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The Relationship Between the Possibility of a Hidden Variable in Time, Possible Photon Mass, Particle's Energy, Momentum and Special Relativity

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Abstract

In this paper we will discuss the relationship between a possible hidden variable in time, f_r , and possible photon mass, particle energy, momentum and special relativity. One of the implications of the possibility of a hidden variable in time that may explains the origin of unstable particle decay time distributions, is the possible existence of f_r for stable particle such as photons. It will be discussed, that f_r may be linked to the photons spin and wave function, which may lead to the conclusion that the photon has a rest mass. More specifically, it will be argued that in order to explain the photon's large energy range, the photon may have a set of masses. Following the above, a correction to the energy and momentum's expressions given by special relativity will be presented. Possible experimental ways to test the above will be discussed.

Keywords: hidden variable, time, photon, spin, wave function, energy, special relativity

1. Introduction

In this paper we will discuss the relationship between a possible hidden variable in time, f_r , and possible photon mass, particle energy, momentum and special relativity. The hidden variable in time possibility, f_r , first suggested in Brodet (2010), attempts to explain unstable particle decay time distribution by a compatible distribution of f_r values. This is where f_r describes a range of frequencies for the unstable particle's internal virtual boson fluctuations. Although, stable particles, such as a photon, do not decay and therefore do not have a defined decay time, it is nevertheless suggested that also a photon should have such a hidden variable, f_r .

This suggestion originate from considering a process such as, $\gamma\gamma \to \mu^+\mu^-$. In this process the outgoing muons have a distribution of decay time. Therefore if the muons do have a hidden variable in time, in f_r , it is logical it originates from the process initial conditions, which in this case are the $\gamma\gamma$ and therefore the $\gamma\gamma$ should also have a hidden variable in time, f_r .

In Brodet (2016), it was suggested that f_r may be linked to the muon's spin and wave function. In this paper, it will be suggested that also in the case of the photon, f_r may be related to the photon's spin and wave function, and that in fact this suggests that the photon may have a non-zero rest mass. More specifically it will be suggested that the photon energy range may be explained by a set of photons with a set of different non-zero rest masses. Consequently, this means the expression for the photon's, energy and momentum, and in general any particle energy and momentum, given by special relativity should be modified. Therefore, a relevant correction is suggested to the energy and momentum expressions given by special relativity. At the end of the paper, general experimental ways are suggested to test the above.

The paper is organized as follows. Section 2 describes the theoretical background. Section 3 describes general experimental ways to test the existence of a non-zero photon mass or massive values and the consequence modification to special relativity. Section 4 contains the conclusions.

2. Theoretical Background

The initial conditions in the process $\gamma\gamma \to \mu^+\mu^-$ may generate two distributions in the final muons; one in space and one in time. As discussed in (1), the muon decay time distribution, may be generated by the possibility of a hidden variable in time, f_r . As discussed in Brodet (2015), the spatial distribution may be generated by a global hidden variable, H_{global} , which is suggested to be responsible for the muon's production angular distribution.

The experimental fact that the spatial and time distribution are not correlated, and the fact that a key ingredient in the $\gamma\gamma$ initial conditions is the $\gamma\gamma$ wave function, makes it logical to associate the final muon spatial and time distributions to the $\gamma\gamma$ initial wave functions which contains separate spatial and time parts.

Therefore, when we consider the spatial and time distributions of a single outgoing muon μ^-, we may argue that it is linked to the initial γ wave function. Since the wavy part of the γ wave function ($e^{i(E\cdot t+P\cdot x)}$) contains two parts, the energy-time phase, $e^{i(E\cdot t)}$ and the momentum-position phase, $e^{i(P\cdot x)}$, it would be logical to associate the muon decay time distribution to the energy-time phase and the muons spatial or angular distribution to the momentum-position phase.

In Brodet (2016) it was argued that one can relate the final muon decay time distribution to its intrinsic angular momentum value which can be identified as the muon's spin and to its wave function value at zero momentum ($P_\mu = 0$). Therefore if we consider such a muon production through a process such as, $e^+e^- \to \mu^+\mu^-$, we may associate, assuming angular momentum conservation, the final muon spin value to the initial electron spin value.

