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The covariant mass ratio of Einstein–Cartan–Evans (ECE) theory

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In the general theory of scattering it has been found recently that the particle mass varies in general, thus refuting the twentieth century physics in the sense that it ceases to be self consistent outside a narrowly defined context. The concept of covariant mass ratio is derived from the ECE wave equation and is defined most simply by elastic scattering, where it becomes the Lorentz factor. The new concept is shown to be self consistent for elastic scattering.

Keywords: Covariant mass ratio, scattering theory, elastic scattering, ECE theory.

1. Introduction

Recently in this series of papers [1–12] the theory of scattering has been considered anew in a rigorous way and a major self inconsistency found between the twentieth century quantum theory and special relativity as combined by de Broglie [13, 14]. In this paper the concept of covariant mass ratio is introduced and shown to be the Lorentz factor in the theory of elastic scattering. At the root of the covariant mass ratio of the ECE theory is the idea that the mass of a moving relativistic particle is different from its rest mass. The latter is the mass of the particle as given in the standards laboratories. In the theory of special relativity the particle mass is constant, but in UFT 158 to 162 of this series it was found that this is not true in the fundamental de Broglie theory, thus refuting the theory that is the most basic expression of twentieth century natural philosophy.

This deep flaw in the twentieth century theory emerges only if particle interaction is considered correctly, using both conservation of energy and momentum simultaneously and in the correct relativistic context. The mass of one of the colliding particles was expressed in terms of the mass of the other and in terms

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of experimental variables such as initial and scattered angular frequency and angle of scattering. It was found that the particle mass is not constant, indicating immediately that there is a concept missing from the de Broglie theory. This problem occurred as soon as photon mass was introduced into Compton scattering theory. Compton scattering is usually considered to be the experiment that proved that the photon has momentum and is a particle. However, in the theory of Compton scattering the photon is still considered to be a wave with no mass, only the electron is treated as a particle. The now available Nobel Prize archives reveal that the committee did not in fact accept the experiment as proof of the particulate nature of light. By now however, photon mass is regularly cited in tables of elementary particle masses, so it is logical to try to deduce the photon mass from Compton scattering. It was found in UFT 158 that as soon as this is done, the de Broglie theory becomes wildly incorrect in that the photon mass varies considerably and is not a constant.

This fundamental failure was found to occur in general scattering theory of one particle from another based on the fundamental de Broglie theory [13, 14]. The latter was found to work and to have been tested precisely only in a narrow context, that of the free particle of fixed rest mass. It was found in UFT 158 to 162 that it had never been tested with rigour in the context of particle interaction, and this has been done in UFT 158 to 162. Even worse for the now thoroughly obsolete twentieth century physics was the collapse of absorption theory when conservation of linear momentum is considered rigorously. It becomes apparent that these flaws exist in all types of twentieth century scattering theory and cannot be addressed at all by quantum electrodynamics or string theory.

In UFT 161 the concept of covariant mass ratio was introduced as a third postulate intended to augment the two postulates of the de Broglie theory, the energy and momentum postulates known as the de Broglie Einstein equations [13, 14]. The concept of covariant mass ratio originates in the tetrad postulate of Cartan geometry, the most fundamental theorem of differential geometry, so it is rigorously based in general relativity as corrected by ECE theory. In Section 2 the general Compton like theory of scattering is developed and specialized in Section 3 to elastic scattering theory, in which case the covariant mass ratio is found to be the Lorentz factor γ self consistently. This means that the dynamical mass in elastic scattering is γm_0, where m_0 is the rest mass, that of the particle in its rest frame. This means in turn that the concept of mass itself is changed, in general mass depends on the velocity through the Lorentz factor, a direct result of the collapse of the de Broglie theory, in which mass is constant. When the particle velocity is zero, the mass is the mass as given in the tables and standards laboratories.

