of covariant derivative in the factorized Evans Lemma. The peaks in the spectrum correspond to particular terms built up from the minimal prescription, and so these peaks (or masses) are, self-consistently, manifestations of particular scalar curvatures and general relativity, not of the Higgs mechanism. There are no loose parameters in the Evans field theory, and each peak in the elementary particle spectrum is defined by a field intensity. In the case of neutrino electron scattering processes these are field intensities corresponding to the vector boson components. These intensities can be interpreted in terms of mass or energy. No assumptions are made in the Evans theory about the nature of the vacuum apart from the fact that the vacuum is Minkowski spacetime, and the path integral method is not used under any circumstances. The Evans field theory consists analytically of second order differential (wave) equations or first order differential equations to be solved simultaneously for matter fields (particles) and radiated fields. These equations are solved numerically, rigorously avoiding the path integral formalism, if they happen to be analytically intractable. This process completely removes the problem of infinities and renormalization thereof. Finally, the radiated fields in the Evans theory are the agents of particle interaction, as in any field theory, and the concepts of general relativity are unified causally with those of wave mechanics by virtue of geometry in the Evans Lemma [3]–[27].

In Section 21.3 a discussion is given of the advantages of the Evans electro-weak theory over its GWS/Higgs predecessor: the former theory is generally covariant, simpler in structure, and easily applied to experimental data; the latter theory has the fatal weaknesses already described in this introduction.

## 21.2 The Evans Electro-Weak Theory

The generally covariant electro-weak theory originates in the Evans Lemma [3]–[27]:

$$\Box q^a{}_\mu = R q^a{}_\mu \tag{21.1}$$

whose eigenfunction is the tetrad $q^a{}_\mu$ and whose eigenvalues are scalar curvatures $R$ (in units of inverse square metres). The Evans Lemma is the subsidiary geometrical proposition leading to the Evans wave equation:

$$\left(\Box + kT\right) q^a{}_\mu = 0, \tag{21.2}$$

where $k$ is Einsteins constant and $T$ the index contracted energy - momentum tensor. Eq. (21.2) follows from Eq. (21.1) using the Einstein field equation in index contracted form [28]:

$$R = -kT. \tag{21.3}$$

As discussed originally by Einstein [28] Eq. (21.3) must be interpreted as applying to all fields and particles, not only the gravitational field.

As is customary in differential geometry [29] Eq. (21.1) may be written simply as:

$$\Box q^a = R q^a, \tag{21.4}$$

i.e. as an equation of the orthonormal tangent bundle spacetime for all indices $\mu$ of the base manifold. The tetrad is the invertible matrix defined for any vector $\boldsymbol{V}$ by:

$$V^a = q^a{}_\mu V^\mu \tag{21.5}$$

where $\boldsymbol{V}^a$ is defined in the tangent bundle and $\boldsymbol{V}^\mu$ in the base manifold [29]. Any suitable basis set and representation space can be used to describe the orthonormal tangent bundle spacetime for any type of base manifold (non-Minkowski spacetime). It follows that all the equations of physics are equations of the tangent bundle spacetime for all base manifolds. In the limit of an empty universe (the vacuum) devoid of all matter fields and radiated fields the base manifold asymptotically approaches Minkowski spacetime everywhere, there is no mass, spin or helicity, and the tangent and base manifold spacetimes become static and indistinguishable. All tetrad components become constants and $R$ vanishes. The Evans Principle of Least Curvature [3]–[27] states that the minimum $R$ of the Evans Lemma is:

$$R_0 = -\left(\frac{mc}{\hbar}\right)^2 \tag{21.6}$$

where $m$ is the mass of the particle, $\hbar$ is the reduced Planck constant and $c$ the velocity of light in vacuo. Here:

$$\lambda_0 = \frac{\hbar}{mc} \tag{21.7}$$

is the Compton wavelength of any particle. Eq. (21.6) is the special relativistic limit of the Evans field theory. Note carefully that the special relativistic limit is not defined as the limit of everywhere flat (Minkowski) spacetime without spin. In the latter limit there is no $R$ and no mass anywhere in the universe. Evidently, mass m must be non-zero in special relativity, mass is the first Casimir invariant of the Poincare group of special relativity [3]–[27]. The other Casimir invariant of special relativity is spin, and the two Casimir invariants define any particle. In general relativity however the appropriate Lie group is the Einstein group, so in the Evans field theory mass m is the first Casimir invariant of the Einstein group, and spin is the second Casimir invariant of the Einstein group. The Evans field theory is generally covariant for all matter and radiated fields, i.e objective in any frame of reference moving with respect to any other frame of reference in any way. This is a fundamental requirement of everywhere objective physics which is missing entirely in the standard model and GWS/Higgs electro-weak theory. General covariance is of course the fundamental axiom of general relativity, and without it physics is not an objective subject, physics to one observer would be different from physics to another observer. In the Evans field theory the absence of gravitational interaction between particles is defined by Eq. (21.6). In this asymptotic limit of no gravitation, the tetrad of Eq. (21.6) defines the spinning of the base manifold with respect to the tangent bundle spacetime. This spinning motion defines the electromagnetic, weak and strong fields in the absence of gravitation, and so defines the electro-weak field. In the presence of gravitation the base manifold is both spinning and curving with respect to the orthonormal (Minkowski) spacetime of the tangent bundle. The Evans Principle of Least Curvature embodied in Eq. (21.6) is so called because the least possible total curvature in the universe occurs when there is no gravitational attraction between particles of mass m, in which limit Eq. (21.6) applies. The Evans Principle of Least Curvature is a unification of the Hamilton Principle of Least Action and the Fermat Principle of Least Time [30]. Therefore all the equations of the electromagnetic, weak and strong fields in the absence of gravitation are equations of spin in either the tangent bundle spacetime or base manifold. One frame is spinning with respect to the other and both are Minkowski spacetimes when there is no gravitation present. The equations of physics have the same form in both frames and so are generally covariant as required. In geometrical terms this statement means that the equations are valid both for the tetrad and inverse tetrad. In the rest of this paper we develop a generally covariant electro-weak theory in the absence of gravitation. The effect of gravitation on this theory can always be considered by curving the base manifold. In GWS/Higgs theory and the standard model, the effect of gravitation on the other three sectors cannot be analyzed and the concept of tetrad is confined to gravitation only. Spin in GWS/Higgs and the standard model is something extraneous to general relativity, as is the Higgs mechanism itself. This means that the concept of spin is not objective in the standard model, a fatal flaw.

