Universe of Photons and Dark Matter

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Abstract

An alternative hypothesis to the dark matter theory is analysed, using the Photon Universe model to give an explanation to the "missing gap" phenomenon in the rotation curves of some galaxies.

Keywords: dark matter, visible matter, photon-photon collision probability, Photon Universe model, galaxy, missing mass, rotation curve, MOND, High Energy Astrophysics.

1. Introduction

The phenomenon of "missing mass" in the study of the rotation curves of some galaxies has fascinated the scientific community for a long time (**[1]**, **[2]**, **[3]**) and attempts to explain its origin see, to date, the same scientific community divided into at least two large blocks: some scientists support the theory of Dark Matter (and Dark Energy), **[4]**, and other scientists lean towards the model that revises the Newtonian theory, modifying it (MOND), **[5]**. Within the large scientific community there seems to be a sort of battle between two contenders, waiting to find out which of the two protagonists will inevitably get the better of the other. However, the scientific community itself is faced with increasingly clear evidence that neither of the two theories finds definitive experimental confirmation and skepticism, after much research, is starting to be more evident **[6]**.

The author of the present work believes that both perspectives (Dark Matter and MOND) do not represent a correct way to resolve the enigma of rotation curves (and other phenomena observable in the Universe): the characteristics of Dark Matter, so elusive, recall those of the ether of nineteenth-century memory, just as the need to modify the Newtonian theory with the *ad hoc* introduction of a parameter is not convincing, **[5]**.

It is believed that the resolution of the problem can occur with a total change of perspective: for this reason we have tried to propose some reflections, as a simple exercise by Fermi (1901-1954), with the sole purpose of trying to observe the problem from a another point of view. Through previous works (**[7]**, **[8]**, **[9]**, **[10]**, **[11]**, **[12]**), with the sole aid of numerical estimates, an attempt was made to change perspective, focusing on the pay attention to the fact that the Universe is a unique physics laboratory where many phenomena can be normal despite the experimental difficulties observable on Earth in recreating some conditions.

As already observed, **[12]**, "through the use of the Photon Universe model it was proved:

(a) to theoretically estimate the total mass (visible and hidden) of a galaxy **[7]**, **[12]**;
(b) to estimate the total mass of the observable universe **[8]**;
(c) to estimate the value of the Limit Radius of a galaxy **[9]**;
(d) to predict the trend of the rotation curve **[10]**;
(e) to derive, theoretically, the value of the parameter a_0 introduced *ad hoc* in the MOND model, **[11]**.

All estimates obtained fall within the values currently known in the literature.

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What we have presented, as already observed **[11]**, is an "interpretive model of the rotation curves of galaxies which highlight the problem of the "hidden mass" (**[1]**, **[2]**, **[3]**) such that:

(i) it does not modify the Newtonian law of motion (contrary to the MOND theory);

(ii) does not use an unknown phenomenology (or particle) as the source of the "hidden mass" (or energy) but hypothesizes photon-photon photoproduction (contrary to the theory of dark matter)".

This work aims to highlight, through numerical estimates, how it is possible to reflect on the phenomenon of photon-photon photoproduction with the creation of mass (energy) with large-scale gravitational effects: we are aware that this phenomenon is of a statistical nature and the simplifications that follow do not claim to be exact results but, as already indicated, we want to try to propose an alternative in the scientific panorama regarding the study of the enigma of rotation curves.

2. Probability of the photoproduction phenomenon

In the scientific literature, the study of photon-photon photoproduction has been studied by several scientists who, aware of the experimental difficulties, have focused their attention on the "Universe laboratory".

Let us recall the pioneering study by Nikishov (1962), **[13]**, who calculated the probability that a photon with energy $(10^{11}<E_1<10^{13})$ eV collides with a photon from the CBMR background; so Jelley (1966), **[14]**, calculated the probability that a photon with energy $(10^{14}<E_1<10^{18})$ eV collides with a photon from the CBMR background generating mass: this range of energy values of the incident photon is precisely what allows for the best conditions for the creation of mass by the Breit-Wheeler effect with photons targeting the photons from the CBMR background (**[12]**, **[22]**). Other studies have explored the same issue (**[15]**, **[16]**, **[17]**, **[18]**, **[19]**, **[20]**, **[21]**).

As already observed in the previous work **[12]**, the rigorous study of photon-photon photoproduction leads to the observation that if the target photon is in the infrared (0.1 eV) the projectile photon must have at least an energy of 10 TeV; with target photons of the CMBR background (10^{-3} eV) pair production becomes possible when the projectile photon has an energy of the order of 10^{15} eV, **[22]**.