2. General Compton type theory

In a Compton type theory, the photon is massless and there is exchange of energy and momentum between the photon and electron. In the original Compton theory the latter is static, part of an atom making up a foil subjected to gamma ray or X ray irradiation. In general however both the photon and electron are moving prior to collision, and also after collision. Energy conservation is therefore given by:

$$\hbar(\omega-\omega')=E_2-E_1 \tag{1}$$

and momentum conservation by:

$$\hbar(\boldsymbol{\kappa}-\boldsymbol{\kappa}')=\boldsymbol{p}_2-\boldsymbol{p}_1. \tag{2}$$

The total relativistic energies of the electron before and after collision are respectively E_1 and E_2. The relativistic momenta of the electron before and after collision are respectively $\boldsymbol{p}_1$ and $\boldsymbol{p}_2$. The initial and final angular frequencies of the photon are ω and ω' respectively. The initial and final wave vectors of the photon are $\boldsymbol{\kappa}$ and $\boldsymbol{\kappa}'$ respectively. Finally, $\hbar$ is the reduced Planck constant.

Denote:

$$\boldsymbol{\pi}=\boldsymbol{p}_2-\boldsymbol{p}_1 \tag{3}$$

The original momentum postulate of de Broglie (wave particle duality) means that:

$$\boldsymbol{p}_1=\hbar\,\boldsymbol{\kappa}_1,\quad \boldsymbol{p}_2=\hbar\,\boldsymbol{\kappa}_2. \tag{4}$$

So:

$$\pi^2=\hbar^2\left(\kappa_1^2+\kappa_2^2-2\kappa_1\kappa_2\cos\theta'\right), \tag{5}$$

where θ' is the angle between $\boldsymbol{p}_1$ and $\boldsymbol{p}_2$ of the electron. If the photon is assumed to be massless then:

$$\pi^2=\hbar^2\left(\kappa^2+\kappa'^2-2\kappa\kappa'\cos\theta\right) \tag{6}$$

where θ is the angle between κ_1 and κ_2 of the photon. Eq. (6) is:

$$\pi^2=\left(\frac{\hbar}{c}\right)^2\left(\omega^2+\omega'^2-2\omega\omega'\cos\theta\right) \tag{7}$$

because for a massless photon:

$$\omega = \kappa c, \quad \omega' = \kappa' c. \tag{8}$$

Denote:

$$E = E_2 - E_1 \tag{9}$$

then:

$$E^2 = \hbar^2 \left(\omega^2 + \omega'^2 - 2\omega\omega' \right) \tag{10}$$

so

$$c^2 \pi^2 - E^2 = 2\hbar^2 \omega\omega' \left(1 - \cos\theta\right). \tag{11}$$

The electron properties on the left hand side are balanced by the photon properties on the right hand side. Equation (11) can now be used as a rigorous experimental test. The two de Broglie postulates for the electron [13, 14] and any particle in general mean that:

$$E_1 = \hbar\, \omega_1, \;\; E_2 = \hbar\, \omega_2, \tag{12}$$

$$\boldsymbol{p}_1 = \hbar\, \boldsymbol{\kappa}_1, \;\; \boldsymbol{p}_2 = \hbar\, \boldsymbol{\kappa}_2. \tag{13}$$

The energies and momenta are related by the Einstein equations that originate in the concept of relativistic momentum:

$$E_1^2 = c^2 p_1^2 + m^2 c^4, \tag{14}$$

$$E_2^2 = c^2 p_2^2 + m^2 c^4, \tag{15}$$

with:

$$\pi^2 = p_1^2 + p_2^2 - 2 p_1 p_2 \cos\theta' \tag{16}$$

Define the rest energy:

$$E_0 = m c^2 \tag{17}$$

then:

$$p_1^2 + p_2^2 = \frac{1}{c^2}\left(E_1^2 + E_2^2 - 2\, E_0^2 \right), \tag{18}$$

$$E_1\, E_2 - E_0^2 - \, c^2 p_1 p_2 \, \cos\theta' = \hbar^2 \omega\omega' \, \left(1 - \cos\theta\right), \tag{19}$$

where:

$$p_1 = \frac{1}{c}\left(E_1^2 - E_0^2 \right)^{1/2}, \tag{20}$$

$$p_2 = \frac{1}{c}\left(E_2^2 - E_0^2\right)^{1/2}. \tag{21}$$

If the electron or any particle of mass m is initially stationary then:

$$\hbar\,\omega_1 = E_1 = mc^2, \tag{22}$$

$$\hbar\,\omega_2 = E_2 = \hbar\left(\omega - \omega'\right) + mc^2 \tag{23}$$

and Eq. (19) reduces to the standard Compton formula:

$$\omega - \omega' = \frac{\hbar}{mc^2}\omega\omega'\left(1 - \cos\theta\right). \tag{24}$$

Q.E.D.

The general result (19) could be tested experimentally in electron diffraction in a Young interferometer when one beam is perturbed by gamma rays, thus shifting the frequency in one arm and shifting the interferogram at the screen of the interferometer. In this process the rest energy of the electron should be constant, so this prediction of the de Broglie theory can be tested accurately by experiment. Solving Eq. (19) for E_0^2 gives:

$$E_0^2 = \frac{1}{2a}\left(-\mathrm{b} \pm \left(\mathrm{b}^2 - 4\,a\,\mathrm{c}'\right)^{1/2}\right) \tag{25}$$

where:

$$a = 1 - \cos^2\theta', \tag{26}$$

$$\mathrm{b} = \left(E_1^2 + E_2^2\right)\cos^2\theta' - 2\mathrm{A}, \tag{27}$$

$$\mathrm{c}' = \mathrm{A}^2 - E_1^2 E_2^2\,\cos^2\theta', \tag{28}$$

$$\mathrm{A} = E_1 + E_2 - \hbar^2\omega\omega'\left(1 - \cos\theta\right). \tag{29}$$

This result is derived in the Compton theory with a massless photon, but with an initially moving electron. Despite the simplicity of the collision process the result (25) is very complicated and dependent on several experimental parameters. If de Broglie is correct these have to combine in such a way as to give the correct electron mass, known to a relative uncertainty of 10^{-8} in the standards laboratories. In the light of the findings in UFT 158 to 162 this seems unlikely to happen, but should be tested experimentally.

3. Elastic scattering

In elastic scattering the energy conservation is a special case of:

$$\gamma m_1 c^2 + m_2 c^2 = \gamma' m_1 c^2 + \gamma'' m_2 c^2 \tag{30}$$

in which a particle of rest mass m_1 collides with a stationary particle of rest mass m_2. The two scattered particles have a combined energy on the right hand side of this equation equal to the combined energy on the left hand side. Their velocities are represented by the various gamma factors of Lorentz. In elastic scattering the following is true:

$$\gamma = \gamma', \tag{31}$$

$$\omega = \omega' \tag{32}$$

and the particle m_2 remains static in consequence. Therefore:

$$\hbar\omega'' = m_2 c^2 \tag{33}$$

which means that the energy of m_2 after collision is its rest energy. So far, the theory seems so to give a sensible result.

However, the rigorously correct consideration of momentum exchange leads to:

$$\omega''^2 v''^2 = \omega^2 v^2 + \omega'^2 v'^2 - 2\omega\omega' v v' \cos\theta \tag{34}$$

as shown in UFT 158 to 162. This equation means that:

$$\mathrm{K}''^2 = \mathrm{K}^2 + \mathrm{K}'^2 - 2\mathrm{K}\mathrm{K}'\cos\theta. \tag{35}$$

In elastic scattering:

$$\mathrm{K}^2 = \mathrm{K}'^2 \tag{36}$$

so

$$\omega^2 v^2 = \omega'^2 v'^2 \tag{37}$$

i.e.

