On the rotation curve of galaxies

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Abstract

Using the model of the universe of photons, as an alternative to the models of the "missing mass" (dark matter, MOND, etc.), a possible interpretation of the rotation curve of galaxies is presented by introducing two parameters: the critical mass and the limit radius for a galaxy.

Keywords: dark matter, visible matter, photon-photon collision, universe model photons, galaxy, missing mass, rotation curve, Breit-Wheeler.

1. Introduction.

The mystery of the rotation curves of galaxies is known (**[1]**, **[2]**): the unknown phenomenology has led in the past years to different models for their interpretation. In this work, which must be understood as a Fermi exercise (1901-1954), we want to try to use the photon universe model introduced in the previous works (**[3]**,**[4]**) to propose an interpretation of the rotation curves .

The phenomenon of annihilation of photons produces a mass per cubic centimeter of the order of magnitude of 10^{-26} *kg* (Breit-Wheeler or similar): in the photon universe model it is imagined that on a large scale the creation of mass has gravitational effects (**[3]**, **[4]**).

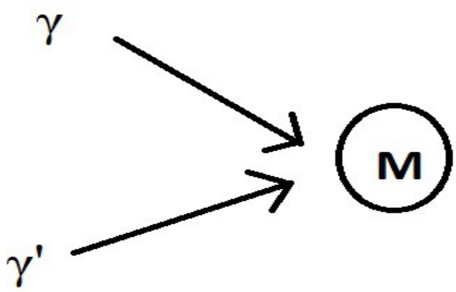

Fig. 1: photon-photon collision that generates mass **[3]**.

We introduce the function that describes the growth rate of mass by annihilation in spherical symmetry as a dependence on the distance from the galactic center, $M_{BW}(r)$:

$$M_{BW}(r) \sim \delta_{BW} \cdot r^3$$

where

- δ_{BW} is the mass per cubic centimeter produced by the single annihilation phenomenon and which has an order of magnitude equal to 10^{-26} kg/cm^3;
- r is the distance from the galactic center in spherical symmetry.

The mathematical relationship just introduced allows us to evaluate the order of magnitude of the mass produced by photon-photon annihilation; fixed a value of the distance from the galactic center it is possible to have an order of magnitude of the mass produced by annihilation (Breit-Wheeler or similar) *within* the considered volume.

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We now introduce two concepts that will be useful to us in the exposition of the following work:

definition 1: **Critical Mass of a galaxy**
defines itself as the "Critical Mass of a galaxy", M_{BWC}, *the value of the mass (kilograms) generated by the phenomenon of annihilation of photons, in a certain volume, with which the value of the total visible mass of a galaxy is equal,* M_{VIS} (the total visible mass is intended as the quantity that can be experimentally measured and assimilated only to the visible matter of the entire galaxy);

definition 2: **Limit Radius of a galaxy**
defines itself as the "Limit Radius of a galaxy", R^L, *the distance from the galactic center for which the mass created by the annihilation of photons is equal to the total visible mass of a galaxy*, $M_{BWC} \sim M_{BW}(r{=}R^L)$.

2. Rotation curve of galaxies.

Applying the mathematical relationship $M_{BW}(r) \sim \delta_{BW} \cdot r^3$ to the Solar System we arrive at a quantity of matter created by annihilation that can produce measurable effects: just as there are some similar attempts in the literature that use the concept of dark matter **[5]**. However, as we consider the "galaxy structure", the value of the mass produced by annihilation of photons increases.
The interpretation of the rotation curve of the galaxies that open up to the "missing mass" problem is set out below:

in the rotation curves that introduce the "missing mass" model it is possible to note, starting from a certain distance from the galactic center (which we indicate with R_0), a non-Keplerian behavior (the curve tends to reach a constant value of the rotation speed). We suppose that the value of the distance from the galactic center from which there is no longer a Keplerian behavior is the limit radius of a galaxy, i.e. *as the distance from the galactic center and therefore the volume considered increases, the value of the mass produced by photonic annihilation increases*; *it is assumed that at a certain distance from the galactic center, denoted by $r = R^L$, a critical value of the mass created is reached, denoted by M_{BWC}, which is able to equal the total value of the visible mass of a galaxy*. In our photon universe model, the R_0 value that can be experimentally obtained from the rotation curves is identified by us with the limit radius of a galaxy (definition 2).

Experimentally **[6]** the order of magnitude of the R_0 value is approximately[2] $10^{20}m$; let's try to use the hypothesis of the interpretation of the rotation curve exposed to estimate the order of magnitude of R_0 which in our model is the limit radius, R^L.
For example in the galaxy NGC 3198 **[7]** we know that:
- the total visible mass is of the order of magnitude of $M_{VIS} \sim 10^{40}$ *kg* (approximately equal to about 10^{10} solar masses);
- the distance from the galactic center from which the non-Keplerian behavior begins, which can be obtained experimentally, is approximately $R_0 \sim 10$ *kpc* $\sim 10^{20}m$.

Let's try to derive the experimentally observable R_0 value from the rotation curve using the photon universe model (R_0 interpretable as R^L). We then obtain the value of the limit radius of the galaxy NGC 3198 using the data in our possession and verify if it is of the same order of magnitude as the R_0 value:

$$R^L \sim \sqrt[3]{\frac{M_{VIS}}{\delta_{BW}}} \sim \sqrt[3]{\frac{10^{40} kg}{10^{-20} kg/m^3}} \sim \sqrt[3]{10^{60} m^3} \sim 10^{20} m$$

2 In rotation curves, kpc is generally used as a measure of distance from the galactic center.

The order of magnitude of the limit radius (according to definition 2) is of the same order of magnitude as the R_0 parameter that can be obtained experimentally.

Let us now make the following observation: in our interpretation of the rotation curves of galaxies that show a "missing mass" to be understood, we imagine that the "missing mass" is the mass produced by photonic annihilation and that, on a large scale, this mass created can be used to explain the rotation curves. Experimentally **[8]** galaxies have been observed for which there is no "missing mass": we interpret this situation by imagining that for this type of galaxies the critical mass for which at least the total visible mass is at least equaled has not yet been reached . Once the critical value is exceeded, the mass created by photonic annihilation exceeds the value of the visible mass, generating the known behavior of the rotation curves. In the volume of the galaxy structure, the mass created by the annihilation of photons will eventually reach a value greater than the total visible mass consistent with the values of the estimated masses and associated, in other works, with the presence of dark matter (in a previous article **[3]** we used the photon universe model to calculate the total mass of the galaxy M31, a "missing" and visible component): the consequence is that the rotation curves will change over time.

3. Conclusions.

The creation of matter due to the photon-photon collision (Breit-Wheeler or similar), on a large scale, can be an alternative to the "missing mass" models: in this hypothesis we have tried to present an interpretation of the behavior of the rotation curves galaxies showing a "missing mass".

By introducing the concept of "limit radius" of a galaxy, we tried to derive the order of magnitude of the distance from the galactic center (in spherical symmetry) at which the non-Keplerian behavior begins.

The following work must also be considered as a Fermi exercise.

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