The Galaxies and the Dark Matter

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Abstract To understand the rotation of galaxies, the idea of the existence of dark matter was created. Through a better observation of reality, analyzing the distribution of matter, we conclude that this distribution is very close to that proportional to the radius cube, thus remembering the spherical distribution. With the appearance of the accretion disk, it retained a large part of the matter that gravitated the gravitational sphere of the galaxy, maintaining its distribution proportional to the cube of the radius, part of the total matter will be contained in the Accretion Disc and the rest will continue to gravitate to the galaxy. Given the large size of the galaxy, the latter may be practically printable given its dispersion in the total volume of the galaxy. We conclude that the idea of the existence of dark matter is not necessary to justify the rotation of the galaxy.

Keywords: universe, gravitation, potential, gravity, velocity, mass, physics, variable

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1. Introduction

1.1. Dark Matter Concept

In cosmology, dark matter is a speculative type of matter that interacts only gravitationally and, therefore, its presence can be inferred from gravitational effects on visible matter, such as galaxies. Although not directly observable, scientists believe that dark matter exists due to its consequences on gravitational effects, as visible matter moves and distributes itself in space, explaining the rotation curves of galaxies.

![Figure 1. Rotation curve of a typical spiral galaxy: predicted (A) and observed (B). Dark matter can explain the ‘flat’ appearance of the velocity curve out to a large radius. Dark matter - Wikipedia](image)

2. Study Method

2.1. Galactic structure analysis

Four arms were drawn, the outer arm in orange, the Scutum-Centaurus arm in yellow, the Sagittarius arm in blue and the Perseus arm in red.

We divided the plane of the galaxy into eight quadrants, 0.125 turns, to study the radius value of each arm between each quadrant.

We consider that there is a symmetry at the moment of the galaxy's initial creation and, therefore, we measure what the gravitational radius is for an initial exterior location and which gravitational radii for the locations located in multiple positions of +0.125 turn, that is, in the locations of n + 0.125, n + 0.25, n + 0.375, etc.

![Figure 2. Milk Way, Marking of arms and 8 quadrants from Milky Way - Wikipedia](image)
2.2. Motion Analysis

We take for granted the information that the Sun is 26000 ly (light years) from the center of the galaxy and that it has a rotation speed of 220,000 m·s⁻¹ within the galaxy. We were thus able to define the number of turns taken at each point in the galaxy.

For this purpose, we must not forget that the galaxy is expanding, "Ref. [2]", "Ref. [3]" and "Ref. [4]" and as such we should consider the average translation perimeter of the Sun, for calculations.

The average perimeter.
Being:

- \( L \) - Total distance traveled by the Sun in its translation movement.
- \( P_m \) - Average translation perimeter of the Sun.
- \( I \) - Age of the universe, 15 224 021 588 years, ["Ref. [4]"]
- \( V_{Sun} \) - Sun's translation speed.
- \( C \) - Speed of Light

\[
L = I \times 365.2564 \times 24 \times 3600 \times V_{Sun} \quad (1.2)
\]

\[
L = 1,05697 \times 10^23 \text{ m} \quad (2.2)
\]

\[
P_m = \frac{2 \times \pi \times 26000 \times 365.2564 \times 24 \times 3600 \times C}{2} \quad (3.2)
\]

\[
P_m = 7,72779 \times 10^{-20} \text{ m} \quad (4.2)
\]

\[
N^\circ \text{ Laps} = \frac{L}{P_m} = 136,7754488 \quad (5.2)
\]

### Table 1. Radius and nº of laps

| Orange | Radius (ly) | Nº of laps |
|--------|-------------|------------|
| 62 570 | n           | 0,125      |
| 55 880 | n           | 0,125      |
| 45 960 | n           | 0,125      |
| 40 510 | n           | 0,125      |
| 34 230 | n           | 0,125      |
| 29 000 | n           | 0,125      |
| 22 930 | n           | 0,125      |
| 19 750 | n           | 0,125      |
| 14 960 | n           | 0,125      |
| 12 390 | N+1,125     |            |