The Evans Lemma in the asymptotic limit of no gravitation, Eq. (21.4), can be factorized into a Dirac equation by expanding the dAlembertian operator in terms of the Dirac matrices :

$$\square = \partial^b \partial_b = \eta_{ab} \partial^a \partial^b = \eta^{ab} \partial_a \partial_b = \gamma^a \gamma^b \partial_a \partial_b, \tag{21.8}$$

$$g_{\mu\nu} = q^a{}_\mu q^b{}_\nu \eta_{ab} \tag{21.9}$$

where $g_{\mu\nu}$ and $\eta_{ab}$ are the manifold and tangent space metrics respectively. It follows that Eq. (21.4) is:

$$\left(-i\gamma^b \partial_b - m_e c/\hbar\right) \left(i\gamma^a \partial_a - m_e c/\hbar\right) q^c{}_\mu = 0 \tag{21.10}$$

and that there exist two Dirac equations, one the complex conjugate of the other:

$$\left(i\gamma^a \partial_a - m_e c/\hbar\right) q^c{}_\mu = 0 \tag{21.11}$$

$$\left(-i\gamma^b \partial_b - m_e c/\hbar\right) q^c{}_\mu{}^* = 0. \tag{21.12}$$

It also follows that the Dirac spinor originates in a tetrad of differential geometry [3]–[27]. Therefore the effect of gravitation on the Dirac equation can be analyzed by curving the base manifold. In the absence of gravitation the Dirac equation is an equation of spin, in this case the half integral spin of the Dirac electron with right and left handed components. It follows that the right and left handed electrons are each described by tetrad components - the right and left Pauli spinors. The tetrad appearing in Eqs. (21.10) is the four by four matrix defined by:

$$\sigma^a = q^a{}_\mu \sigma^\mu \tag{21.13}$$

where $\sigma$ are Pauli matrices (basis elements) respectively in the tangent bundle spacetime and base manifold. The Dirac spinor is obtained by transposing the row vectors of the tetrad ($q^a{}_\mu$) into column vectors, giving a column four-vector:

$$q^a{}_\mu = \begin{bmatrix} q^1{}_1 & q^1{}_2 \\ q^2{}_1 & q^2{}_2 \end{bmatrix} \rightarrow \begin{bmatrix} q^1{}_1 \\ q^1{}_2 \\ q^2{}_1 \\ q^2{}_2 \end{bmatrix} \tag{21.14}$$

and the two Pauli spinors (for the right and left handed electron) are:

$$\xi^1 = \begin{bmatrix} q^1{}_1 \\ q^1{}_2 \end{bmatrix}, \xi^2 = \begin{bmatrix} q^2{}_1 \\ q^2{}_2 \end{bmatrix}, \tag{21.15}$$

and are therefore column two-vectors made up of two tetrad elements. The Dirac spinor is therefore a column vector made up of two Pauli spinors, one right handed, the other left handed. All the elements in these column vectors are tetrad elements defined by geometry as required in general relativity.

In the presence of gravitation the Dirac equations (21.10) and (21.11) become the first order differential Evans equations:

$$\left(i\gamma^a \partial_a - |R|^{1/2}\right) q^c{}_\mu = 0 \tag{21.16}$$

$$\left(-i\gamma^b \partial_b - |R|^{1/2}\right) q^c{}_\mu{}^* = 0. \tag{21.17}$$

The generally covariant electro-weak theory of this paper is built up from these first order differential equations in the absence of gravitation. To illustrate the method used first consider the interaction of two electrons mediated by the electromagnetic potential field. The latter is defined by a tetrad within a factor $A^{(0)}$:

$$A^a{}_\mu = A^{(0)} q^a{}_\mu \tag{21.18}$$

In the absence of gravitation this tetrad is also governed by the Evans Lemma:

$$\left(\Box + (m_p c/\hbar)^2\right) A^a{}_\mu = 0 \tag{21.19}$$

where $m_p$ is the exceedingly small but non-zero mass of the photon [3]–[27]. The interaction of the photon and electron is accordingly described by the covariant derivative or minimal prescription written in the tangent bundle spacetime:

$$(i\hbar\gamma^a (\partial_a - ieA_a) m_e c) q^c = 0. \tag{21.20}$$

This equation is a form of the fundamental tetrad postulate of differential geometry [3]–[29]:

$$D^\mu (D_\mu q^a{}_\nu) = 0 \tag{21.21}$$

i.e. the covariant derivative of a tetrad is always zero. Therefore the interaction of an electron and a photon is analyzed by solving Eqs. (21.20) simultaneously with:

$$(i\hbar\gamma^a (\partial_a - ieA_a) m_e c/) A^c = 0. \tag{21.22}$$

This can be done numerically on contemporary computers without use of the path integral method. In so doing the problems of infinities and renormalization are completely avoided. Eq (21.22) describes the momentum lost by the photon, Eq. (21.20) describes the momentum gained by the electron, Eq. (21.11) governs the motion of the free electron and Eq. (21.19) that of the free photon. Here $m_e$ and $m_p$ are the electron and photon masses respectively.

