Chapter 8

ECE Equation of the Fermion with Finite Momentum

by

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Abstract

It is shown that the equation of the fermion with finite momentum is the free fermion limit of the Einstein Cartan Evans (ECE) wave equation of the unified field, the limit in which the fermion becomes free of the influence of other fields. In this limit the curvature becomes proportional to the square of the Compton wavenumber. The wavefunction of the equation is a 2 x 2 tetrad matrix, and the equation of the fermion with finite momentum consist only of 2 x 2 matrices. It is a deterministic equation derived directly from geometry. Its method of derivation makes it part of a rigorously objective generally covariant unified field theory in which there is no "indeterminacy" or objects that are "unknowable" as claimed subjectively by the Copenhagen school. The ECE equation of the anti-fermion is obtained by reversing helicity. In order to conserve CPT, the electric charge of the ECE anti-fermion must be opposite to that of the ECE fermion.

Keywords: ECE fermion equation, tetrad wavefunction, 2 x 2 matrices.

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8.1 Introduction

In previous papers of this series on the Einstein Cartan Evans (ECE) unified field theory the equation of the fermion has been derived [1] - [10] from the ECE wave equation of the unified field and expressed in terms of the Dirac equation of the fermion. In this paper it is shown that the ECE equation of the fermion can be written in terms of 2 x 2 matrices and that the anti-fermion can be obtained straightforwardly by reversing helicity and conserving CPT symmetry [11] [12]. We therefore adopt the nomenclature "ECE equations of the fermion and antifermion" because these are simpler in structure and philosophy than the Dirac equation and are therefore preferred by Ockham's Razor. The ECE equations also contain more information than the Dirac equations because the former are part of a generally covariant unified field theory whereas the latter are equations of special relativity un-unified with other fundamental fields, notably gravitation. It has hitherto been thought impossible to write the equation of the fermion without the use of 4 x 4 matrices, the Dirac matrices [11], [12]. In Section 2, however, it is shown that the equation of the fermion may be written with 2 x 2 matrices because its wavefunction is a 2 x 2 tetrad. The ECE fermion equation is written entirely in terms of Pauli matrices. The ECE equation of the anti-fermion is obtained by reversing the helicity $\boldsymbol{\sigma} \cdot \boldsymbol{p}$ of the fermion equation. Here $\boldsymbol{p}$ is the linear momentum and denote the Pauli matrix basis set of SU(2) symmetry. In order to conserve CPT the electric charge of the anti-fermion must be of opposite sign as observed experimentally in the positron.

In Section 3 some remarks are given on the philosophy of the ECE fermion and antifermion equations and on the similarities and differences between the ECE and Dirac equations of the fermion and antifermion. They are similar in that Dirac derived his equation originally using geometry and without indeterminacy, a subjective and non-Baconian concept introduced by Bohr several years later. Dirac remained opposed to indeterminacy, as did Einstein, Schroedinger, de Boglie and others, notably Bohm and Vigier. The Dirac equation contains 4 x 4 matrices as is well known, these are the Dirac matrices which factorize the 4 x 4 Minkowski metric. The wavefunction of the Dirac equation is the Dirac spinor, which is a column vector with four entries. The column vector consists of two Pauli spinors placed on top of each other. The Pauli spinor is a column vector with two entries and one Pauli spinor (right handed) is opposite in parity to the other (left handed). This is quite a complicated construction therefore, and initially the Dirac equation was rejected, notably by the non-Baconian scholar Heisenberg, who described it as "a low point in physics" because of this complexity of structure and lack of understanding on the part of Heisenberg. Later, however, the Dirac equation was used to explain for example the Landè factor of the electron, the fine structure in the H atom and Zeeman effect, spin orbit coupling, and above all, to produce ESR, NMR and MRI. Using the Dirac sea concept it was claimed that the Dirac equation also predicted the antifermion, observed experimentally as the positron, and the Dirac equation has become the basis of electroweak and strong field theory using gauge theory.