We now introduce the simplified model to study the phenomenon through numerical estimation:

(i) the galaxy is imagined as a sphere of radius RG;

(ii) the source of high-energy photons is located at the center of the galaxy and there is no preferred direction for the propagation of high-energy photons in the galactic volume;

(iii) the entire galactic volume is permeated by the CBMR background whose density, δ_{CBM}, is assumed to be of approximately 400 photons per cm^3;

(iv) the probability for having photon-photon photoproduction for high-energy photons in the range $(10^{14}<E_1<10^{18})$ eV with background photons CBMR, **[14]**, has a maximum peak for $(10^{15}<E_1<10^{16})$ eV and it's worth it $P_{MAX}\sim 10^{-20}\, 1/m$ thus being able to write $P(r)\sim P_{MAX}\cdot r$ (with r distance from the galactic center).

The probability of interaction increases with increasing distance from the galactic center (in the simplified physical model) and the expected consequences are the following:

(a) the mass halo with large-scale gravitational effects, created by photoproduction, increases with increasing distance from the galactic center;

(b) it is expected that near the galactic center there may be a halo of matter created as a result of photoproduction of smaller dimensions compared to the halo of matter produced by photoproduction which is generated at greater distances from the galactic center where, at distances of approximately 10^{20} meters, the phenomenon becomes highly probable.

Photoproduction is more efficient for increasing distances, *r*, with respect to the galactic center: it is

emphasized once again, however, that this phenomenon is statistical.
Below we will develop the following points:

- action of the photoproduction phenomenon;
- estimate of the average mass generated as a result of photoproduction in a galaxy;
- asymptotic trend of the rotation speed of the stars within the mass halo created by photoproduction for distances greater than 10^{20} meters.

2a. Action of the photoproduction phenomenon.

The phenomenon of photoproduction is a quantum phenomenon whose action is comparable with the fundamental quantum of action, Planck's constant.
Taking into account the energies of the incident photons $E \sim \sqrt{E_1 \cdot E_2}$ you can write:

$$A \sim E \cdot \tau \sim h$$

where τ characteristic time interval of the phenomenon, where $E_1 \sim 10^{15}$ eV and $E_2 \sim 10^{-3}$ eV.
By substituting the known values a characteristic time interval is obtained:

$$\tau \sim \frac{h}{\sqrt{E_1 \cdot E_2}} \sim 10^{-21}\, s$$

2b. Estimate of the average mass generated as a result of photoproduction in a galaxy.

In order to estimate the average total mass produced in the galactic volume as a result of photon-photon photoproduction which is imagined to have large-scale gravitational effects, we write the following:

$$\overline{M} \sim \sqrt{\frac{E_1 \cdot E_2}{c^4}} \cdot P_{MAX} \cdot \delta_{CBM} \cdot (R_G)^4$$

which, with the known values, leads to an estimate for the order of magnitude of the mass generated equal to approximately 10^{12} *Solar Masses*. This value is averaged over the entire volume but the photoproduction phenomenon, as we have already underlined, has a probability that increases with the distance from the galactic center.
This value is for the Milky Way, for example, of the same order of magnitude relative to the real total mass of the entire galaxy (visible component and missing component).

2c. Asymptotic trend of the rotation speed of the stars inside the halo of mass created by photoproduction for distances greater than 10^{20} meters.

We have introduced elsewhere **[10]** the simplified form of the rotation curve of a galaxy in which the term linked to the mass produced by photoproduction appears. For distances from the galactic center greater than 10^{20} meters, the photoproduction phenomenon has a high probability of occurring and, at such distances, the asymptotic trend of the rotation speed, V_L, is equal to:

$$V_L > \sqrt{G \cdot \sqrt{\frac{E_1 \cdot E_2}{c^4}} \cdot P_{MAX} \cdot \delta_{CBM} \cdot (R_G)^3}$$

where G is the universal gravitational constant. The order of magnitude of the asymptotic velocity leads to values greater than 10^4 *m/s*.

3. Conclusions.

The aim of the following work, in continuity with the previous ones, is to offer a reflection on a different way of thinking about the solution to the enigma of the missing mass in the rotation curves of some galaxies. Photon-photon photoproduction can also explain why in some areas of the Universe there are "dark" masses that create slow gravitational effects: in some areas, probably, the photoproduction phenomenon could have occurred with a high probability, because they were far from sources of high energy photons, which photons interacting with the CBMR background can give rise, in the Universe, to halo islands of matter generated as a result of photoproduction; matter that, on a large scale, can have gravitational effects.

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