It is clear from the complex conjugate Eqs. (21.11) and (21.12) that there exist:

$$(\gamma^a (i\hbar\partial_a - eA_a) - m_e c/) q^c = 0. \tag{21.23}$$

$$(\gamma^a (-i\hbar\partial_a - eA_a^*) - m_e c/) q^{c*} = 0. \tag{21.24}$$

Therefore a wave equation can be constructed as follows:

$$(\gamma^a (-i\hbar\partial_a - eA_a^*) - m_e c/) \left(\gamma_b \left(i\hbar\partial^b - eA^b\right) - m_e c/\right) q^c = 0. \tag{21.25}$$

This wave equation is:

$$\left(\Box + \frac{em_e c\gamma^a}{\hbar^2} (A_a + A_a^*) + \left(\frac{e}{\hbar}\right)^2 A_a^* A^a + \left(\frac{mc}{\hbar}\right)^2\right) q^c = 0 \tag{21.26}$$

and is the Evans Lemma describing the interaction of a photon and an electron. The interaction is described through extra scalar curvatures:

$$|R_1| = e^2 A_a^* A^a / \hbar^2, \tag{21.27a}$$

$$|R_1| = em_e c\gamma^a (A_a + A_a^*) / \hbar^2 \tag{21.27b}$$

which appear when the photon and electron interact, collide or scatter. Depending on the preferred terminology . The scalar curvatures (21.27) are characteristic of the scattering process and do not exist in Eq (21.11) for the free electron or in Eq. (21.19) for the free photon.

It is these scalar curvatures that describe the electro-weak interactions in the generally covariant Evans theory. Having set the scene in this way it is now possible to develop a simple type of electro-weak theory for the scattering of the neutrino and electron. We proceed by setting up the appropriate tetrad postulate and finding the interaction scalar curvatures for neutrino electron scattering analogous to (21.27a) for photon electron scattering. Similar procedures can be used for any type of particle scattering, but in this paper the theory is illustrated by neutrino electron scattering. The fundamental principle is that all scattering processes are governed by the tetrad postulate, i.e. by the first order Evans equations and the Evans Lemma.

These equations are straightforwardly generalized to any type of fermion boson scattering (or any type of particle scattering) by generalizing the electron to the fermion and the photon to the boson. In so doing no preconceived ideas concerning a hypothetical massless photon or neutrino are used, and no preconceived ideas about hyper-charge and vacuum symmetry breaking. These ideas are all extraneous to general relativity and thus to fundamental physics. Furthermore the abstract fiber-bundle index of gauge theory is replaced by the physical (i.e geometrical) tangent-bundle index, an index which is rigorously defined and governed (or constrained) by fundamental differential geometry. Again, the abstract fiber-bundle index of gauge field theory is extraneous to general relativity, and is not needed in our geometrical development. We therefore reject almost all of the ideas of the standard model, retaining general relativity. Only in this way can a truly foundational theory of particle scattering ever evolve, and only in this way can we ever hope to evolve a theory in which the effect of gravitation on radio-activity (electro-weak field) can be analyzed foundationally. It is known experimentally [31] that radio-activity evolved from gravitational events and the standard model is unable to analyze these data even at a qualitative level. The reason is that in the standard model there is no mechanism with which the effect of gravitation on the electro-weak field can be analyzed. It should come as no surprise therefore that the SU(2) internal (gauge) space used in GWS/Higgs must also be discarded. The much vaunted internal gauge space of GWS/Higgs (used to define the iso-spinor) is no more than a useful summary of a particular mathematical structure that can be understood much more simply and more clearly in the Evans unified field theory. The latter is generally covariant and can be used to analyze the effect of gravitation on radio-activity, and to prove conclusively that radio-activity evolved from gravitation [31]. Gauge theory must therefore itself be rejected in favor of a theory such as the Evans field theory, a generally covariant unified field theory developed [3]–[27] with the geometrical guidelines drawn up by Einstein. If we adhere to these guidelines, particle scattering theory becomes much far clearer and much simpler than that offered by GWS/Higgs. The latter is a mixture of concepts based on Minkowski spacetime. The use in GWS/Higgs of ideas extraneous to general relativity is effectively the use of loose parameters which are adjusted to force agreement with experimental data from particle colliders. In the Evans electro-weak theory there appear only the fundamental constants of physics and the foundational boson intensities analogous to electromagnetic field intensity which must be determined experimentally. These intensities indicate the observed boson masses as energy peaks in particle collider data of many different varieties. When the so called standard model attempts field unification all that really happens is the introduction of more loose parameters. This contemporary situation is strikingly reminiscent of the use of epicycles (many loose parameters) before Kepler discovered the laws of planetary motion, and before Newton rationalized these laws into powerful, simple equations using ONLY the Newtonian gravitational constant $G$, a fundamental constant of physics proportional to the Einsteinian constant $k$ of general relativity. It becomes painfully clear therefore that the standard model (like Aristotelian epicycles) is historically another example of pathological or pseudo physics. Even worse is the infinity plagued complexity of Feynman calculus, and the meaningless and multidimensional mathematical process known as string theory: any rational scientist must surely know that an overhaul and drastic simplification of academic physics is long overdue before the subject loses all credibility and predictive ability.

