# The Einstein De Broglie Feynman Quantum Equivalence Principle

Nikola Perkovic*

*Institute of Physics and Mathematics, Faculty of Sciences, University of Novi Sad, Serbia

**Abstract**

Combining the equation for mass energy equivalence and the De Broglie equations for wavelength with Feynman's work on Quantum Electrodynamics, this paper will provide an equation of quantum equivalence using the fine structure constant which is measured to incredible accuracy in the study of QED. This equation will serve to prove that energy mass equivalence is a product/consequence of quantum effects. Electrons will be used to test the equation for both rest mass and rest energy as well as the wavelength, with the help of using the Rydberg constant $R_\infty$ to simplify the calculus.

## Introduction

There is a number of ways to attain the mass energy equivalence equation, the simplest one being via kinetic energy. In classical mechanics, we know that a material point $m_0$, moving with a velocity v, has a momentum $p = m_0 v$ and has the kinetic energy $T = 1/2\, m_0 v^2$.

Applying the Lorentz transformations, we attain:

$$p = \gamma m_0 v = \frac{m_0 v}{\sqrt{1-\beta^2}} = \frac{m_0 v}{\sqrt{1-\frac{v^2}{c^2}}} = mv$$

where m stands for relativistic mass as opposed to $m_o$ which stands for rest mass [1]. The two masses are in a relationship described by the equation:

$$m = \gamma m_0 = \frac{m_0}{\sqrt{1-\beta^2}} = \frac{m_0}{\sqrt{1-\frac{v^2}{c^2}}}$$

Therefore transforming the equation for kinetic energy to $T = mc^2 - m_0 c^2$ where the concept of rest energy corresponds to the rest mass:

$$E_0 = m_0 c^2$$

and we attain the relativistic energy $E = T + E_0 = mc^2$ [2][3].

Wavelength has a relationship

$$m = \frac{E}{c^2} = \frac{h}{\lambda c}$$

with energy and mass. Since we will be describing a quantum equivalence principle, it is more practical to use angular wavelength $\lambda = 2\pi\Upsilon$ where $\Upsilon$ is the angular wavelength.

Finally we need the fine structure constant α also known as the electromagnetic coupling constant. Its value is one of the most accurately experimentally measured in science with a high certainty [4] that is frequently improved even further [5] it is usually measured in equations for the anomalous magnetic dipole moment

$$a_e = A_1 \frac{\alpha}{\pi} + A_2 \left(\frac{\alpha}{\pi}\right)^2 + A_3 \left(\frac{\alpha}{\pi}\right)^3 + \cdots + a\left(\frac{m_e}{m_\mu}, \frac{m_e}{m_\tau}, \ldots\right)$$

and has a value of approximately $\alpha = 0.00729735256$ which we will be using in this paper.

## The Einstein De Broglie Feynman Equation

We will formulate this equivalence principle by combining all three E, m and ′ϒ in a single equation with α, in a similar way as the equation above. To do so we must describe mass and energy in a different manner than before, by using α and ′ϒ.

For rest mass we have:

$$m_0 = \frac{\mu_0 e^2}{4\pi' \Upsilon}\Big/_{\alpha} \tag{1a}$$

and for rest energy:

$$E_0 = \frac{e^2}{4\pi \varepsilon_0 ' \Upsilon}\Big/_{\alpha} \tag{1b}$$

which collectively forms the equation for the Einstein De Broglie Feynman equivalence principle:

$$\alpha = \frac{\mu_0 e^2}{4\pi' \Upsilon}\Big/_{m_0} = \frac{e^2}{4\pi \varepsilon_0 ' \Upsilon}\Big/_{E_0} \tag{2}$$

if we use relativistic mass, energy and wavelength then the equation is:

$$\alpha = \frac{\mu_0 e^2}{4\pi' \Upsilon'}\Big/_{\Delta m'} = \frac{e^2}{4\pi \varepsilon_0 ' \Upsilon'}\Big/_{E'} \tag{3}$$

where $\Delta m'$ is relativistic mass, $E'$ is relativistic energy and $'\Upsilon'$ is relativistic angular wavelength.

We will proceed to test the equations 1a and 1b which define the quantum equivalence of mass, energy and wavelength, individually, for electrons.

