APPLICATION OF THE ECE FERMION EQUATION TO PARTICLE COLLISION THEORY AND LOW ENERGY NUCLEAR REACTORS (LENR).

by

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ABSTRACT

A new general theory of particle collisions is developed using the ECE fermion equation, or chiral representation of the Dirac equation, and the theory applied to low energy nuclear reactors with use of quantum tunnelling through the Coulomb barrier. Two colliding particles are considered to produce many products of the collision, so this is a general theory. Many new measurable phenomena appear in general, because the theory can be reduced to the format of an ECE fermion interacting with an electromagnetic field. This precise and well known theory is generalized for the interaction of any two particles, giving any number of products.

Keywords: ECE fermion equation, particle collision theory, low energy nuclear reactors.

UFT 248

1. INTRODUCTION

In recent papers of this series a new development has been initiated of particle collision theory using the duality equations of ECE theory {1 - 10}. In general two particles such as an electron and positron can collide to give many products, depending on the energy of the initial particles. There can be scattering, annihilation, and nuclear fusion. Low energy nuclear reactors (LENR) achieve fusion at low energies. Papers such as UFT226 ff. of www.aias.us give a first explanation of LENR using quantum tunnelling theory based on the Schroedinger equation. Therefore it is an advantage to reduce the equations of particle collision theory to the Schroedinger equation. Thereafter a description of all kinds of particle collision is achieved with incorporation of quantum tunnelling theory as in UFT226 ff.

In Section 2 the equations of conservation of energy and momentum are considered of the collision of two particles to give many products. In a well defined low energy approximation these equations are reduced to a Schroedinger equation, from which quantum tunnelling may be inferred as is well known {11}. In the SU(2) basis the equations of conservation of energy and momentum translate to a fermion equation, or chiral representation of the Dirac equation. Using the fermion equation many new phenomena of particle scattering can be predicted, using calculational methods parallel to the well known case of an ECE fermion interacting with an electromagnetic field. The semi classical description of the latter type of interaction gives many precise results, notably the g factor of the ECE fermion, the Landé factor, the Zeeman effect, ESR, NMR, MRI, the Thomas factor, spin orbit coupling and the Darwin shift, all of which have been observed experimentally to great precision. The use of a complex vector potential gives five more terms in general, one of which is radiatively induced fermion resonance (RFR) {1 - 10}. Parallels to all these phenomena occur in particle collision theory and low energy nuclear reaction theory.

In Section 3 some of these results are discussed and evaluated numerically.

2. GENERAL THEORY AND THE ECE FERMION EQUATION.

The collision of two particles in general can be described by:

$$E + E_1 = E' + E'' \quad -(1)$$

$$\underline{p} + \underline{p}_1 = \underline{p}' + \underline{p}'' \quad -(2)$$

which are the equations of conservation of total energy and linear momentum. There is also conservation of total angular momentum and total charge. Each of the energy and momentum terms in Eqs. (1) and (2) obey the Einstein energy equation, for example:

$$E''^2 = c^2 p''^2 + m^2 c^4 \quad -(3)$$

where m is the mass of the particle of energy E'' and momentum $\underline{p}''$. This may be a scattered particle, the product of annihilation, a particle created in the collision process, or the product of a nuclear fusion. The Einstein energy equation may be expressed as the ECE duality equation:

$$E'' = \gamma'' mc^2 = \hbar\omega'' \quad -(4)$$

where γ'' is the Lorentz factor and ω'' the angular frequency associated with the energy E''. If many particles are produced by the collision then:

$$E' = E_1' + E_2' + \dots + E_n' \quad -(5)$$

$$\underline{p}' = \underline{p}_1' + \underline{p}_2' + \dots + \underline{p}_n' \quad -(6)$$

and each particle has its energy and linear momentum. In the usual theory of Compton scattering for example:

$$E_1 = mc^2 \quad -(7)$$

$$\underline{p}_1 = \underline{0} \quad -(8)$$

for an initially stationary electron, and a "massless" photon is said to collide with the electron.