For example, if we wish to consider the collision of a weak neutral $Z$ boson with a neutrino, then we solve numerically the following simultaneous Evans equations (generally covariant Dirac equations):

$$\left(i\hbar\gamma^a\left(\partial_a - igZ_a\right)m_\nu c/\right)\nu^b = 0 \tag{21.28}$$

$$\left(i\hbar\gamma^a\left(\partial_a + igZ_a\right)m_z c/\right)Z^b = 0 \tag{21.29}$$

where $\nu^b$ is the neutrino wave-function and where $Z^b$ is the weak neutral boson wave-function, a tetrad defined by:

$$Z^a{}_\mu = Z^{(0)} q^a{}_\mu . \tag{21.30}$$

The neutrino is a fermion and its wave-function is a tetrad of the type defined in Eq. (21.12). The non-zero neutrino mass appears in Eq. (21.28). The fact that the neutrino has a mass has now been established experimentally [2]. This one experimental fact is enough for the rejection of GWS/Higgs, because the latter is built entirely around the supposition that there exist two massless particles, the photon and neutrino. This supposition is again extraneous to general relativity (in which there can be no massless particles, as in Newtonian physics) and the supposition is thus extraneous to objective physics. Unsurprisingly the supposition has been found experimentally to be a false one. As in the case of epicycles, it might take some time for the standard model to be rejected, but if physics is to remain a generally covariant and thus objective study of nature, rejected it must be.

In Eqs. (21.28) and (21.29) $m_\nu$ and $m_Z$ are therefore the non-zero neutrino and $Z$ boson masses respectively, and g is the appropriate coupling constant which is $C$ negative and so is proportional to the charge on the electron $-e$. There is no need for the obscure notion of modified hypercharge, introduced by Weinberg and accepted uncritically in GWS/Higgs. The use of hypercharge originated in gauge theory of the strong nuclear field, shortly after the introduction of the abstract internal gauge index by Yang and Mills. From the point of view of Einsteinian (i.e. objective or generally covariant) natural philosophy, this was another false turn in the development of physics. The index a of the tetrad, in contrast, is geometrical in origin, and thus physical according to general relativity. The abstract fiber-bundle index is just that, an abstract or loose parameter arbitrarily superimposed on flat or Minkowski spacetime without any regard to base manifold geometry and thus without any regard to gravitation, and worse, to objective physics. The abstract fiber-bundle index may be used to define internal gauge symmetries, but these must always remain extraneous to general relativity. Worse still is the use in the standard model of approximate internal gauge symmetries in nuclear strong field and quark theory. The obvious truth in mathematics is that a symmetry is exact and can never be approximate. Quarks cannot exist approximately, yet this is what we are told, i.e. what must follow logically from the use of approximate symmetry as a foundational idea. The rational mind would conclude that quarks do not exist, they have merely been postulated to exist.

In the Evans field theory the abstract index of gauge theory is replaced by the geometrical index a of the tetrad, and that index is of course governed rigorously by the rules of differential geometry itself. There is no room for approximate geometry in human thought, and no room for subjective thought-entities such as quarks which exist approximately and are confined so as to be unobservable. Natural philosophy is the objective study of the observable in nature. Having rid ourselves of this cupboard full of skeletons known as the standard model it becomes much easier to see that the interaction of a Z boson and a neutrino is a matter of solving the Evans equations (21.28) and (21.29) on a desktop computer, avoiding the floating point overflow inevitably caused by infinities, i.e. avoiding the path integral method by using robust integrating software. Nature abhors a Feynman infinity as much as it abhors a broken Higgs vacuum. Both the infinity and the broken vacuum are untested products of the human mind (i.e. of subjective thought untested by data) and cannot exist in nature. The latter can be defined only by objective measurement.

In the diagrammatic form of the type familiar in particle scattering theory textbooks the Evans equations (21.20) and (21.22) are summarized by: This diagram summarizes the interaction of two electrons through the

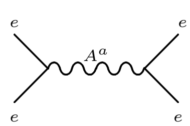


**Fig. 21.1.** Feynman Diagram

photon. Eqs. (21.28) and (21.29) are summarized by the diagram: illustrating the weak neutral current. An interaction between a $Z$ boson and an electron is defined by the following two simultaneous Evans equations:

$$\left(i\hbar\gamma^a\left(\partial_a - ig_1 Z_a\right) - m_e c\right) q^a = 0 \tag{21.31}$$

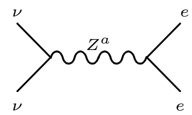


**Fig. 21.2.** Feynman Diagram

$$(i\hbar\gamma^a\left(\partial_a + ig_1 Z_a\right) - m_Z c)\, Z^a = 0 \tag{21.32}$$

where $g_1$ is the appropriate coupling constant again proportional to $e$.

In general scattering theory it is customary to use the momentum exchange diagram: which indicates the following processes:

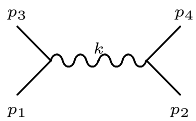


**Fig. 21.3.** Feynman Diagram

$$p_1 + p_2 = p_3 + p_4 \tag{21.33}$$

$$p_1 + k = p_3 \tag{21.34}$$

$$p_2 - k = p_4 \tag{21.35}$$

By adding Eqs. (21.34) and (21.35) it becomes clear that a boson momentum $k$ is gained and lost simultaneously as follows:

$$(p_1 + k) + (p_2 - k) = p_3 + p_4 \tag{21.36}$$

This is what is known with traditional obscurity of language as a virtual boson. This general process is also describable by the appropriate simultaneous Evans equations. In order to describe the transmutation processes that occur in radio activity more than two Evans equations must solved simultaneously using powerful enough contemporary hardware and software. This fact is illustrated by the scattering process: mediated by the charged weak field boson $W^-$. In