In Section 3 it is shown that the equation of the fermion can be greatly simplified in concept, and thus made much more powerful, by using the tetrad as the wavefunction. In SU(2) representation the tetrad is a 2 x 2 matrix, and so it becomes possible to write the ECE fermion equation entirely in terms of the Pauli matrices, without needing to use the more complicated 4 x 4 matrices. In the philosophy of the ECE fermion equation the concept of negative energy is rejected on the classical level, and so does not enter into quantization at all. This philosophy eliminates the need for the non-Baconian Dirac sea concept, and eliminates the obscurities, complexities, and ad hoc methods of second quantization in the quantum field theory of the fermion [11] - [12]. The ECE equation of the fermion thereby produces the antifermion much more straightforwardly, by reversing the helicity and conserving CPT. The ECE equation of the fermion is part of a unified field theory so may be extended systematically to describe the interaction of the fermion with other fields.

8.2 Derivation of the ECE Fermion Equation

The equation is derived straightforwardly from Cartan's well known geometry [1] - [11] developed in the early twenties, and one basic hypothesis which links the geometry to physics using general relativity. Cartan also inferred spinors in 1913. The starting point of the derivation is the equation:

$$D_\mu q^a_\nu = 0 \tag{8.1}$$

where D_μ denotes the covariant derivative of Cartan, using his spin connection, and where q^a_ν is the well known Cartan tetrad. Eq. (8.1) is the result of the constancy of the complete vector field [1] - [11]. The complete vector field is independent of its components and basis elements and so Eq. (8.1) is always true in physics. It is rather obscurely known as "the tetrad postulate", more accurately it is a fundamental property of the vector field in any spacetime in any dimension and for any connection. It can be re-expressed [1] - [10] as a rigorous identity of geometry in any spacetime and in any dimension, the ECE Lemma:

$$\partial^\mu \partial_\mu q^a_\nu := R q^a_\nu \tag{8.2}$$

where the scalar curvature follows directly from the tetrad postulate and is:

$$R := q^\lambda_a \partial^\mu (\Gamma^\nu_{\mu\lambda} q^a_\nu - \omega^a_{\mu b} q^b_\lambda). \tag{8.3}$$

Here $\Gamma^\nu_{\mu\lambda}$ is the general Riemannian connection and $\omega^a_{\mu b}$ the general spin connection. The ECE Lemma is the geometrical basis for the wave equation of the unified field. All the wave equations of physics are geometrical equations, including all the equations of quantum mechanics on any level. The ECE Lemma unifies quantum mechanics and general relativity in a straightforward manner, without non-Baconian indeterminacy. The latter has been refuted experimentally [13] - [14] in many ways, and is clearly incorrect. The reason is that it is pure subjectivity, not physics at all, pure guesswork that went wildly wrong.

The geometry of the ECE Lemma is transformed into physics with the hypothesis:

$$R = -kT \tag{8.4}$$

in which k is a proportionality between R and T, a quantity with the units of mass density (kilograms pre cubic metre). The units of R are inverse square metres. It is convenient to retain the Einstein constant k as the proportionality constant between geometry and physics, its units are metres per kilogram. The minus sign in Eq. (8.4) is also a convention from the received wisdom of general relativity. Therefore the ECE wave equation of the unified field is [1] - [10]:

$$(\partial^\mu \partial_\mu + kT) q^a_\nu = 0 \tag{8.5}$$

and was first derived in 2003. The wavefunction in Eq. (8.5) is the Cartan tetrad. In general the dimensionalities of μ, ν, and a are different. The tetrad is defined by [1] - [11]:

$$V^a = q^a_\nu V^\nu . \tag{8.6}$$

For example, if the dimensionality of a is 2 and that of ν is also 2, the tetrad is defined by:

$$\begin{bmatrix} V^a \\ V^b \end{bmatrix} = \begin{bmatrix} q^a_1 & q^a_2 \\ q^b_1 & q^b_2 \end{bmatrix} \begin{bmatrix} V^1 \\ V^2 \end{bmatrix} \tag{8.7}$$

and is a 2 x 2 matrix. If the dimensionality of a is 2 and that of ν is 3, then:

$$\begin{bmatrix} V^a \\ V^b \end{bmatrix} = \begin{bmatrix} q^a_1 & q^a_2 & q^a_3 \\ q^b_1 & q^b_2 & q^b_3 \end{bmatrix} \begin{bmatrix} V^1 \\ V^2 \\ V^3 \end{bmatrix} \tag{8.8}$$

and in general, if the dimensionality of a is nm and that of ν is m, the tetrad is:

$$\begin{bmatrix} V^a \\ \cdot \\ \cdot \\ \cdot \\ V^n \end{bmatrix} = \begin{bmatrix} q^a_1 & \cdot & \cdot & \cdot & q^a_m \\ \cdot & & & & \cdot \\ \cdot & & & & \cdot \\ \cdot & & & & \cdot \\ q^n_1 & \cdot & \cdot & \cdot & q^n_m \end{bmatrix} \begin{bmatrix} V^1 \\ \cdot \\ \cdot \\ \cdot \\ V^m \end{bmatrix} . \tag{8.9}$$