Eq. (3) can be written as:

$$E''^2 - m^2 c^4 = c^2 p''^2 \quad -(9)$$

i.e. as:

$$(E'' - mc^2)(E'' + mc^2) = c^2 p''^2 \quad -(10)$$

so the equation may be linearized as:

$$E_2 = E'' - mc^2 = \frac{c^2 p''^2}{E'' + mc^2} \; . \quad -(11)$$

The non relativistic kinetic energy may be obtained from this equation in the low energy approximation {11}:

$$E'' \sim mc^2 \quad -(12)$$

so:

$$E_2 = \frac{1}{2m} p''^2 . \quad -(13)$$

The Schroedinger equation is obtained as usual using:

$$\underline{p}'' = -i\hbar \underline{\nabla} \quad -(14)$$

so:

$$-\frac{\hbar^2}{2m} \nabla^2 \phi = E_2 \phi = (E + E_1 - E' - mc^2)\phi . \quad -(15)$$

This is the required quantized description of the general particle collision process described by Eqs. (1) and (2). One of the many predictions of the Schroedinger equation is quantum tunnelling, which may be applied to LENR as in UFT226 ff. on www.aias.us. That theory can be generalized conceptually to any process involving the collision of two particles, notably scattering and annihilation.

For Compton scattering:

$$E_1 = mc^2 \quad -(16)$$

$$E_2 = E - E' \quad -(17)$$

so the Schroedinger equation becomes:

$$-\frac{\hbar^2}{2m}\nabla^2\phi = (E - E')\phi \quad -(18)$$

A nuclear potential may be added to Eq. (18) as discussed in UFT226 ff. and a transmission coefficient calculated. For example this may be a Coulomb potential, a Woods Saxon potential, or a combination of both, and the theory developed in that way. So for Compton scattering the translation rule is:

$$\begin{aligned} E + mc^2 &= E' + E'' \\ \underline{p} &= \underline{p}' + \underline{p}'' \end{aligned} \rightarrow -\frac{\hbar^2}{2m}\nabla^2\phi = (E - E')\phi \quad -(19)$$

in the non relativistic quantum approximation.

The ECE fermion equation may be obtained from Eq. (3) using the Pauli matrices of the SU(2) basis {1 - 11} as follows:

$$(E'' - mc^2)(E'' + mc^2) = c^2 \underline{\sigma}\cdot\underline{p}''\,\underline{\sigma}\cdot\underline{p}'' \quad -(20)$$

so:

$$E_2 = E'' - mc^2 = \frac{c^2 \underline{\sigma}\cdot\underline{p}''\,\underline{\sigma}\cdot\underline{p}''}{E'' + mc^2} \quad -(21)$$

This equation may be developed to give many new phenomena of particle collision theory and low energy nuclear reaction theory. In the low energy approximation (12):

$$E_2 = \frac{1}{2m}\,\underline{\sigma}\cdot\underline{p}''\,\underline{\sigma}\cdot\underline{p}'' . \quad -(21)$$

If $\underline{p}''$ is real valued:

$$\underline{\sigma}\cdot\underline{p}''\,\underline{\sigma}\cdot\underline{p}'' = p''^2 + i\underline{\sigma}\times\underline{p}''\times\underline{p}'' = p''^2 \quad -(22)$$

and Eq. (15) is obtained again. However if $\underline{p}''$ is complex valued:

$$E_2 = \frac{p''^2}{2m} + \frac{i}{2m}\,\underline{\sigma}\cdot\underline{p}''\times p''^{*} \quad -(23)$$

and:

$$-\frac{\hbar^2}{2m}\nabla^2\psi + \frac{i}{2m}\,\underline{\sigma}\cdot\underline{p}''\times\underline{p}''^{*}\psi = (E-E')\psi . \quad -(24).$$