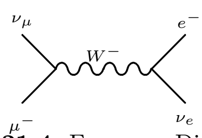


**Fig. 21.4.** Feynman Diagram

the above diagram the customary notation of particle scattering theory has been followed. Here $\mu^-$is the muon, a fermion with a mass about 207 times greater than the electron and a lifetime of $2.2 \times 10^{-8}$ sec, $\nu_\mu$ is the muon–neutrino, $e^-$ is the electron, and $\nu_e$ is the electron-neutrino. By reference to diagram (21.4) the process in diagram (21.3) is the following conservation of momentum:

$$p\left(\mu^-\right) + p\left(\nu_e\right) = p\left(\nu_\mu\right) + p\left(e^-\right) \tag{21.37}$$

and Eq. (21.4) is denoted by the nuclear reaction, transmutation or radioactive process:

$$\mu^- + \nu_e = \nu_\mu + e^- \tag{21.38}$$

observed in particle colliders. By reference to Eq. (21.34) diagram (21.4) means that the muon momentum plus $W^-$ momentum gives the muon-neutrino momentum:

$$p\left(\mu^-\right) + p\left(W^-\right) = p\left(\nu_\mu\right). \tag{21.39}$$

By reference to Eq. (21.35) diagram (21.4) also means that the electron-neutrino momentum minus the $W^-$ momentum gives the electron momentum:

$$p\left(\nu_e\right) - p\left(W^-\right) = p\left(e^-\right). \tag{21.40}$$

The total momentum of all four particles is conserved as follows:

$$\left(p\left(\mu^-\right) + p\left(W^-\right)\right) + \left(p\left(\nu_e\right) - p\left(W^-\right)\right) = p\left(\nu_\mu\right) + p\left(e^-\right). \tag{21.41}$$

The general momentum exchange or particle scattering process illustrated in diagram (21.3) can now be seen to be described by the Evans equations:

$$\left(i\hbar\gamma^a\left(\partial_a + igk_a\right) - m_1 c\right) p^b{}_1 = \left(i\hbar\gamma^a\partial_a - m_3 c\right) p^b{}_3 \tag{21.42}$$

$$\left(i\hbar\gamma^a\left(\partial_a - igk_a\right) - m_2 c\right) p^b{}_2 = \left(i\hbar\gamma^a\partial_a - m_4 c\right) p^b{}_4. \tag{21.43}$$

In this notation $p^b{}_1, \cdots, p^b{}_4$ are the four wavefunctions of the interacting matter waves (particles). If this collision process results in transmutation (radio activity) then the particles emerging after collision are two different particles. The wavefunctions after collision are those of the two different particles. Each wave function is a tetrad and so carries the label b of the tangent bundle spacetime. If there is no collision or scattering, then:

$$k_a = 0, p_1 = p_3, p_2 = p_4 \tag{21.44}$$

and the following equations describing the two free particles are obtained self-consistently:

$$\left(i\hbar\gamma^a\partial_a - m_1 c\right) p^b{}_1 = 0 \tag{21.45}$$

$$\left(i\hbar\gamma^a\partial_a - m_2 c\right) p^b{}_2 = 0. \tag{21.46}$$

Eq. (21.42) is the description of Eq. (21.34) in the Evans unified field theory, and Eq. (21.43) is the description of Eq. (21.34). These are the basic equations which describe any particle scattering process in the Evans unified field theory. Evidently, the scattering process may or may not involve transmutation, and is mediated by the boson $k_a$. The free boson is itself governed by an Evans equation:

$$\left(i\hbar\gamma^a\partial_a - m_k c\right) k^b{}_i = 0 \tag{21.47}$$

where $m_k$ is the mass of the boson. In Eq. (21.47), $k^b{}_a$is the wavefunction of the boson before colliding with the particle. Eq. (21.47) is found using Eq. (21.9) by factorizing the Evans wave equation:

$$\left(\Box + \left(\frac{m_k c}{\hbar}\right)^2\right) k^b{}_i = 0. \tag{21.48}$$

The collision of the boson with the particle then reduces the boson momentum as follows:

$$\left(i\hbar\gamma^a\left(\partial_a - igk_a\right) - m_k c\right) k^b = \left(i\hbar\gamma^a\partial_a - m_k c\right) k^b{}_f = 0 \tag{21.49}$$

where $k^b{}_f$ is the final wavefunction of the boson after collision. Eq. (21.49) is balanced through conservation of momentum by:

$$\left(i\hbar\gamma^a\left(\partial_a + igk_a\right) - m_k c\right) k^b = \left(i\hbar\gamma^a\partial_a - m_k c\right) k^b{}_i = 0. \tag{21.50}$$

Eqs (21.42), (21.43), (21.49) and (21.50) must be solved simultaneously, and are generally covariant unified field equations describing any type of collision between two particles mediated by any type of boson (field quantum). They describe the virtual boson exchange process summarized in:

$$(p_1 + k) - (p_2 - k) = p_3 + p_4. \tag{21.51}$$

In integrating these equations robust contemporary software should be used, and not the sixty year old path integral method, which produces well known pathological infinities. The criterion for acceptability of any theory must be general covariance (objectivity) and not renormalizability as in the standard model. The vastly complicated process of renormalization is merely a response to a flawed theory of special relativity (the standard model) and string theory merely compounds the problem with more loose parameters and meaningless concepts.