## Testing the equation with $m_e$ $'\Upsilon_e$ and $E_e$

Angular wavelength of electrons corresponds to $\lambda_e = 2\pi' \Upsilon_e$. From experiments we know that the mass of electrons can be described as:

$$m_e = \frac{2R_\infty h}{c\alpha^2} \tag{4}$$

with the help of the Rydberg constant $R_\infty$ which is:

$$R_\infty = \frac{\alpha}{4\pi a_o} = \frac{\alpha^2}{2\lambda_e} = \frac{\alpha^2}{4\pi\prime\Upsilon_e} \tag{5}$$

where $a_o$ is the Bohr radius. We can now proceed to test the equation 1a:

$$\alpha = {\frac{\mu_0 e^2}{4\pi\prime\Upsilon_e}}\Big/{m_e} \tag{6}$$

and conclude that:

$$\alpha = \frac{\frac{\mu_0 e^2}{4\pi\prime\Upsilon_e}}{\frac{2R_\infty h}{c\alpha^2}} = \frac{\mu_0 e^2 c\alpha^2}{4\pi\prime\Upsilon_e 2hR_\infty} = \frac{\mu_0 e^2 c\alpha^2}{4\pi\prime\Upsilon_e 2h\frac{\alpha^2}{4\pi\prime\Upsilon_e}} = \frac{\mu_0 e^2 c}{2h} = 0.00729735256 \tag{7}$$

which is in agreement with experimental results, see [4,5].

Now we proceed to do the same for energy, equation 1b:

$$\alpha = {\frac{e^2}{4\pi\,\varepsilon_0\prime\Upsilon_e}}\Big/{E_e} \tag{8}$$

and conclude:

$$\alpha = \frac{e^2}{4\pi\varepsilon_0\prime\Upsilon_e}\Big/E_e = \frac{\frac{e^2}{4\pi\varepsilon_0\prime\Upsilon_e}}{\frac{hc}{\lambda_e}} = \frac{e^2}{4\pi\varepsilon_0\prime\Upsilon_e}\cdot\frac{2\pi\prime\Upsilon_e}{hc} = \frac{e^2}{4\pi\varepsilon_0\prime\Upsilon_e}\cdot\frac{\prime\Upsilon_e}{\hbar c} = \frac{e^2}{4\pi\varepsilon_0\hbar c} = 0.00729735256 \tag{9}$$

which is also in agreement with the experiments and tests on the value of α. Both equations 1a for mass and 1b for energy have passed this test with flying colors which leads to an obvious conclusion that equations 2 and 3 are also correct.

## Conclusions

The conclusion of the paper is that mass energy equivalence is a consequence or a product of quantum effects. In other words, energy mass equivalence emerges from the quantum equivalence principle of mass, energy and wavelength which is described with the Einstein De Broglie Feynman equation, which is the equation 2.

$$E = mc^2 = \left(\frac{\mu_0 e^2}{4\pi\Upsilon}\Big/_{\alpha}\right) \cdot c^2 = \left(\frac{\mu_0 e^2}{4\pi\Upsilon}\Big/_{\alpha}\right) \cdot \frac{1}{\varepsilon_0 \mu_0} = \frac{e^2}{4\pi\,\varepsilon_0\Upsilon}\Big/_{\alpha} \tag{10}$$

This equation is also more practical for determining upper mass limits of gluons and photons. If applied on gluons the equation gives the result

$$m_{gluon} < 0.000187 \ldots \ eV/c^2$$

which is in agreement with the experimental upper bounds [6], [7].

If we apply it for photons the upper mass limit is:

$$m_{\gamma} \lesssim 2.199 \ldots \cdot 10^{-14}\ eV/c^2$$

which is in agreement with the constraints determined in [8], [9] and [10].

This paper makes no assertions on the existence of masses for gluons and photons, or any other claims on the nature of mass in gauge bosons.

The simplicity and effectiveness of the equation make it elegant and simple for use with a wider application than $E = mc^2$ since it is only a consequence of the EDeBF quantum principle.

The main conclusion of this paper is a conjecture that the specific value of the fine structure constant that has been a mystery for a relatively long time, arises due to equivalency of mass and energy and their relationships with wavelength, due to the wave-particle duality which is the nature of all particles, and also due to the nature of vacuum as visible by the $\varepsilon_0$ and the $\mu_0$ constants.

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