A new observable effect occurs via the hamiltonian :

$$H_2 = \frac{i}{2m}\,\underline{\sigma}\cdot\underline{p}''\times\underline{p}''^{*} \quad -(25)$$

which translates into the RFR hamiltonian {1 - 10} with the minimal prescription:

$$\underline{p}'' \rightarrow \underline{p}'' - e\underline{A} . \quad -(26)$$

For example if:

$$\underline{p}'' = p^{(0)}(\underline{i} - i\underline{j}),\ \underline{p}''^{*} = p^{(0)}(\underline{i} + i\underline{j}) \quad -(27)$$

the hamiltonian (25) reduces to:

$$H_2 = \frac{p^{(0)2}}{2m}\,\sigma_Z \quad -(28)$$

and resonance can be observed between the two states of

$$\sigma_Z = \begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix} \quad - (29)$$

Using:

$$p''^2 = p^2 + p'^2 - 2pp'\cos\theta \quad - (30)$$

the Schroedinger equation (18) reduces to:

$$\frac{1}{2m}\left(p^2 + p'^2 - 2pp'\cos\theta\right) = E - E' \quad - (31)$$

For the "massless" photon:

$$E = \hbar\omega, \quad p = \hbar\frac{\omega}{c} \quad - (32)$$

so Eq. (31) becomes:

$$\frac{\hbar}{mc^2}\left(\frac{1}{2}\left(\omega^2 + \omega'^2\right) - \omega\omega'\cos\theta\right) = \omega - \omega' \quad - (32)$$

which is the Compton formula:

$$\frac{\hbar}{mc^2}\,\omega\omega'\left(1 - \cos\theta\right) = \omega - \omega' \quad - (33)$$

in the approximation:

$$\omega \sim \omega' \quad - (34)$$

equivalent to the approximation (12). This type of resonance could be searched for using a circularly polarized electromagnetic field scattered off an initially stationary electron.

Eq. (21) can be written as:

$$E + E_1 - E' + mc^2 = \frac{c^2\left(\underline{p} + \underline{p_1} - \underline{p}'\right)^2}{E + E_1 - E' - mc^2} \quad - (35)$$

This equation has the same structure as the fermion equation describing the interaction of a classical electromagnetic field with the ECE fermion:

$$(E - e\phi)^2 = c^2(\underline{p} - e\underline{A})^2 + m^2c^4 \quad -(36)$$

provided that:

$$e\phi \rightarrow E' - E_1 \quad -(37)$$

$$e\underline{A} \rightarrow \underline{p}' - \underline{p}_1 . \quad -(38)$$

So all the precise results obtainable from Eq. (36) can be applied to particle collision theory. These results emerge from Eq. (36) in the format:

$$\left[(mc^2 + e\phi) + \frac{1}{2m}\left(\underline{\sigma} \cdot (\hat{p} - e\underline{A})\left(1 + \frac{e\phi}{2mc^2}\right)\underline{\sigma} \cdot (\hat{p} - e\underline{A}\right)\right]\psi = E\psi \quad -(39)$$

of a Schroedinger type equation:

$$\hat{H}\psi = E\psi \quad -(40)$$

where the hamiltonian operator is:

$$\hat{H} = \hat{H}_1 + \hat{H}_2 + \hat{H}_3 \quad -(41)$$

All details are given in notes 248(5) to 248(10) accompanying UFT248 on www.aias.us. The hamiltonian can be analysed to give many well known observable effects, and the entire theory can be developed for particle collisions and LENR.

There are three main hamiltonian operators summarized in the equation:

$$(\hat{H}_1 + \hat{H}_2 + \hat{H}_3)\psi = E\psi \quad -(42)$$

They are:

$$\hat{H}_1 = mc^2 + e\phi \quad -(43)$$

the second hamiltonian:

$$\hat{H}_2 = \frac{1}{2m}\left(\underline{\sigma}\cdot\left(-i\hbar\underline{\nabla}-e\underline{A}\right)\underline{\sigma}\cdot\left(-i\hbar\underline{\nabla}-e\underline{A}\right)\right) \quad -(44)$$

and the third hamiltonian:

$$\hat{H}_3 = \frac{1}{2m}\left(\underline{\sigma}\cdot\left(-i\hbar\underline{\nabla}-e\underline{A}\right)\phi\,\underline{\sigma}\cdot\left(-i\hbar\underline{\nabla}-e\underline{A}\right)\right) \quad -(45)$$