We are now ready to describe a transmutation process such as that in diagram (21.4) with the appropriate Evans equations of objective and unified field theory. An objective theory of physics is by definition a theory of general relativity, so the standard model fails this first and fundamentally important test of natural philosophy. In diagram (21.4), a muon $\mu^-$ of momentum $p_1$ collides with an electron-neutrino $\nu_e$ of momentum $p_2$. The collision is mediated or buffered by the weak charged boson $W^-$. The two particles which emerge from the collision are different from the two particles that were present before collision. The emerging or transmuted particles are the muon-neutrino $\nu_\mu$ with momentum $p_3$ and the electron $e^-$ with momentum $p_4$. Eq. ((21.42) and (21.34) means that the final momentum $p_3$ of the muon neutrino is the sum of the initial momentum of the muon and the momentum of the boson. This is represented by the Evans equation (21.42):

$$\left(i\hbar\gamma^a\left(\partial_a + igW_a^-\right) - m_\mu c\right)\mu^b = \left(i\hbar\gamma^a\partial_a - m_{\nu_\mu}c\right){\nu^b}_\mu = 0 \tag{21.52a}$$

$$\left(i\hbar\gamma^a\left(\partial_a - igW_a^-\right) - m_W c\right)W^b = 0 \tag{21.52b}$$

where in accord with contemporary practice in particle physics we have denoted the wavefunction of the muon by $\mu^b$ and that of the muon-neutrino by ${\mu^b}_\mu$. The coupling constant $g$ in equation (21.52) measures the strength of the collision, during the course of which the boson ${W^-}_a$ must lose the momentum it has transferred to the muon. The left hand side of Eq (21.52) describes the way in which the muon gains momentum from the boson. The right hand side of Eq. (21.52) describes the result of this momentum change, i.e. describes the free muon-neutrino after the collision has taken place. The final momentum

$$p_3\left(\nu_\mu\right) = p_1\left(\mu^-\right) + k\left(W^-\right) \tag{21.53}$$

that emerges from the collision is therefore that of the muon-neutrino. This is therefore the objective way of describing a transmutation process in unified field theory.

By reference to diagram (21.4) and Eq. (21.35) the electron $e^-$ that emerges form the collision has a final momentum $p_4$, which is defined by the initial momentum $p_2$ of the electron-neutrino minus the boson momentum $k$. The appropriate Evans equation for this process are accordingly:

$$\left(i\hbar\gamma^a\left(\partial_a - igW_a^-\right) - m_{\nu_e}c\right){\nu^b}_e = \left(i\hbar\gamma^a\partial_a - m_e c\right)e^b = 0 \tag{21.54a}$$

$$\left(i\hbar\gamma^a\left(\partial_a + igW_a^-\right) - m_W c\right)W^b = 0. \tag{21.54b}$$

Therefore the complete process in diagram ((21.4)) can be described either by solving the two Equations (21.52a) and (21.52b) simultaneously or by solving the two equations (21.54a) and (21.54b) simultaneously. By adding Eqs (21.52a), (21.52b), (21.54a) and (21.54b) we obtain the conservation of energy/momentum equation for the complete process:

$$\begin{aligned}&\left(i\hbar\gamma^a\left(\partial_a + igW_a^-\right) - m_\mu c\right)\mu^b + \left(i\hbar\gamma^a\left(\partial_a - igW_a^-\right) - m_{\nu_e}c\right){\nu^b}_e \\ &= \left(i\hbar\gamma^a\partial_a - m_{\nu_\mu}c\right){\nu^b}_\mu + \left(i\hbar\gamma^a\partial_a - m_e c\right)e^b = 0.\end{aligned} \tag{21.55}$$

Finally eqn. (21.54) is expressed as the two SU(2) symmetry equations:

$$(i\hbar\gamma^a \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \partial_a + i\hbar\gamma^a \begin{bmatrix} 0 & igW_a \\ -igW_a & 0 \end{bmatrix} - \begin{bmatrix} m_{\nu_e}c & 0 \\ 0 & m_\mu c \end{bmatrix}) \begin{bmatrix} \nu_e \\ \mu \end{bmatrix} = 0 \tag{21.56}$$

$$(i\hbar\gamma^a \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} - \begin{bmatrix} m_{\nu_e}c & 0 \\ 0 & m_e c \end{bmatrix}) \begin{bmatrix} \nu_{\mu_b} \\ e_b \end{bmatrix} = 0 \tag{21.57}$$

familiar from that part of the GWS/Higgs theory that is conventionally used to describe the weak charged current process of diagram (21.4).

## 21.3 Discussion

Glashow, Weinberg and Salaam independently arrived at some aspects of electro-weak (or GWS) theory based directly on the Higgs mechanism. We have shown in this paper that nearly all the assumptions of the GWS/Higgs theory contradict the basic tenet of physics, that of objectivity or general covariance. Therefore GWS/Higgs theory simply does not stand up to scholarly scrutiny. One of the basic ideas of GWS/Higgs is that the neutrino is massless, but recently the neutrino has been shown experimentally to have mass. Therefore it is an experimental fact that there are no massless fermions in nature. Indeed, it is now thought in some quarters that relic neutrinos are responsible for dark matter, and therefore for about 80 of the mass of the universe. Neutrino oscillations are observed experimentally in the muon-neutrino, which appears and disappears as it travels hundreds of kilometres through the earth (super Kamiokande collaboration). The electron-neutrino was first inferred theoretically by Fermi in about 1930 (from the observed energy deficit in beta particle decay) and the electron-neutrino was first observed experimentally in 1956. The muon-neutrino was discovered in 1961 and the tau-neutrino in 1974. All three types of neutrino have finite mass. This fact is inexplicable in the standard model but is explained in the Evans field theory as discussed in Section 21.2. In the equations of that section the neutrino mass always appears as non-zero. We exemplified the Evans field theory by considering the muon-neutrino in a charged weak current process, but the theory is generally applicable to all three types of neutrino and to all fermions and bosons in nature. Neutrino oscillation is explained in the Evans theory as a particular type of mass energy transmutation. Neutrino oscillation has no explanation in GWS/Higgs because the latter theory assumes that neutrino mass is always zero, so no neutrino oscillation (changing or transmutation of finite neutrino mass/energy) is possible in GWS/Higgs. It follows that the Higgs mechanism has been falsified experimentally and that there is no Higgs boson in nature, all that remains to us after forty years of speculation is an adjustable parameter in an experimentally falsified theory. Therefore there is no point in looking experimentally for a Higgs boson as in the heavy hadron collider experiments planned at CERN. It would be more logical to interpret the new heavy hadron collider data with the Evans theory and developments thereof.