### Table 2. Radius, Average Perimeter and Rotation Velocity (E->10^4)

| Blue | Radius (ly) | Nº of laps |
|------|-------------|------------|
| 50 570 | n           | 0,125      |
| 42 730 | n           | 0,125      |
| 35 520 | n           | 0,125      |
| 29 800 | n           | 0,125      |
| 25 600 | n           | 0,125      |
| 21 200 | n           | 0,125      |
| 17 550 | n           | 0,125      |
| 13 890 | n           | 0,125      |
| 10 940 | N+1,125     |            |

### Table 3. Radius, Travelled distance, nº of laps and Mass (E->10^4)

| Red  | Radius (ly) | Nº of laps |
|------|-------------|------------|
| 50 000 | n           | 0,125      |
| 45 900 | n           | 0,125      |
| 39 900 | n           | 0,125      |
| 30 420 | n           | 0,125      |
| 25 810 | n           | 0,125      |
| 20 230 | n           | 0,125      |
| 17 450 | n           | 0,125      |
| 15 090 | n           | 0,125      |
| 10 000 | N+1,125     |            |

It can be seen that the masses located at the same distance from the center of the Galaxy made about the same number of turns. So we can consider the largest radius in which matter is, 62570 ly and make the calculations for every tenth of that radius.

For this purpose, we must not forget that the galaxy is expanding, "Ref. [2]", "Ref. [3]", "Ref. [4]" and as such we should consider the average translation perimeter of the Sun, for calculations.
2.3. Analysis of the Quantity of Matter and Its Distribution

![Figure 3](Image)

Figure 3. Speed measured from the Solar System (Blue), speed calculated based on the visible masses (orange). Milky Way - Wikipedia

For the calculation of the material necessary to bring about the balance of the previous table, we will consider that only the material inside the calculation radius participates in the calculation of its potential.

\[ M = \frac{R V_{\text{Sun}}^2}{G} \]  

(6.2)

When considering the measured masses, from Figure 3, we will have an external speed of 183000 m/s for a radius of 51500 ly which will imply a quantity of matter of $2.445 \times 10^{41}$ Kg.

If we take into account the speeds measured by man, from Figure 3, we will have a speed of 238000 m/s, for a radius of 51800 ly which will imply a quantity of matter of $4.159 \times 10^{41}$ Kg.

As we see the calculation we did, it gives us a quantity of matter of $2.509 \times 10^{42}$ kg for a speed of 531867 m/s in a radius of 62,570 ly, which is 5 and 10 times more than we imagined.

Thus, most of the matter continues to gravitate out of the Accretion Disc.

The distribution of matter necessary to obtain the results we can see, is practically a density of constant, in volume proportion, distributed in the Accretion Disc. There is a variation in density from the periphery to the central zone of +1.90%.

This distribution did not seem unreal to us because the galaxy, before presenting a significant accretion disk, started like all other structures in its spherical shape and the accretion disk captured much of the matter in the respective gravity ray, that is, it maintained the position now associated with the accretion disk. The existence of Dark Matter does not seem necessary to explain the movement in galaxies.

Perhaps some feel that there is a flaw in the number of stars in the periphery, but if we take into account that considering 5 ly of the disk thickness, we can have between a maximum density around $6.9126 \times 10^{-17}$kgm\(^{-3}\) and a minimum of less than $4.7441 \times 10^{-18}$kgm\(^{-3}\). If we discount the star material then this density drops significantly. As the largest amount of this gas will undoubtedly be hydrogen and helium, they would be very dispersed. Much of that gas and others elements, will continue to belong to the initial spherical surface. If the material is hydrogen, we would have a maximum part in volume of $6.014 \times 10^{-25}$. In the case of being helium we would have a maximum part in volume of $9.797 \times 10^{-26}$, which seems to be undetectable.

