1) Note 83(5): Electron / Photon / Graviton Interaction

This problem may be set up as:

$$(p_1 + p_2) + p_5 = (p_3 + p_4) + p_6 \quad -(1)$$

where:

$$p_3 = p_1 + A + g \quad -(2)$$

$$p_4 = p_2 - A + g \quad -(3)$$

$$p_6 = p_5 - 2g. \quad -(4)$$

So:

$$p_1 + p_2 + p_5 = p_1 + A + g + p_2 - A + g + p_5 - 2g, \quad -(5)$$

and total energy/momentum is conserved.

In this model the electron gains momentum from the photon and graviton. The photon loses A but gains g from the gravitational field. The graviton loses g to both the electron and photon.

Free Particle Equations

Electron

$$\left(\Box + \left(\frac{m_e c}{\hbar}\right)^2\right) \psi_\mu^a = 0, \quad -(6)$$

$$\Box = -\frac{1}{\hbar^2} p^\mu p_\mu. \quad -(6a)$$

Photon

$$\left(\Box + \left(\frac{m_p c}{\hbar}\right)^2\right) A_\mu^a = 0 \quad -(7)$$

$$\Box = -\frac{1}{\hbar^2} \pi^\mu \pi_\mu \quad -(7a)$$

2) Graviton

$$\left(\Box + \left(\frac{m_g c}{\hbar} \right)^2 \right) \sigma_\mu^a = 0 \quad -(8)$$

$$\Box = -\frac{1}{\hbar^2} g^\mu g_\mu \quad -(8a)$$

Interaction

$$p^\mu \to p^\mu + eA^\mu + \epsilon \sigma^\mu \quad -(9)$$

$$\pi^\mu \to \pi^\mu - eA^\mu + \epsilon \sigma^\mu \quad -(10)$$

$$g^\mu \to g^\mu - 2\epsilon \sigma^\mu \quad -(11)$$

The Wave Equation

$$\left(i\hbar \partial^\mu + eA^\mu + \epsilon \sigma^\mu \right)\left(i\hbar \partial_\mu + eA_\mu + \epsilon \sigma_\mu \right) q_\mu^a = m_e^2 c^2 q_\mu^a \quad -(12)$$

$$\left(i\hbar \partial^\mu - eA^\mu + \epsilon \sigma^\mu \right)\left(i\hbar \partial_\mu - eA_\mu + \epsilon \sigma_\mu \right) A_\mu^a = m_p^2 c^2 A_\mu^a \quad -(13)$$

$$\left(i\hbar \partial^\mu - 2\epsilon \sigma^\mu \right)\left(i\hbar \partial_\mu - 2\epsilon \sigma_\mu \right) g_\mu^a = m_g^2 c^2 g_\mu^a \quad -(14)$$

where:

$$A_\mu := A_\mu^{(0)} + A_\mu^{(1)} + A_\mu^{(2)} + A_\mu^{(3)}$$

$$\sigma_\mu := \sigma_\mu^{(0)} + \sigma_\mu^{(1)} + \sigma_\mu^{(2)} + \sigma_\mu^{(3)} \quad -(15)$$

by definition.

3) Eqns. (12) to (14) must be solved as simultaneous equations.

Classical

$$(p^\mu + eA^\mu + \epsilon G^\mu)(p_\mu + eA_\mu + \epsilon G_\mu) = m_e^2 c^2 \quad -(16)$$

$$(\pi^\mu - eA^\mu + \epsilon G^\mu)(\pi_\mu - eA_\mu + \epsilon G_\mu) = m_p^2 c^2 \quad -(17)$$

$$(q^\mu - 2\epsilon G^\mu)(q_\mu - 2\epsilon G_\mu) = m_g^2 c^2 \quad -(18)$$

These again must be solved simultaneously.

Standard Model

The photon and graviton masses are zero. All that is usually considered is:

$$(p^\mu + eA^\mu)(p_\mu + eA_\mu) = m_e^2 c^2 \quad -(19)$$

Photon - Graviton Interaction

This method shows that gravitational charges all the fundamentals of the photon. The simultaneous classical equations are:

$$(\pi^\mu + \epsilon G^\mu)(\pi_\mu + \epsilon G_\mu) = m_p^2 c^2$$

$$(q^\mu - \epsilon G^\mu)(q^\mu - \epsilon G^\mu) = m_g^2 c^2$$

$$-(20)$$

4) The light deflection by gravitation is:

$$\theta = \int \frac{v}{r}\, dt \qquad -(21)$$

In the standard model this method cannot be used because the basic wave equation of gravitation is missing. This is the ECE wave equation:

$$\left(\Box + kT \right) q_\mu^a = 0 \qquad -(22)$$

General Equations

These are eq. (22) and:

$$\left(\Box + kT \right) q_\mu^a = 0 \qquad -(23)$$

$$\left(\Box + kT \right) A_\mu^a = 0. \qquad -(24)$$

Example of an Expression for kT $\qquad -(25)$

From eq. (12):

$$\left(\partial^\mu - i\frac{e}{\hbar} A^\mu - i\frac{\epsilon}{\hbar} \sigma^\mu \right)\left(\partial_\mu - i\frac{e}{\hbar} A_\mu - i\frac{\epsilon}{\hbar} \sigma_\mu \right) q_\mu^a = -\frac{m_e^2 c^2}{\hbar^2} q_\mu^a$$

so:

$$\left(kT \right)_{electron} = \frac{m_e^2 c^2}{\hbar^2} - \frac{1}{\hbar^2}\left(eA^\mu + \epsilon\sigma^\mu \right)\left(eA_\mu + \epsilon\sigma_\mu \right)$$

$$- \frac{i}{\hbar}\left(\left(eA^\mu + \epsilon\sigma^\mu \right)\partial_\mu + \partial^\mu \left(eA_\mu + \epsilon\sigma_\mu \right) \right) \qquad -(26)$$

where:

$$p^\mu = i\hbar \partial^\mu \qquad -(27)$$

5) Comments

In QM advantage:

$$|eA^\mu| \gg |\epsilon G^\mu| \quad -(28)$$

by about thirty orders of magnitude. So for all practical purposes, and after averaging:

$$(kT)_{electron} = \frac{m_e^2 c^2}{\ell^2} - \frac{e^2}{\ell^2} A^\mu A_\mu \quad -(29)$$

In a cosmological context, light bending by gravitation is observed, and also many other effects of gravitation on light predicted recently by ECE physics, e.g. change of polarization.

Eqs. (20) predict that there is a Faraday effect and IFE on light caused by gravitation.