Another basic idea of GWS/Higgs is that the neutrino (which is parity violating, or left handed only) forms a physically meaningful isospinor with a left handed fermion, but not with a right handed fermion. The arguments of Section 21.2 shows, however, that the isospinor has no particular physical meaning over and above that already present in conservation of energy/momentum. Eq. (21.56) or Eq. (21.57) shows that there is, rather, an ordinary column vector with two entries in a convenient mathematical representation of simultaneous Evans equations. The latter are generally covariant and are the fundamental and objective equations of electro-weak theory (radio-activity). It may be true experimentally that the neutrino is left handed (and so violates parity experimentally), but it does not follow that it must form an isospinor with a left handed fermion such as an electron or muon. So another fundamental tenet of GWS/Higgs has been shown to be false. It follows that if there is no isospinor in nature there can be no modified hypercharge as introduced by Weinberg and uncritically accepted in the standard model. It also follows that the SU(2) symmetry internal gauge space of GWS/Higgs theory has no particular physical significance. (Eq. (21.56) shows that this symmetry is conservation of momentum in the Evans equations.) In the standard model this SU(2) mathematical space is superimposed on a theory of special relativity which is only Lorentz covariant and so cannot be objective to all observers. Being a superimposed abstract space, its parameters are in the last analysis adjustable parameters which must be found from experimental data. They can never be used to predict data foundationally. All gauge theories of the standard model (the electromagnetic, weak and strong sectors) have this weakness inbuilt, so internally inconsistent gauge theory should be replaced by self-consistent general relativity, and the abstract fiber bundle of gauge theory replaced by the physically meaningful tangent bundle in differential geometry and general relativity as originally intended in Einsteins work. This is what has been done in Section 21.2 for the theory of radio activity. There is no purpose in accepting Einsteins work on the one hand, and rejecting it on the other. Yet this is what the standard model does all the time, it accepts Einsteinian general relativity in its gravitational sector and rejects it entirely in its other three sectors.

These elementary (i.e. foundational) considerations put the standard model in ever more serious difficulties, because the much vaunted quark model of the strong sector is built on an assumed SU(3) internal gauge space. It is certain that this gauge symmetry has no physical meaning in general relativity. It becomes ever clearer that all elementary particle physics should be interpreted with the generally covariant Evans theory, which is firmly based on the tetrad postulate of differential geometry and is a rigorously objective theory of Einsteinian natural philosophy as required. It is absurd to propose a theory of physics which is not objective to all observers, yet this is precisely what occurs in the standard model. The quark model can be criticised in several ways, the data for quarks are based on low angle scattering, and are equivocal. They could be interpreted as inhomogeneities due to the spatial characteristics of a given type of nuclear wavefunction, for example a proton wavefunction described by the inhomogeneities of the spherical harmonics (akin to the electronic s, p, d, ... orbitals). No one would claim that the spatially inhomogeneous electronic s, p, d,.... orbitals indicate the existence of a particle more fundamental than the electron, so why should the spatially inhomogeneous proton be made up of quarks? There is no reason in other words why an elementary particle such as a proton should be perfectly homogeneous, its internal density may vary from quantum mechanics. In other words there is no reason why the vague inhomogeneities of low angle scattering data should be interpreted in terms of other, more fundamental particles in nature (the quarks). It is true that elementary particle data appear to display an equally vague gauge symmetry akin to SU(3) but this is openly referred to as an approximate gauge symmetry, a term which should have no meaning whatsoever in objective physics or mathematics. So vague bumps in low angle scattering theory are all we really have on quarks, the rest is surmise in abstract gauge theory with loose parameters from an experimentally falsified Higgs mechanism. What the standard model really tells us is that quarks must exist only approximately, they are the only manifestations in nature of an approximate reality but must be confined so as to be unobservable. This is a great absurdity for which Nobel Prizes are habitually given. Add to this the many gross absurdities of renormalization and string theory then we must conclude that there is no physics at all in the standard model. Compared with this contemporary and hugely expensive contrivance, epicycles were models of foundational clarity.

In the Evans theory scattering data for all types of elementary particles can always be interpreted straightforwardly with equations of the type developed in Section 21.2, and no effort is made to look for the physically non-existent but mathematically convenient gauge symmetries of the standard model, symmetries which do not exist in general relativity and therefore do not exist in objective physics. Only in this way will it ever be possible to analyze the effect of gravity on nuclear processes or chemical reactions.

In addition to these severe foundational failings the GWS/Higgs theory cannot predict data from particle accelerators, as if often claimed. The theory can only fit data using adjustable parameters. The charged and neutral weak boson masses in GWS/Higgs are parameterized as follows:

$$m_W = g\eta/\sqrt{2} = m_Z \cos\theta_W \tag{21.58}$$

$$\eta^2 = \frac{1}{2\sqrt{2}G}, \tag{21.59}$$

therefore:

$$m_W = f\left(g, g^{'}, \eta\right) = f\left(g, g^{'}, G\right). \tag{21.60}$$

Here $\theta_W$ is the Weinberg angle, $g$ and $g^{'}$ are coupling parameters, $\eta$ is the Higgs parameter and $G$ is the Fermi coefficient. Eq (21.59) shows that $G$ is just replaced by $\eta$. In other words the straightforward $G$ of Fermi is surmised to have something to do with a vacuum symmetry breaking which gives mass to mysterious, initially massless fermions but not to others. Since all fermions have mass experimentally this surmise is false and is erroneous in both special and general relativity. The origin of mass is now known from the Evans Lemma [3]–[27] to be least curvature. A massless particle corresponds to nothing at all. No experimental evidence for vacuum symmetry breaking is ever given in GWS/Higgs, what really happens is that two scattering peaks (for the neutral and charged boson) are fitted with three adjustable parameters ($g$, $g^{'}$ and $\eta$

or $G$). This could just as well be done with a curve fitting program without recourse to any physics at all.