Today it is news that the solar system is going through material from a supernova and in reality nothing tells us that it is not residual material that gravitates our galaxy.

2.4. Values Measured from the Solar System.

The values measured from the Solar System regarding the rotation of the galaxy are apparently at odds with the proposal previously made.

2.4.1. Regarding Speeds

Let us now analyze these measured values from Figure 3.

| Radius (al) | Speed (m/s) | Apparent speed (m/s) | Theoretical speed (m/s) |
|-------------|-------------|----------------------|------------------------|
| 1.496       | 250 000     |                      |                        |
| 6.157       | 205 900     |                      |                        |
| 8.557       | 196 070     |                      |                        |
| 10.393      | 199 150     |                      |                        |
| 13.002      | 213 680     |                      |                        |
| 17.598      | 225 310     |                      |                        |
| 22.397      | 227 070     |                      |                        |
| 26.000      | 221 550     |                      |                        |
| 30.455      | 209 760     |                      |                        |
| 40.011      | 233 570     |                      |                        |
| 46.104      | 237 190     |                      |                        |
| 51.747      | 237 820     |                      |                        |

What will be equivalent for the radius considered previously to:

| Radius (al) | Speed (m/s) |
|-------------|-------------|
| 6.257       | 205 492     |
| 12.514      | 210 963     |
| 18.771      | 214 110     |
| 25.028      | 224 044     |
| 31.285      | 211 828     |
| 37.542      | 227 418     |
| 43.799      | 235 821     |
| 50.056      | 237 631     |
| 56.313      | 238 330     |

Let us compare the two speeds obtained, the apparent measured from the Solar System, the theoretical and the differential between them.

| Radius (al) | Apparent speed (m/s) | Theoretical speed (m/s) | Differential Speeds (m/s) |
|-------------|----------------------|------------------------|--------------------------|
| 6.257       | 205 492              | 53 313                 | 152 179                  |
| 12.514      | 210 963              | 106 394                | 104 569                  |
| 18.771      | 214 110              | 159 244                | 54 866                   |
| 25.028      | 224 044              | 221 862                | 12 182                   |
| 31.285      | 211 828              | 264 249                | -52 421                  |
| 37.542      | 227 418              | 316 40                 | -88 986                  |
| 43.799      | 235 821              | 368 328                | -132 507                 |
| 50.056      | 237 631              | 420 020                | -182 388                 |
| 56.313      | 238 330              | 471 480                | -233 150                 |
Let see its graphic representation.

Figure 4. Radius, V Apparent Med, V theoretical and differential centered on the Solar System.

Now, we see that the Solar System rotates about itself in the same direction as the Milky Way.

Discounting the translation speed of the solar system, we will have:

Table 8. Differential of speeds and respective rotation

| Radius  | Diff. Theor. Vel. | Diff. Theor. Vel. | Difference |
|---------|------------------|------------------|------------|
|         | m/s              | m/s              | m/s        |
| -14 508 | -166 687         | 152 179          |
| -9 037  | -113 606         | 104 569          |
| -5 890  | -60 756          | 54 866           |
| 4 044   | -8 138           | 12 182           |
| -8 172  | 44 249           | -52 421          |
| 7 418   | 96 404           | -88 986          |
| 15 821  | 148 328          | -132 507         |
| 17 631  | 200 020          | -182 388         |
| 18 330  | 251 480          | -233 130         |
| Rotation (m/s/ly) | 0.73485 | 8.44285 | -7.708 |

Let’s see its graphic representation.

Figure 5. Radius, V Apparent Med, V theoretical and differential centered on the Solar System.

As it turns out, Milk Way has an apparent rotation of 0.73485 m s^{-1} ly, theoretical of 8.44285 m s^{-1} ly, t follows that the solar system has a same rotation to the Milk Way of more 7.7080 m s^{-1} ly. This rotation is what causes the discrepancy between measured and actual values.