These emerge from the equation:

$$E = mc^2 + e\phi + \frac{c^2\left(\underline{p}-e\underline{A}\right)^2}{E - e\phi + mc^2} \quad -(46)$$

in the low energy approximation (12), so that Eq. (46) becomes:

$$E = mc^2 + e\phi + \frac{1}{2m}\underline{\sigma}\cdot\left(\underline{p}-e\underline{A}\right)\left(1+\frac{e\phi}{2mc^2}\right)\underline{\sigma}\cdot\left(\underline{p}-e\underline{A}\right) \quad -(47)$$

As in Note 248(6):

$$\hat{H}_2\phi = \frac{1}{2m}\Big[-\hbar^2\nabla^2\phi + e^2A^2\phi + ie\hbar\,\underline{\nabla}\cdot\left(\underline{A}\phi\right) - e\hbar\,\underline{\sigma}\cdot\underline{\nabla}\times\left(\underline{A}\phi\right) + ie\hbar\,\underline{A}\cdot\underline{\nabla}\phi - e\hbar\,\underline{\sigma}\cdot\underline{A}\times\underline{\nabla}\phi\Big] \quad -(48)$$

There are therefore many effects present in general, all of which can occur in particle collision theory and LENR with the translation (38). The most well known result of Eq. (48) is obtained from:

$$\begin{aligned}\hat{H}_2\phi &= -\frac{e\hbar}{2m}\underline{\sigma}\cdot\left(\underline{\nabla}\times\left(\underline{A}\phi\right)+\underline{A}\times\underline{\nabla}\phi\right)+\ldots\\ &= -\frac{e\hbar}{2m}\underline{\sigma}\cdot\left(\left(\underline{\nabla}\times\underline{A}\right)\phi+\underline{\nabla}\phi\times\underline{A}+\underline{A}\times\underline{\nabla}\phi\right)+\ldots\\ &= -\frac{e\hbar}{2m}\underline{\sigma}\cdot\left(\underline{\nabla}\times\underline{A}\right)\phi+\ldots \quad -(49)\end{aligned}$$

using the standard physics definition of the magnetic flux density:

$$\underline{B} = \underline{\nabla} \times \underline{A} \quad -(50)$$

In ECE physics the structure is greatly enriched with the spin connection {1 - 10}. Eq. (49) gives the g factor of the ECE electron, the Landé factor, ESR, NMR and MRI. There are parallel effects in particle collision theory and LENR which can be tested experimentally.

As shown in all detail in Note 248(7) the use of a complex valued potential gives five new effects through the hamiltonians:

$$\hat{H}_{21}\phi = \frac{1}{2m}\left[ie^2 \underline{\sigma} \cdot \underline{A} \times \underline{A}^* \phi - e\hbar\, \underline{\sigma} \cdot \underline{A} \times \underline{\nabla}\phi - e\hbar\, \underline{\sigma} \cdot \underline{\nabla}\phi \times \underline{A}^* - e\hbar\, \underline{\sigma} \cdot (\underline{\nabla} \times \underline{A}^*)\phi + \dots \right] \quad -(51)$$

and:

$$\hat{H}_3 \phi = \frac{1}{2} ec \left(1 + \frac{e\phi}{2mc^2}\right) \underline{\sigma} \cdot \left(\underline{A}^* - \underline{A}\right) \quad -(52)$$

One of these is the RFR hamiltonian:

$$\hat{H}_{RFR} = \frac{ie^2}{2m} \underline{\sigma} \cdot \underline{A} \times \underline{A}^* \quad -(53)$$

as discussed further in Note 248(7) in all detail.

As discussed in notes 248(8) and 248(9) in all detail, the hamiltonian (45) gives spin orbit coupling and the Darwin shift and again there will be equivalents of these phenomena in particle collision theory and LENR. So it is possible to develop a comprehensive new theory of particle collisions.

3. NUMERICAL DISCUSSION.

Section by Horst Eckardt and Douglas Lindstrom

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