Also, in the fundamental definition of the covariant derivative in Riemann geometry:

$$D_\mu V^\rho = \partial_\mu V^\rho + \Gamma^\rho_{\mu\lambda} V^\lambda \tag{8.10}$$

the dimensionalities of μ, ρ and λ are different in general.

Now consider the case when:

$$\mu = 0, 1, 2, 3 \tag{8.11}$$

in Eq. 8.5, then the Lemma reduces to

$$(\Box + kT)q^a_\nu = 0 \tag{8.12}$$

where $\Box$ is the Minkowski spacetime d'Alembertian operator:

$$\Box = \partial^\mu \partial_\mu. \tag{8.13}$$

In Eq. (8.12), the dimensions of a and ν may be different from four. Consider the two dimensional complex space of the spinor used in the SU(2) group of unitary matrices with unit determinant [12]. This spinor is a two dimensional column vector. Now define the 2 x 2 tetrad from two of these spinors as follows [1] - [10]:

$$\begin{bmatrix} V^R \\ V^L \end{bmatrix} = \begin{bmatrix} q^R_1 & q^R_2 \\ q^L_1 & q^L_2 \end{bmatrix} \begin{bmatrix} V^1 \\ V^2 \end{bmatrix}. \tag{8.14}$$

The ECE wave equation for this tetrad is:

$$(\Box + kT) \begin{bmatrix} q^R_1 & q^R_2 \\ q^L_1 & q^L_2 \end{bmatrix} = 0 \tag{8.15}$$

where we have used the d'Alembertian in four dimensions for $\Box$. In four dimensions the derivatives are defined, as is well known, by:

$$\partial^\mu = (\frac{1}{c}\frac{\partial}{\partial t}, -\boldsymbol{\nabla}) \tag{8.16}$$

$$\partial_\mu = (\frac{1}{c}\frac{\partial}{\partial t}, \boldsymbol{\nabla}) \tag{8.17}$$

so that the d'Alembertian eigenoperator in four dimensions is:

$$\Box = \frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \nabla^2. \tag{8.18}$$

This operates on the wavefunction denoted:

$$\psi = \begin{bmatrix} \psi^1 & \psi^2 \\ \psi^3 & \psi^4 \end{bmatrix} = \begin{bmatrix} \phi^R_1 & \phi^R_2 \\ \phi^L_1 & \phi^L_2 \end{bmatrix} = \begin{bmatrix} q^R_1 & q^R_2 \\ q^L_1 & q^L_2 \end{bmatrix} \tag{8.19}$$

to produce the eigenvalues R or $-kT$. Finally define the free fermion limit by:

$$(\Box + \kappa^2)\psi = 0 \tag{8.20}$$

where kT is a constant:

$$\kappa^2 = kT. \tag{8.21}$$

Here κ is the Compton wavenumber:

$$\kappa = \frac{mc}{\hbar} \tag{8.22}$$

where m is the fermion mass, $\hbar$ is the reduced Planck constant and c the vacuum speed of light, a universal constant. The ECE wave equation of the free fermion is therefore:

$$(\Box + (\frac{mc}{\hbar})^2)\psi = 0. \tag{8.23}$$

This is the same as the wave format of the Dirac equation and also the Klein Gordon equation:

$$(\Box + (\frac{mc}{\hbar})^2) \begin{bmatrix} \psi^1 \\ \psi^2 \\ \psi^3 \\ \psi^4 \end{bmatrix} = 0 \tag{8.24}$$

so we identify the components of ψ as the four components of the Pauli spinors:

$$\phi^R = \begin{bmatrix} \psi^1 \\ \psi^2 \end{bmatrix}, \quad \phi^L = \begin{bmatrix} \psi^3 \\ \psi^4 \end{bmatrix}. \tag{8.25}$$