Therefore, comparing the $e^+e^- \to \mu^+\mu^-$ to the process, $\gamma\gamma \to \mu^+\mu^-$, one can similarly relate the final muon decay time distribution to the initial photon spin and wave function value. This means that the photon spin is related to the energy-time phase of the photon's wave function which means that the photon must have a non-zero rest mass. That is:

$S_\gamma = E_\gamma \cdot t_\gamma$ where E_γ is the photon rest energy equals to $E_\gamma = M_\gamma \cdot c^2$ and $t_{\gamma(i)}$ is photon's i internal time, which may be given in terms of photon's i possible hidden variable in time $f_{r(i)}$:

$$t_{\gamma(i)} = \tau_\gamma \cdot \ln\left(\frac{M_\gamma}{f_{r(i)}}\right) \tag{1}$$

The above suggestion for a non-zero photon rest mass, poses an inconsistency with Einstein's special relativity as if a photon is an object with mass, according to special relativity its energy should be given by:

$$E = \gamma_{b\_original} \cdot M_\gamma \cdot c^2 \text{, where } \gamma_{b\_original} = \sqrt{1-\frac{v_\gamma^{\ 2}}{c^2}}\,.$$

However, since the velocity of a photon is always $v_\gamma = c$, the factor $\gamma_{b\_original} \to \infty$, and so the photon gets an infinite energy. This contradicts off Corse experimental observations where the photon's energy is measured with a range of values, from very low energy to very high but certainly not infinity.

Therefore, if we were to adopt the possibility of a hidden variable in time, f_r, the factor $\gamma_{\_b\_original}$ should be modified to agree with experimental observations.

It is suggested here to include, for every particle the value of its hidden variable in time f_r, in the expression for its boost factor, γ_b, such:

$$\gamma_{b(i)} = \sqrt{1-\frac{v^2}{(c+\frac{a1}{f_{r(i)}})^2}} \tag{2}$$

Where $a1$ is a constant with the appropriate dimension to transform the term $\frac{a1}{f_{r(i)}}$ to be in velocity dimension.

It appears experimentally that a photon may have any energy value from very low to almost infinite energy values. If the above is correct, this would mean that low energy photons always have low f_r values and high energy photons have high f_r values and that the whole f_r spectrum is divided to parts according to the photon's energy spectrum. This would make the f_r idea not consistent with the experimental observation that even high energy photons(with large f_r values) may produce muons with long decay time values which should correspond according to the initial f_r idea to low f_r values (Brodet, 2010).

Therefore, it is suggested that the photon in fact comes with a discrete range of masses $j = 1,2,3.... \to n$ which are compatible to its energy range. Hence, a photon with large energy has a larger mass value and larger f_r and γ_b values and a photon with low energy has a low mass value and a low f_r and γ_b values. More specifically, it is suggested that each photon f_r shape variable, τ_γ ,(according to equation 1), is related to the mean photon mass, $M_{mean(j)}$ by:

$$\tau_{mean(j)} = f(M_{mean(j)}) \tag{3}$$

The function $f(M_{mean)})$ is unknown at this stage but maybe similar to the Standard Model function that calculated the mean lifetime of a particle as a function of its rest mass.

Therefore, the above means that behind each photon with a different given mean rest mass $M_{mean(j)}$ stands a different distribution of $f_{r(j)_i}$ values. Therefore, behind a photon with high energy and large $M_{mean(j)}$ mass value, stands a distribution of $f_{r(j,i)_i}$ values from $i \to n$ and $f_{r(j,i)_i}$ from zero to $M_{mean(j)}$ $(0 \to M_{mean(j)})$ according to its $\tau_{(mean)j}$ and equation 1. This means that even a photon with a large rest mass, $M_{mean(j)}$, that usually may be associated with high energies, could get low $f_{r(j,i)}$ and $\gamma_{b(j,i)}$ values and have low energies. However this situation is not expected to be very abundant as its $\tau_{(mean)j}$ would be very small and the number of such photon particles should be very small also.