$$\omega''^2 v''^2 = 2\omega^2 v^2 (1 - \cos\theta) \tag{38}$$

leading to:

$$\omega^2 = x_1^2 + \left(\omega^2 - x_1^2\right)\cos\theta \tag{39}$$

for all x_2, where x_1 and x_2 are defined by:

$$x_1 = \frac{m_1 c^2}{\hbar}, \quad x_2 = \frac{m_2 c^2}{\hbar}. \tag{40}$$

So either:

$$x_1 = \omega \tag{41}$$

or

$$\cos\theta = 1 \tag{42}$$

Equation (41) means that for all x_2:

$$m_1 c^2 = \hbar\,\omega. \tag{43}$$

This result is a fundamental contradiction within the context of twentieth century physics, in which the mass m_1 is a constant. The reason is that initially:

$$\gamma\, m_1 c^2 = \hbar\,\omega. \tag{44}$$

Equation (42) simply means no scattering at all, another contradiction, because the two particles interact and scatter by definition.

It is obvious from Eq. (43) that m_1 of that equation is different from the rest mass defined by:

$$\gamma\, m_0 c^2 = \hbar\,\omega. \tag{45}$$

From Eqs. (43) and (45):

$$\frac{m_1}{m_0} = \gamma. \tag{46}$$

Equation (46) means that the dynamic mass m_1 in the collision process is γm_0, where m_0 is the mass defined by the rest frequency:

$$m_0 c^2 = \hbar\,\omega. \tag{47}$$

Therefore

$$\frac{R_1}{R_0} := \left(\frac{m_1}{m_0}\right)^2 = \gamma^2. \tag{48}$$

If the velocity of the particle is zero:

$$m_1 = m_0 \tag{49}$$

and if the velocity of the particle approaches *c*:

$$m_1 \to \infty \tag{50}$$

If it is possible to consider a hypothetically defined:

$$m_0 \to 0 \tag{51}$$

then m_1 is defined by the hyper-relativistic limit and is indeterminate:

$$m_1 \to \frac{0}{0}. \tag{52}$$

From Eq. (52) m_1 can remain infinitesimally close to zero. In this case Eq. (30) becomes:

$$\hbar\omega + m_2 c^2 = \hbar\omega' + \gamma'' m_2 c^2 \tag{53}$$

which is the Compton effect equation where:

$$\omega \neq \omega'. \tag{54}$$

It seems clear that the covariant mass ratio:

$$\frac{m_1}{m_0} = \gamma \tag{55}$$

is self-consistent if m_2 is assumed constant.

The covariant mass ratio is defined as:

$$m_1 = \gamma m_0 = \hbar\,\omega / c^2 \tag{56}$$

so the R_1 factor of the ECE wave equation:

$$\left(\Box + R_1\right) q^a_\mu = 0 \tag{57}$$

is

$$R_1 = q_a^\nu \partial^\mu \left(\omega_{\mu\nu}^a - \Gamma_{\mu\nu}^a\right) = \left(\frac{m_1 c}{\hbar}\right)^2 = \left(\frac{\omega}{c}\right)^2 = \gamma^2 \left(\frac{m_0 c}{\hbar}\right)^2 \tag{58}$$

If we consider only $q_3^{(3)}$ for simplicity then:

$$q_3^{(3)} = \exp\left(\pm i\,\omega t\right), \tag{59}$$

$$\partial^\mu \left(\omega_{\mu 3}^{(3)} - \Gamma_{\mu 3}^{(3)}\right) = \left(\frac{\omega}{c}\right)^2 \exp\left(\mp i\ \omega t\right). \tag{60}$$

The particle of mass m is governed by:

$$\omega^2 = \kappa^2 c^2 + \frac{c^4 m_0^2}{\hbar^2} \tag{61}$$

so

$$\omega^2 = \kappa^2 c^2 + \frac{\omega^2}{\gamma^2} = \frac{\kappa^2 c^4}{v^2}. \tag{62}$$

Therefore, the wave vector is found, self-consistently, to be:

$$\kappa = \frac{\omega v}{c^2}. \tag{63}$$

In elastic scattering the particle of mass m_2 does not move, so the covariant mass ratio for m_2 is always unity. Further work will extend this new concept to the general theory of scattering.

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