Using the well known operator equivalence of quantum mechanics (the de Broglie wave particle dualism):

$$p^\mu = i\hbar\partial^\mu \tag{8.26}$$

transforms Eq. (8.23) into the Einstein energy equation of special relativity:

$$E^2 - c^2p^2 = m^2c^4 \tag{8.27}$$

in which E is the total energy, p is the momentum and in which the rest energy is:

$$E_0 = mc^2. \tag{8.28}$$

The basis elements of the SU(2) representation are the hermitian and traceless Pauli matrices:

$$\sigma^1 = \begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}, \quad \sigma^2 = \begin{bmatrix} 0 & i \\ -i & 0 \end{bmatrix}, \quad \sigma^3 = \begin{bmatrix} 0 & 1 \\ 0 & -1 \end{bmatrix}. \tag{8.29}$$

There is also the zero order Pauli matrix, which is the 2 x 2 unit matrix:

$$\sigma^0 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}. \tag{8.30}$$

The three Pauli matrices are related by the SU(2) symmetry cyclical equations with the factor $\frac{1}{2}$:

$$\left[\frac{\sigma^1}{2}, \quad \frac{\sigma^2}{2}\right] = i\frac{\sigma^3}{2} \tag{8.31}$$

et cyclicum.

In this representation the helicity is defined by:

$$h = \boldsymbol{\sigma} \cdot \boldsymbol{p} \tag{8.32}$$

and is the projection of spin on to a given direction of linear momentum. In this SU(2) basis Eq. (8.27) factorizes as follows:

$$(E - \boldsymbol{\sigma} \cdot \boldsymbol{p})(E + \boldsymbol{\sigma} \cdot \boldsymbol{p}) = m^2 c^4. \tag{8.33}$$

Write this equation as:

$$(E - \boldsymbol{\sigma} \cdot \boldsymbol{p})\phi^R (E + \boldsymbol{\sigma} \cdot \boldsymbol{p})\phi^L = m^2 c^4 \phi^L \phi^R \tag{8.34}$$

from which:

$$(E - c\boldsymbol{\sigma} \cdot \boldsymbol{p})\phi^R = mc^2 \phi^L \tag{8.35}$$

and

$$(E + c\boldsymbol{\sigma} \cdot \boldsymbol{p})\phi^L = mc^2 \phi^R \tag{8.36}$$

follow. Note carefully that Eqs. (8.35) and (8.36) may also be obtained by applying the two Lorentz boost transforms in the SL(2,C) group [12] as follows:

$$\phi^R(\boldsymbol{p}) = \exp\,(\frac{1}{2}\boldsymbol{\sigma} \cdot \boldsymbol{\phi})\phi^R(0) \tag{8.37}$$

and

$$\phi^L(\boldsymbol{p}) = \exp\,(-\frac{1}{2}\boldsymbol{\sigma} \cdot \boldsymbol{\phi})\phi^L(0) \tag{8.38}$$

where $\phi^R(0)$ and $\phi^L(0)$ denote rest spinors.

Finally combine Eqs. (8.35) and (8.36) to give the ECE equation of the free fermion:

$$(\sigma^0 E - \sigma^3 c\boldsymbol{\sigma} \cdot \boldsymbol{p})\psi = mc^2 \sigma^1 \psi \tag{8.39}$$

Q.E.D. This equation has been derived from Cartan's geometry in the limit (8.21) without use of indeterminacy and without the use of the 4 x 4 matrices of Dirac. Eq. (8.39) contains only Pauli matrices with the wavefunction:

$$\psi = \begin{bmatrix} \psi^1 & \psi^2 \\ \psi^3 & \psi^4 \end{bmatrix}. \tag{8.40}$$

Written out in full, Eq. (8.39) is:

$$E \begin{bmatrix} \psi^1 & \psi^2 \\ \psi^3 & \psi^4 \end{bmatrix} + c\boldsymbol{\sigma} \cdot \boldsymbol{p} \begin{bmatrix} -\psi^1 & -\psi^2 \\ \psi^3 & \psi^4 \end{bmatrix} = mc^2 \begin{bmatrix} \psi^3 & \psi^4 \\ \psi^1 & \psi^2 \end{bmatrix} \tag{8.41}$$

and represents four simultaneous equations:

$$(E - c\boldsymbol{\sigma} \cdot \boldsymbol{p})\psi^1 = mc^2 \psi^3 \tag{8.42}$$

$$(E - c\boldsymbol{\sigma} \cdot \boldsymbol{p})\psi^2 = mc^2\psi^4 \tag{8.43}$$

$$(E + c\boldsymbol{\sigma} \cdot \boldsymbol{p})\psi^3 = mc^2\psi^1 \tag{8.44}$$

$$(E + c\boldsymbol{\sigma} \cdot \boldsymbol{p})\psi^4 = mc^2\psi^2. \tag{8.45}$$