The formal structure of the GWS/Higgs theory is a combination of

$$\left(i\hbar\gamma^a\left(\begin{bmatrix}1&0\\0&1\end{bmatrix}\partial_a+\frac{ig^{'}}{2}\begin{bmatrix}1&0\\0&1\end{bmatrix}X_\mu-\frac{ig}{2}\begin{bmatrix}W^3{}_\mu & W^1{}_\mu-igW^2{}_\mu\\ W^1{}_\mu+igW^2{}_\mu & -W^3{}_\mu\end{bmatrix}\right)\right.$$
$$\left.-\begin{bmatrix}m_\nu & 0\\ 0 & m_ec\end{bmatrix}^c\right)\begin{bmatrix}\nu\\ e_L\end{bmatrix}=i\gamma^a\left(\partial_a+\frac{i}{2}\left(g^{'}X_a-g\boldsymbol{\sigma}\cdot\boldsymbol{W}_\mu\right)\right)L \tag{21.61}$$

and

$$\begin{aligned}&\left(i\hbar\gamma^a\left(\partial_a+ig^{'}X_a\right)-m_e\right)\begin{bmatrix}1&0\\0&1\end{bmatrix}e_R\\ &=\left(i\hbar\gamma^a\left(\partial_a+ig^{'}X_a\right)-m_e\right)R\end{aligned} \tag{21.62}$$

so the complete formal structure consists of two simultaneous equations:

$$\begin{aligned}&i\hbar\gamma^a\left(\partial_a+\frac{i}{2}\left(g^{'}X_a-gW^3{}_a\right)-m_\nu c\right)\nu+i\hbar\gamma^a\left(-\frac{i}{2}W_a\right)e_L\\ &+\left(i\hbar\gamma^a\left(\partial_a+ig^{'}X_a\right)-m_ec\right)e_R=0\end{aligned} \tag{21.63}$$

$$\begin{aligned}&i\hbar\gamma^a\left(-\frac{ig}{2}W_a^*\right)\nu+i\hbar\gamma^a\left(\partial_a+\frac{i}{2}\left(g^{'}X_a+gW^3{}_a\right)-m_ec\right)e_L\\ &+\left(i\hbar\gamma^a\left(\partial_a+ig^{'}X_a\right)-m_ec\right)e_R=0.\end{aligned} \tag{21.64}$$

However, in the original GWS/Higgs theory the mass term is missing from these equations. The correct way of expressing the theory is the combination of Evans equations in Eqs. (21.63) and (21.64), a combination in which the mass terms appear correctly as a result of general relativity. It is then possible to define the electromagnetic field as:

$$A_\mu=\left(g^{'}W^3{}_\mu+gX_\mu\right)/\left(g^2+g^{'2}\right)^{1/2}=W^3{}_\mu\sin\theta_W+X_\mu\cos\theta_W \tag{21.65}$$

and the weak neutral field by:

$$Z_\mu=\left(gW^3{}_\mu-g^{'}X_\mu\right)/\left(g^2+g^{'2}\right)^{1/2}=W^3{}_\mu\cos\theta_W-X_\mu\sin\theta_W \tag{21.66}$$

However, no particular physical significance is attached to the Weinberg angle:

$$\theta_W=sin^{-1}g^{'}/\left(g^2+g^{'2}\right)^{1/2} \tag{21.67}$$

Finally, the way in which particle scattering data is explained in the Evans theory is illustrated by taking two conjugate Evans equations such as:

$$\left(\gamma^a\left(i\hbar\partial_a - eA_a\right) - mc\right)q^b = 0 \tag{21.68}$$

$$\left(\gamma^a\left(-i\hbar\partial_a - eA_a^*\right) - mc\right)q^b = 0 \tag{21.69}$$

and from these equations forming the wave equation:

$$\left(\Box + \frac{emc}{\hbar^2}\gamma^a\left(A_a + A_a^*\right) + g^2 A^a A_a^* + \left(\frac{mc}{\hbar}\right)^2\right)q^b = 0. \tag{21.70}$$

The two equations (21.68) and (21.69) or the wave equation (21.70) illustrate the interaction of a an electron with a photon, and the interaction energy is defined by:

$$En_{int} = mc^2 = \hbar gc\left(A^a A_a^*\right)^{1/2} = ecA^{(0)} \tag{21.71}$$

in terms of the mean square amplitude $A^{(0)2}$ of the electromagnetic field. Similarly the interaction of the ${Z^3}_a$ boson with the neutrino (weak neutral current) is described from Eq. (21.28) of Section 21.2 by the interaction energy: It can be seen that there are no adjustable parameters in the Evans field theory. The mean square amplitudes $A^{(0)2}$ and $Z^{3(0)2}$ are foundational properties of the boson itself, as is the intrinsic boson mass. In the GWS/Higgs theory both the boson masses and the interaction energy must be described through the lose parameters $g$, $g^{'}$ and $G$ or $\eta$. The boson masses are:

$$m_W = g\eta/\sqrt{2}, \;\; m_3 = m_W/\cos\theta_W, \tag{21.72}$$

and the interaction energies are defined through:

$$\begin{aligned} m_W^2 &= \frac{e^2}{4\sqrt{2}\,G\sin^2\theta_W} = (78.6GeV/c^2)^2 \\ &= f\left(g, g^{'}, G\right). \end{aligned} \tag{21.73}$$

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