The above may be related to the known photon's energy of: $E = h \cdot \nu$ by:

$$E_\gamma = a2 \cdot S_{\gamma(j,i)} \cdot \nu_j \tag{4}$$

Where $S_{\gamma(j,i)} = M_j \cdot (c + \frac{a1}{f_{r(i)}})^2 \cdot \tau_j \ln(\frac{M_j}{f_{r(i)}})$, ν_j is the photon's frequency and $a2$ is a constant with yet an unknown value.

3. Experimental Search for Photon Mass

In the case the above suggestion is correct; there should be experimental evidence for that. The above suggestion may affect the photon's spin and energy. Therefore, we should look at situations in which the photon's spin or energy may affect the experimental results.

For the spin case, it is not clear at this stage how to bias the photon's spin distribution and measure the possible effect it may have on measurements as the total cross section of a process such as: $\gamma\gamma \to \mu^+\mu^-$. So at this stage it may be easier to concentrate on the energy case.

For the energy case, if indeed the photon comes with different masses according to its energy, then there must be an evidence for that.

One may therefore suggest studying the process $\mu^+\mu^- \to \gamma\gamma$ more carefully in an experimental setup as a muon collider (2016). Therefore one may divide the above process into several data sets according to the initial muons decay time values; the first data set may be for muons that were just produced and we let them immediately to interact and produce the two photons, a second sample may consist muons that live a longer time after they are produced and a third sample may consist muons that are even more long lived before they annihilate to give the two outgoing photons. In every one of the three samples we measure the outgoing photons average energy. If the suggestion made in section 2 is correct, then we may observe differences in the average energies of the final photons. This is so since if the photons have a rest mass and a γ_b boost structure, then their energy depends on their hidden variable $f_{r(j,i)}$ which may be different in the 3 samples as muons with different average decay times may have different $f_{r(i)}$'s according to Brodet (2010). The above measurement may be carried out in different muon initial energies which may investigate this possible effect more thoroughly. Therefore if such final photon energy dependence is observed, then it will support the suggestion that the particle boost structure depends on $f_{r(j,i)}$ and that the photons have indeed a rest mass.

Another possibility, is that it could be argued that if the energy of the photon depends on its hidden variable value, f_r, and if indeed its energy spectrum contains different photon masses, then the photons energy spectrum depends on a sum of exponential distributions. Therefore one can attempt to measure the photons energy spectrum and try to fit to it the function:

$$E_{\gamma} = \sum_{j=1...n} W_j \cdot \gamma_{b(j)} \cdot M_{\gamma(j)} \cdot (c + \frac{a1}{f_{r(j,i)}})^2 \quad (5)$$

Where W_j is the weight associated with specific photon mass j. This procedure may reveal how many masses does the photon state contains, and whether it indeed fits a combination of exponential distributions.

The suggested measurement of the spectrum may be done by generating a part of the photon energy spectrum, from photons in the low radio frequency up to the visible range by an appropriate antenna. This photon energy generation may be done gradually from low energy (frequency) to the visible range where at each frequency the intensity of the generated radiation is measured. This will allow plotting a curve of the photons energy verses their intensity, and then attempt to fit equation 4 to this curve and test if it matches a combination of exponential distributions as suggested in this paper.

4. Conclusions

The relationship between the possibility of a hidden variable in time, f_r , the photon's mass ,particle's energy, momentum and special relativity were discussed. It was suggested, that as unstable particle's, also a stable particle such as a photon may have a hidden variable in time, f_r . More over it was suggested that as fermions, also a photons may have a link between their f_r and their spin and wave function values, and that in the case of a photon it may mean that the photon has a non-zero rest mass. More specifically, it was suggested that the photon's large energy range is explained by a set of different non-zero rest masses for the photons. Consequently, the relevant, modification was made for the energy and momentum expression given by special relativity. Finally, experimental ways to test the above were also suggested.

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