The first two may be written as:

$$(E - c\boldsymbol{\sigma} \cdot \boldsymbol{p})\phi^R = mc^2\phi^L \tag{8.46}$$

and the second two may be written as:

$$(E + c\boldsymbol{\sigma} \cdot \boldsymbol{p})\phi^L = mc^2\phi^R \tag{8.47}$$

where ϕ^R and ϕ^L are row vectors:

$$\phi^R = [\psi^1\psi^2], \quad \phi^L = [\psi^3\psi^4]. \tag{8.48}$$

The wavefunction is obtained by superimposing these two row vectors. The Dirac equation is obtained by factorizing Eq. (8.23), but in a different way, using the property:

$$\Box = \gamma^\mu\partial_\mu\gamma^\nu\partial_\nu \tag{8.49}$$

where the Dirac matrices are [12]:

$$\gamma^\mu = (\gamma^0, \gamma^i), \quad \gamma^0 = \begin{bmatrix} 0 & \sigma^0 \\ \sigma^0 & 0 \end{bmatrix}, \quad \gamma^i = \begin{bmatrix} 0 & -\sigma^i \\ \sigma^i & 0 \end{bmatrix} \tag{8.50}$$

Eq. (8.49) gives the well known first order format of the Dirac equation [12]

$$(\gamma^\mu p_\mu - mc)\psi = 0 \tag{8.51}$$

Written out in full, Eq. 8.51 is:

$$E \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \end{bmatrix} \begin{bmatrix} \psi^1 \\ \psi^2 \\ \psi^3 \\ \psi^4 \end{bmatrix} + c \begin{bmatrix} 0 & 0 & \multicolumn{2}{c}{\boldsymbol{\sigma}} \\ 0 & 0 & & \\ \multicolumn{2}{c}{-\boldsymbol{\sigma}} & 0 & 0 \\ & & 0 & 0 \end{bmatrix} \cdot \boldsymbol{p} \begin{bmatrix} \psi^1 \\ \psi^2 \\ \psi^3 \\ \psi^4 \end{bmatrix} = mc^2 \begin{bmatrix} \psi^1 \\ \psi^2 \\ \psi^3 \\ \psi^4 \end{bmatrix} \tag{8.52}$$

i.e. are the following two equations placed on top of each other:

$$(E + c\boldsymbol{\sigma} \cdot \boldsymbol{p}) \begin{bmatrix} \psi^3 \\ \psi^4 \end{bmatrix} = mc^2 \begin{bmatrix} \psi^1 \\ \psi^2 \end{bmatrix} \tag{8.53}$$

and

$$(E - c\boldsymbol{\sigma} \cdot \boldsymbol{p}) \begin{bmatrix} \psi^1 \\ \psi^2 \end{bmatrix} = mc^2 \begin{bmatrix} \psi^3 \\ \psi^4 \end{bmatrix}. \tag{8.54}$$

It is seen that these are the same as Eqs. (8.46) and (8.47) but with column vectors used instead of row vectors. These column vectors are the Pauli spinors. The well known Dirac spinor is then:

$$\psi = \begin{bmatrix} \phi^R \\ \phi^L \end{bmatrix} = \begin{bmatrix} \psi^1 \\ \psi^2 \\ \psi^3 \\ \psi^4 \end{bmatrix} \tag{8.55}$$

and is a column four vector. By using a 2 x 2 tetrad wavefunction, the Dirac equation is greatly simplified to Eq. (8.39), which may be generalized to one of unified field theory. This appears to be the first time that the equation of the fermion has been expressed in terms of 2 x 2 matrices, and so this disposes with the need for 4 x 4 matrix Dirac algebra, a major advance in mathematics and physics. This basic advance works its way into fermion, electroweak, strong field and particle theory and this will be the subject of future work.