3. Verification, Pinwheel Galaxy

We are going to look at another galaxy in order to verify if the theory pointed out is verifiable in other galaxies with Accretion Discs and arms.

For this purpose, we chose the Pinwheel galaxy, with a diameter of 170000 ly.

Pinwheel Galaxy has a rotation speed of 241000 m / s on its periphery

Figure 6. Pinwheel Galaxy, Marking of arms and 8quadrants

Table 9. Radius and number of laps

| Green    | Radius | Laps          |
|----------|--------|---------------|
|          | 29 530 | n0+0.375      |
|          | 47 770 | n0+0.250      |
|          | 67 830 | n0+0.125      |
|          | 85 000 | n0            |
| Yellow   | Radius | Laps          |
|          | 20 340 | n1+0.75       |
|          | 24 660 | n1+0.625      |
|          | 29 560 | n1+0.500      |
|          | 34 530 | n1+0.375      |
|          | 39 450 | n1+0.250      |
|          | 43 830 | n1+0.125      |
|          | 49 200 | n1            |
|          | n1=n0+0.24109 |
| Red      | Radius | Laps          |
|          | 25 420 | n2+0.25       |
|          | 42 000 | n2+0.125      |
|          | 60 000 | n2            |
|          | n2+n0+0.17379 |
| Blue     | Radius | Laps          |
|          | 19720  | n3+0.375      |
|          | 24290  | n3+0.250      |
|          | 31410  | n3+0.125      |
|          | 38730  | n3            |
|          | n3+n0+0.43795 |
| Magenta  | Radius | Laps          |
|          | 12000  | n4+0.375      |
|          | 19720  | n4+0.250      |
|          | 32740  | n4+0.125      |
|          | 64370  | n4            |
3.1. Motion Analysis

We take for granted the information that it has a rotation speed of 241,000 m\(^{-1}\) at the outer edge of the galaxy. We were thus able to define the number of turns taken at each point in the galaxy.

For that purpose we must not forget that the galaxy is expanding, "Ref. [2]", "Ref. [3]", and "Ref. [4]" as such we should consider the average perimeter for the calculations.

Being:
- \(L\) - Total distance traveled by the stars at the outer edge of the galaxy.
- \(P_m\) - Average translation perimeter.
- \(I\) - Age of the universe 15,224,021,588 years.
- \(V_{Sun}\) - Speed of light.

\[L = I \times 365.2564 \times 24 \times 3600 \times V_{Sun}\]  
(1.3)

\[L = 1,1579 \times 10^6 + 23 \text{ m}\]  
(2.3)

\[P_m = \frac{2 \times \pi \times 85000 \times 365.2564 \times 24 \times 3600 \times C}{2}\]  
(3.3)

\[P_m = \frac{2,5264 \times 10^6 + 21 \text{ m}}{2}\]  
(4.3)

\[N^\circ \text{ laps} = \frac{L}{P_m} = 45,83075\]  
(5.3)

### Table 10. Radius, Average Perimeter and Rotation Velocity (E->10^6)

| Radius | Perimeter | Average Perim. | Velocity |
|--------|-----------|----------------|----------|
| ly     | m         | m              | m/s      |
| 8,500  | 5.0528E+20| 2,5264E+20     | 23 556  |
| 17,000 | 1.0106E+21| 5.0528E+20     | 47 232  |
| 25,500 | 1.5158E+21| 7.5792E+20     | 71 030  |
| 34,000 | 2.0211E+21| 1.0106E+21     | 94 948  |
| 42,500 | 2.5264E+21| 1.2624E+21     | 118 988 |
| 51,000 | 3.0317E+21| 1.5158E+21     | 143 148 |
| 59,500 | 3.5370E+21| 1.7685E+21     | 167 430 |
| 68,000 | 4.0422E+21| 2.0211E+21     | 191 832 |
| 76,500 | 4.5475E+21| 2.2738E+21     | 216 356 |
| 85,000 | 5.0528E+21| 2.5264E+21     | 241 000 |

3.2. Analysis of the Quantity of Matter and Its Distribution

Analysis of the quantity of matter and its distribution.

\[M = \frac{R \times V_{Sun}^2}{G}\]  
(6.3)

Once again we verify that the mass distribution is very close to the proportionality to the radius cube and that its density is practically constant throughout the radius. In this galaxy we find that this density decreases from the periphery to the center by -4.47%.

