# Does the Deflection of High-Energy Photons Contradict General Relativity?

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**Abstract:** According to the Scale-Symmetric Theory (SST), photons and rotating neutrinos produce around them discs in the Einstein spacetime - there is obligatory the Einstein formula E = Mcc, where E is the photon/neutrino energy (the rotational energy) and M is the mass of photon/neutrino disc. In the discs, when they interact with fermions, there are created virtual pairs. Due to the quantum phenomena, the Principle of Equivalence (PE) is locally "broken" for photons with energy higher than 10 GeV - it leads to the incorrect conclusion that the deflection of high-energy photons contradicts general relativity. Here we show that general relativity describes correctly the bending of high-energy photons by masses when the weak interactions of the photon discs with matter are eliminated.

## 1. Introduction

It is obvious that general relativity is incomplete without quantum phenomena and vice versa. There are the fruitful Einstein equations of the General Theory of Relativity (GR) and the fundamental equations in the Standard Model (SM). But the methods used in GR and SM are not effective in describing discontinuous phenomena related to the inflation field i.e. in the description of phase transitions at the level of spacetime. First, we need to pick out symmetries and quantized laws of conservation that can apply to the inflation field and spacetime, taking into account the huge amount of experimental data. Such a mathematically simple but physically very difficult method leads to the origin of the fundamental physical constants and subsequent phase transitions that can not be described within GR and SM – it is done within the Scale-Symmetric Theory (SST) [1], [2]. In our opinion, deciphering the internal structure and phenomena characteristic for spacetime is the most important thing in physics today.

According to SST, photons (they are the rotational energies of the Einstein spacetime (ES) components which are the neutrino-antineutrino pairs [2]) and rotating neutrinos produce around them discs in the Einstein spacetime – there is obligatory the Einstein formula $E = Mc^2$, where $E$ is the photon/neutrino energy (the rotational energy) and $M$ is the mass of photon/neutrino disc [3].

It is very difficult to detect the photon disc around free photon, even indirectly, because it looks as the ES with a little higher mass density than ES.

In the discs, when they interact with fermions, there are created the ES condensates which are the "black holes" in respect of the weak interactions i.e. on the surfaces of the ES

condensates, the ES components are moving on circular orbits. There are two types of such ES condensates: the nucleon condensates (their mass density is a little shifted: 1 part in 40,636 parts) and muon condensates (their mass density is shifted: 1 part in 195 parts) [2].

According to SST, inside the nuclear strong fields, the photons behave as gluons [2].

**2. Virtual objects**

SST shows that in fields can appear virtual objects. A virtual object consists of particle-antiparticle pairs or/and condensates carrying positive mass and of a gravitational "hole" in the Einstein spacetime, or other fields, which carries negative mass. Total mass of such a system is equal to zero [4]. On the other hand, to create an object with a mass of $M$ there must appear rotational energy $E$ (it is the pure energy i.e. it does not gravitate) and $M = E/c^2$. We can see that total involved mass/energy is $M + E = 2E$. According to SST, such maximum energy can have the created virtual pairs so the biggest negative mass of the "hole" can be: $-2M$.

**3. Deflection of high-energy photons**

Photon carrying energy $E$ creates disc with a mass of $M = E/c^2$. Such a disc can create a virtual pairs with a maximum total mass $+2M$ and "hole" with a negative mass $-2M$. The "hole" and the pairs are produced in the photon disc but the virtual pairs annihilate each to two photons that are emitted by the system composed of the initial photon, photon disc and the "hole" in the photon disc. But the emitted photons are entangled with the initial photon and they produce photon discs too. It leads to conclusion that inertial mass of whole system is invariant and is $M_{inertial} = +M$ whereas minimum value of the local gravitational mass near the initial photon is $M_{gravitational,local,minimum} = +M + (-2M) = -M$.

According to GR, for a light grazing surface of a body, the total deflection angle is

$$\varphi_{GR} = 4\, G\, M_o / (c^2\, R)\,, \tag{1}$$

where $G$ is the gravitational constant, $c$ is the speed of light in "vacuum" and $M_o$ and $R$ are respectively the mass and radius of the body. We obtain such formula because of validity of the Principle of Equivalence (PE).

But SST shows that PE, due to the quantum phenomena in the photon discs, is locally "broken" for high-energy photons because there are produced the virtual objects. The above remarks lead to following formula for the total deflection angle

$$\varphi_{SST} = (M_{gravitational,local} / M_{inertial})\, 4\, G\, M_o / (c^2\, R)\,. \tag{2}$$

For low-energy photons interacting with matter or free photons (then the photon discs do not produce virtual objects) is $M_{gravitational,local} = M_{inertial}$ so the GR formula (1) is valid. For high-energy photons interacting with matter (then the photon discs produce virtual objects) is

$$-1 \le M_{gravitational,local} / M_{inertial} \le 1\,. \tag{3}$$

Mean value is

$$M_{gravitational,local} / M_{inertial} \approx 0\,, \tag{4}$$

so the total deflection angle for photons with energy higher than some threshold energy should be close to zero i.e. absolute value should be much lower than it follows from the GR formula.

**4. The threshold energy**

The photon disc is built of the ES components. When such disc interacts with matter there appear the nucleon condensates and muon condensates [3]. Such condensates interact with matter due to the weak interactions. The coupling constant for the weak interactions of the nucleon condensate is $\alpha_{w(proton)} = 0.0187228615$ whereas the coupling constant for the weak interactions of the muon condensate is $\alpha_{w(electron\text{-}muon)} = 9.511082 \cdot 10^{-7}$ [2]. The threshold energy is for the electron-positron pairs interacting with matter via the nucleon condensates. It means that the threshold energy should be (or even lower)

$$[(m_{electron} + m_{positron}) / 2] \, \alpha_{w(proton)} / \alpha_{w(electron\text{-}muon)} = 10.0 \text{ GeV} . \quad (5)$$

The factor 2 is because the maximum mass of the created pairs is two times higher than the photon energy.

**5. Summary**

In experiments, in which we are slowing down high-energy photons, the photon discs interact virtually in a quantum way with the medium in which the photons propagate. The virtual interactions decrease mass density of the photon disc. Such interactions do not change inertial mass of the system but they decrease the local gravitational mass so the Principle of Equivalence is locally "broken". It decreases deflection angle to about zero for photon energy higher than the threshold energy (it can be negative as well but absolute value should be much lower than it follows from GR). This result is consistent with experimental data [5].

Here we showed that general relativity describes correctly the bending of high-energy photons by masses when the weak interactions of the photon discs with matter are eliminated.

**References**

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