# The Fine Structure Constant from the Feynman Path Integrals

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***Supplement to*:**

The Connection between Electric Charge, Gravitation, and the Feynman Sum over All Histories View of Quantum Electrodynamics [1, 4]

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*The referenced paper details this development, but this supplement is extracted from separate sections.*

The change in the speed of c as the result of gravitation is well known. It is found from GR by flattening GR onto Minkowski four-space, and it is known by the experimental measurements of the Shapiro effect [6], [7], its value is:

$$1-\eta^{-1}=\frac{\Delta c}{c_0}=\frac{2\mu}{r} \tag{1}$$

The relation between $\Delta c$ and the conventional index of refraction is $1-\eta^{-1}=\Delta c$ This same value can be calculated by the presumption that mass particles generate an extensive probability field of circulating photons as the result of the Feynman action path probabilities of the internal motion of the internal particles.

By presuming the change in c is proportional to the probability of a photon intersecting a photon the size of a Planck particle inside the volume of the Compton radius of a second photon, the change is found to be:

$$\frac{\Delta c}{c_0}=\frac{\lambda\!\!\!^{-2}_{PL}}{\lambda\!\!\!^{-2}} \tag{2}$$

$\lambda\!\!\!^{-}_{PL}$ is the radius of the Planck particle $\mu\lambda\!\!\!^{-}$, and $\lambda\!\!\!^{-}$ is the Compton radius of a mass particle. A probability density per unit volume of Feynman photons as a function of the distance from the particle generated by a mass particle has been found from other considerations to be [1]:

$$d = \frac{2\lambda}{r} \tag{3}$$

The radius r is the distance from an observation point of the density to the particle center of mass

The gravitational change in the speed of light in the vicinity of a mass particle is the probability of the change due to a photon times the probability density of encountering a Feynman photon from the mass particle in the vicinity of the particle:

$$\frac{\Delta c}{c_0} = \frac{\lambda_{PL}^2}{\lambda^2}\frac{2\lambda}{r} = \frac{2\mu}{r} \tag{4}$$

The same as the value as noted in Eq.(1). We take this as the origin of the change in c as a result of the Feynman photons generated by the internal action paths of photons in mass particles.

Rewriting this in in terms of the energy ratio of the gravitational energy to the total energy of the particle in the field gives:

$$\frac{\Delta c}{2c} = \frac{\mu}{r} = \frac{Gm_1}{c^2 r} = \frac{Gm_1 m_2}{\left(m_2 c^2\right) r} \tag{5}$$

To state this: It represents the ratio of the change in the potential energy, to the total energy of the $m_2$ particle, as the result of being in the probability density field of the Feynman photons of $m_1$

For a particle the change in the energy potential as a ratio of its total energy is then:

$$\frac{\Delta\varepsilon}{\varepsilon_T} = \frac{1}{2}\frac{\Delta c}{c} \tag{6}$$

Putting Eq.(4), into this is the form is then:

$$\frac{\Delta c}{c_0} = \frac{\lambda_{PL}^2}{\lambda^2}\frac{2\lambda}{r} \rightarrow \frac{\Delta\varepsilon}{\varepsilon_T} = \frac{1}{2}\left(\frac{\lambda_{PL}^2}{\lambda^2}\frac{2\lambda}{r}\right) \tag{7}$$

## The Electron

An electron as modeled in [3], and [5], is defined as two photons captured in the self-generated index of refraction of the vacuum polarization. The modification to Eq.(7), which is the single pass of a photon through a probability field is that the photon probability from the rotation photons in the electron repeats at the Compton frequency, $\nu_e$ and generates the effect of a higher change in the index of refraction on a passing photon.

$$\frac{\Delta c}{c} = \frac{\lambda_{PL}^2}{\lambda_e^2}\frac{2\lambda}{r}\nu_e = \frac{2\mu}{r}\nu_e \tag{8}$$

Note from Eq.(4), and Eq.(8), the effect of the Feynman photon density is the originating mechanism for both gravitation and electric charge.

In the case of charge particles the change in c of one particle on the other has a reciprocity effect and the interaction on the change in c is multiplicative (see [1]). The relative change in c and the potential energy potential is the product of the individual changes thus:

$$\frac{\Delta c}{c} = \left(\frac{\lambda_{PL}^2}{\lambda_e^2}\frac{2\lambda_1}{r_1}\nu_e\right)\left(\frac{\lambda_{PL}^2}{\lambda_e^2}\frac{2\lambda_1}{r_2}\nu_e\right) \tag{9}$$

And the potential ratio for the two particles Eq.(6), is:

$$\frac{\Delta\varepsilon}{\varepsilon_T} = \frac{1}{2}\left(\frac{\lambda_{PL}^2}{\lambda_e^2}\frac{2\lambda_{e1}}{r_1}\nu_e\right)\left(\frac{\lambda_{PL}^2}{\lambda_e^2}\frac{2\lambda_{e2}}{r_2}\nu_e\right) \tag{10}$$

, or

$$\frac{\Delta\varepsilon}{\varepsilon_T} = \left(\frac{\lambda_{PL}^2}{\lambda_e^2}\sqrt{2}\nu_e\right)\left(\frac{\lambda_{PL}^2}{\lambda_e^2}\sqrt{2}\nu_e\right)\frac{\lambda_{e1}}{r_1}\frac{\lambda_{e2}}{r_2} \tag{11}$$

For this to be correct the right side must be:

$$\frac{\Delta\varepsilon}{\varepsilon_T} = \frac{\alpha\lambda_{e1}}{r_1}\frac{\alpha\lambda_{e2}}{r_2} \tag{12}$$

Thus in Eq.(11), the brackets have to be the fine structure constant $\alpha$, thus:

$$\alpha = \left(\frac{\lambda_{PL}^2}{\lambda_e^2}\sqrt{2}\nu_e\right) = \frac{1}{137.0359997} \tag{13}$$

(Detailed calculations in [4])

$r_1$ and $r_2$ Are the distances from the particle origin to the observation point, thus we can pick the observation point at the classical radius of the electron leaving the expression to be the potential of the second particle in the Feynman field of the second with the same minimum value

$$\frac{\alpha \lambdabar_{e1}}{r_1} = 1 \tag{14}$$

, and

$$\frac{\Delta\varepsilon}{\varepsilon_T} == \frac{1}{mc^2}\frac{Q^2}{r_2} * \tag{15}$$

This is the standard definition of potential energy for an electron:

*Note that the issue of the charge sign of the electric charges has not been addressed here, and is left to a subsequent paper. It could be conventionally assigned in Eq.(11), but it is more complicated than that, and has to do with the structure of the electron.

The coincidence between the calculations for both electric and gravitational interactions, and accuracy of the relation between G and $\alpha$ gives a degree of confidence that this procedure has merit.

From Eq.(8), and Eq.(13), The fine structure constant in terms of the Compton frequency and the gravitational radius of the electron is*:

$$\alpha = \sqrt{2}\frac{\lambdabar_{PL}}{\lambdabar_e}\nu_e \tag{16}$$

*See [4], for calculation details.


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