The Universe of photons: a provocation?

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Abstract

Considering the presence of the cosmic *background radiation*, using the density of 400 photons per cm^3, it is imagined that it is possible that a high-energy photon collides with a photon in the *microwave background*, giving rise to a mass that, on a large scale, produces effects gravitational. Taking into account the average density of dark matter (e.g. in the Milky Way), the order of magnitude of the collisions that can guarantee the formation of a photon-photon collision mass (with gravitational effects) is evaluated. This eventuality is an alternative idea to dark matter. In addition to the Milky Way, we consider the galaxy M31 as an example.

Keywords: dark matter, visible matter, galaxy, photon-photon collision

1. Introduction

Fermi's problems (1901 - 1954) on numerical estimates are well known: this short work can be framed as a similar exercise, a numerical estimate. Taking into account the density of photons per cubic centimeter equal to $\delta_F \sim 400 / cm^3$ we try to hypothesize the following:

a) the galaxy (or the considered system) is permeated by *cosmic background radiation* with a density of 400 photons per cm^3;

b) we consider the high-energy photon collision with a photon of the microwave background that gives rise to a mass (with large-scale gravitational effects);

c) the galaxy (or the considered system) occupies a spatial volume $V \sim r^3$ with r the typical size of the considered system.

2. Dark matter density and photon-photon collision.

From the literature **[1]**, **[2]** we use the value for the average density of dark matter present in the Milky Way equal to $\delta_{MO} \sim 0.4\ GeV/cm^3$ to estimate how many collisions (order of magnitude) can occur in order to obtain a mass capable of generating large-scale gravitational effects, mass created by the photon-photon collision
We schematize the photon-photon collision in the following way:

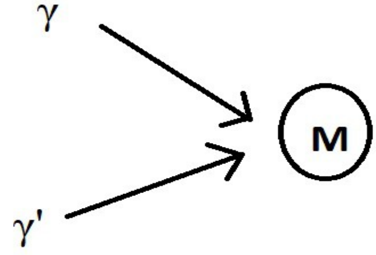

Fig. 1: photon-photon collision that generates mass

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It should be noted that previous studies **[3]** show that the *microwave background* is a practically transparent medium for the most energetic photons, however we want to imagine that some collision is possible. Imagine that a collision could occur between a photon in the gamma ray field and a photon in the microwave field. Through the relativistic kinematic study of the collision, it is possible to estimate the order of magnitude of the mass created as

$$M \approx \frac{E_\gamma}{c^2}$$

where Eγ is the energy of the most energetic photon (imagined in the frequency of gamma rays); so

$$M \approx \frac{E_\gamma}{c^2} \approx \frac{h\nu}{c^2} \approx \frac{6{,}6 \cdot 10^{-34} \cdot 10^{24}}{9 \cdot 10^{16}} kg \approx 10^{-26} kg$$

where the order of magnitude of 10^{24} *Hz* was used for the frequency of the energetic photon.
Let's consider the average density of dark matter in the Milky Way

$$\delta_{MO} \simeq 0{,}4 \frac{GeV}{cm^3} \approx 6{,}4 \cdot 10^{-11} \frac{J}{cm^3}$$

which corresponds to a mass (per cm^3) equal to

$$\delta_{MO} \approx \frac{6{,}4 \cdot 10^{-11} \frac{J}{cm^3}}{9 \cdot 10^{16} \frac{m^2}{s^2}} \approx 10^{-27} \frac{kg}{cm^3}$$

What is the order of magnitude of the photon-photon collisions that can generate a mass density of dark matter like the one obtained? Let's calculate the *N* parameter with the following:

$$N \cdot \delta_F \cdot M \approx \delta_{MO}$$

with the meaning of the symbols used up to now; we get

$$N \cdot 4 \cdot 10^2 \frac{1}{cm^3} \cdot 10^{-26} kg \approx 10^{-27} \frac{kg}{cm^3} \quad \text{from which} \quad N \simeq 10^{-3}$$

This means that of the 400 photons per cm^3 that correspond to the *background radiation* in the microwaves, only a very small part interacts with the more energetic photons, from whose collision an amount of mass is generated that we imagine has large-scale gravitational effects. *The numerical estimate carried out by order of magnitude* indicates that of the population per cm^3 only ("*almost*") a low-energy photon interacts and the microwave photon gas maintains transparency to the most energetic photons as is known in the literature **[3]**.
From the operations carried out so far, let us suppose to consider the following points:

a) it is imagined that a photon-photon collision can occur with a frequency such as to guarantee the microwave photon gas to be practically transparent to the more energetic photons;

b) when the impact occurs it produces a mass whose order of magnitude is 10^{-26} *kg*.

The question we ask ourselves is the following: is it possible that the mass produced by the photon-photon collisions that we are imagining could have, on a large scale, gravitational effects such as to become that missing mass which in the dynamic models of cosmological structures takes the name of *matter dark*?

3. Other galaxies

The galaxy M31 **[4]** has a mass (including the dark component) equal to 10^{12} *solar masses*. We use the previous estimate according to which in every cubic centimeter there is a collision that produces a mass of 10^{-26} *kg* and we try to derive the total mass of the galaxy M31 (M_{Tot} order of magnitude). The typical size (radius) of the galaxy is of the order of 10^5 *light years* and, estimating the volume of the galaxy as r^3, we find an order of magnitude of the volume equal to 10^{63} m^3 (one light year equal to 10^{13} *km*). A mass of 10^{-26} kg/cm^3 corresponds to 10^{-20} kg/m^3.
We estimate the total mass of the galaxy M31 as:

$$M_{Tot} \approx 10^{-20} \frac{kg}{m^3} \cdot 10^{63} m^3 \approx 10^{43} kg$$

which corresponds to 10^{13} *solar masses*.
The order of magnitude of the galaxy M31 obtained with the photon universe model is consistent with the rigorous estimate **[4]**.

4. Conclusion

In our Fermi exercise we tried to estimate the total mass of a galaxy (visible and "dark" component) through the idea that a high-energy photon may occasionally collide with a photon in the *microwave background* giving rise to a mass which, on a large scale, may have macroscopic gravitational effects.

Bibliography.

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