Finally in this section the ECE equation of the antifermion is obtained by reversing the helicity of the ECE fermion equation, so the ECE equation of the antifermion is:

$$(\sigma^0 E + \sigma^3 c\boldsymbol{\sigma}\cdot\boldsymbol{p})\psi = mc^2\sigma^1\psi. \tag{8.56}$$

Note that Eq. (8.56) is obtained from Eq. (8.39) by applying the parity operator. The momentum $\boldsymbol{p}$, being a polar vector, is negative under parity P as is well known [12]. The helicity is also negative under parity:

$$P(h) = -h \tag{8.57}$$

because the spin $\boldsymbol{\sigma}$ is positive under parity. Similarly parity reverses X, Y and Z for a given sense of frame, $\boldsymbol{i}$, $\boldsymbol{j}$, and $\boldsymbol{k}$ in Cartesian coordinates. So:

$$P(r) = -r \tag{8.58}$$

and $\boldsymbol{i}$, $\boldsymbol{j}$, and $\boldsymbol{k}$ remain the same. In short hand notation, negative parity inversion symmetry is denoted:

$$P \rightarrow -P \tag{8.59}$$

The other fundamental operators of symmetry in physics are the motion reversal operator T and the charge conjugation operator C. Under motion reversal the helicity is unchanged:

$$T(h) = h \tag{8.60}$$

because both the spin $\boldsymbol{\sigma}$ and the momentum $\boldsymbol{p}$ are reversed by T. In shorthand denote this by:

$$T \rightarrow -T \tag{8.61}$$

Combinations of the fundamental symmetry operators are also used in physics, and are also fundamental symmetry operators. It is thought that CPT is always conserved. Therefore:

$$CPT = (-C)(-P)T. \tag{8.62}$$

The effect of the charge conjugation operator is to reverse the sign of electric charge e:

$$C(e) = -e \tag{8.63}$$

so it follows that the electric charge of the anti-fermion must be the opposite of that of the fermion because P has become $-P$ from fermion to antifermion and so C must become $-C$ from fermion to antifermion. This is as observed in the positron, which is therefore correctly predicted by the ECE equation of the antifermion, Eq. (8.56). Both equations are derived from geometry without the use of indeterminacy and negative energy, both of which are rejected as unphysical.

8.3 Comparison of the ECE and Dirac Equations

In addition to the advantages of the ECE equation discussed already, the prediction of the antifermion is considerably simplified. In ECE theory the antifermion is produced from the fermion by the helicity operator:

$$\hat{h}(\boldsymbol{\sigma}\cdot\boldsymbol{p}) = -\boldsymbol{\sigma}\cdot\boldsymbol{p} \tag{8.64}$$

This is a well known idea in particle theory [12], the antifermion has opposite helicity and electric charge to the fermion, and similarly for other types of particles and antiparticles. The helicity operator has the following effect:

$$(E - c\boldsymbol{\sigma}\cdot\boldsymbol{p})\phi^R = mc^2\phi^L \tag{8.65}$$

$$(E + c\boldsymbol{\sigma}\cdot\boldsymbol{p})\phi^L = mc^2\phi^R \tag{8.66}$$

are transformed by $\hat{h}$ to:

$$(E + c\boldsymbol{\sigma}\cdot\boldsymbol{p})\phi^L = mc^2\phi^R \tag{8.67}$$

$$(E - c\boldsymbol{\sigma}\cdot\boldsymbol{p})\phi^R = mc^2\phi^L \tag{8.68}$$

Adding Eqs. (8.65) and (8.67) it is seen that momentum is eliminated when a fermion and anti-fermion interact, leaving an equation in energy:

$$E(\phi^R + \phi^L) = mc^2(\phi^L + \phi^R) \tag{8.69}$$

Similarly adding Eqs. 8.66 and 8.68 gives:

$$E(\phi^L + \phi^R) = mc^2(\phi^R + \phi^L) \tag{8.70}$$

When an electron and a positron collide, they produce two photons, pure energy as in Eqs. (8.69) and (8.70). The production of the positron from the Dirac equation on the other hand is a non Baconian process in which the well known Dirac sea has to be used. The Dirac sea is an ad hoc concept and is asserted without experimental evidence to be the vacuum filled with antifermions that obey the Pauli exclusion principle, another ad hoc concept but one which happens to work well in spectroscopy. By definition, the Dirac sea is not directly observable, and so is not a Baconian concept. Otherwise Dirac was a deterministic scientist and rejected the Copenhagen interpretation of quantum mechanics and of his own equation. Indeterminacy is the archetypical non Baconian concept of the twentieth century, in which physics as a subject was thereby weakened towards the end of the century by a plethora of unobservables such as confined quarks, strings, superstrings, multiple dimensions, spontaneous symmetry breaking, black holes, big bang, dark matter, ark flow, dark universe, the unobserved Higgs boson with undefined energy, abstract internal spaces of gauge theory, approximate symmetries and so forth. These unobservables are rejected in ECE theory wherever they occur [1] - [10]. The Einstein field equation has been shown to be mathematically erroneous due to its neglect of spacetime torsion, and Einsteinian cosmology has been replaced by a torsion based cosmology.

The interpretation of the Dirac equation is greatly complicated by negative energy [12]. It is not clear why the unphysical idea of negative energy was introduced, because it was rejected by Einstein on the classical level. The Dirac antifermion is therefore postulated ad hoc, by invoking an unobservable and non Baconian Dirac sea to get rid of an unobservable and non Baconian negative energy. This convoluted thinking leads to the necessity for second quantization, and to the ad hoc introduction of the Dirac Jordan Wigner anti-commutator. This anticommutator is claimed to produce antifermions and to "explain" the Pauli exclusion principle [12]. This is a wholly obscure argument, because it is based only on the reversal of sign of phase. In second quantization the Dirac spinor is expanded in a Fourier series consisting of hermitian operators. These are conventionally claimed to be creation and annhilation operators acting on number states. However, all that is really happening is a Fourier expansion. For a rest fermion, the Dirac equation is conventionally interpreted in terms of two spinors with positive phase, and two with negative phase. The sign of phase is arbitrarily associated with a change of sign of energy.

In the ECE interpretation of the fermion things are Baconian and simple. The observable positron is produced from the observable electron by changing helicity and conserving CPT. The ECE equations of the electron and positron are satisfactory single particle equations, and are both positive energy equations. The ECE fermion and antifermion equations also give rigorously non-zero probability density. For further details of the calculations for this paper see the accompanying notes for papers 129 and 130 on www.aias.us. Each ECE paper has accompanying notes posted with full calculational details.

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Bibliography

[1] M. W. Evans, "Generally Covariant Unified Field Theory" (Abramis, 2005 onwards), vols. 1 - 5, vol. 6 in prep., (see www.aias.us).

[2] L. Felker, "The Evans Equations of Unified Field Theory" (Abramis 2007).

[3] K. Pendergast, "The Life of Myron Evans" (Abramis 2009, preprint on www.aias.us).

[4] M. W. Evans, "Modern Non-Linear Optics" (Wiley 2001, second edition); M. W. Evans and S. Kielich (eds., ibid., first edition, 1992, 1993, 1997).

[5] M. W. Evans and L. B. Crowell, "Classical and Quantum Electrodynamics and the B(3) Field" (World Scientific 2001).

[6] M. W. Evans and J.-P. Vigier, "The Enigmatic Photon" (Kluwer, 1994 to 2002, hardback and softback), in five volumes.

[7] ECE Papers and Articles on www.aias.us www.atomicprecision.com, ECE source papers, ECE papers by other authors and ECE educational articles.

[8] M. W. Evans et al., Omnia Opera section of www.aias.us, notably from 1992 to present on the ECE theory and its precursor gauge theories homomorphic with those of Barrett, Harmuth and Lehnert.

[9] M. W. Evans, Acta Phys. Polonica, 400, 175 (2007); M. W. Evans, Physica B, 403, 517 (2008)

[10] M. W. Evans and H. Eckardt, invited papers to journal special issue, 2010.

[11] L. H. Ryder, "Quantum Field Theory" (Cambridge, 2nd ed., 1996).

[12] J. B. Marion and S. T. Thornton, "Classical Dynamics" (HBC, New York, 1988, 3rd.ed.).

[13] J. S. Croca, "Towards a Non-Linear Quantum Physics" (World Scientific, 2003), with an account of experiments refuting the Heisenberg indeterminacy principle by as many as nine orders of magnitude using advanced microscopy and other methods.

[14] See reference 3 for accounts of well known experiments by Compton and Thomas et al. refuting the Copenhagen School experimentally by Compton scattering and electron microscopy of single atoms.