The distribution of matter necessary to obtain the results we can see, is practically a density of constant, in volume proportion, distributed in the Accretion Disc and all spherical gravitational field.

### Table 11. Radius, Travelled distance, n° of laps and Mass (E->10^6)

| Radius | Travelled dist. | Nº of laps | Mass |
|--------|-----------------|------------|------|
| ly     | n m             | Kg         |
| 8,500  | 1,1317E+22      | 44,7952    | 6,6856E+38 |
| 17,000 | 2,2692E+22      | 44,91055   | 5,3760E+39 |
| 25,500 | 3,4126E+22      | 45,02557   | 1,8237E+40 |
| 34,000 | 4,5617E+22      | 45,14060   | 3,4750E+40 |
| 42,500 | 5,7167E+22      | 45,25562   | 8,5290E+40 |
| 51,000 | 6,8774E+22      | 45,37065   | 1,4814E+41 |
| 59,500 | 8,0440E+22      | 45,48567   | 2,3644E+41 |
| 68,000 | 9,2164E+22      | 45,60070   | 3,5472E+41 |
| 76,500 | 1,0395E+23      | 45,71572   | 5,0761E+41 |
| 85,000 | 1,1579E+23      | 45,83075   | 6,9982E+41 |

### Table 12. Radius, Mass variation, Volume density, Density Accretion Disc with 5 ly thickness (E->10^6)

| Radius | Mass var. | M/(4/3πR^3) | M/(πR^2*(5ly)) |
|--------|-----------|-------------|----------------|----------------|
| ly     | kg        | Kg/m^3      | Kg/m^3         |
| 8,500  | 6,6856E+38| 3,0690E-22  | 3,4782E-18     |
| 17,000 | 4,7074E+39| 3,0848E-22  | 3,6922E-18     |
| 25,500 | 1,2861E+40| 3,1066E-22  | 1,0542E-17     |
| 34,000 | 2,5213E+40| 3,1165E-22  | 1,4128E-17     |
| 42,500 | 4,1846E+40| 3,1324E-22  | 1,7570E-17     |
| 51,000 | 6,2845E+40| 3,1483E-22  | 2,1408E-17     |
| 59,500 | 8,8296E+40| 3,1643E-22  | 2,5103E-17     |
| 68,000 | 1,1828E+41| 3,1803E-22  | 2,8835E-17     |
| 76,500 | 1,5289E+41| 3,1964E-22  | 3,2603E-17     |
| 85,000 | 1,9221E+41| 3,2125E-22  | 3,6408E-17     |

### References

[1] José Luis Pereira Rebelo Fernandes, The Relativity of the Time with the Universal Density of Potential Energy at Different Stationary Reference Frames, International Journal of Physics. 2020, 8(1), 11-13.

[2] José Luis Pereira Rebelo Fernandes, The Universal Gravitational Variable, International Journal of Physics. 2020, 8(1), 35-38.

[3] José Luis Pereira Rebelo Fernandes, The Real Removal of the Moon from the Earth. The Age of the Universe, International Journal of Physics. 2020, 8(3), 114-119.

[4] José Luis Pereira Rebelo Fernandes, The Variation of the Atomic Radius with the Universal Density of Potential Energy, International Journal of Physics. 2020, 8(4), 127-133.

[5] Boehle, A.; Ghez, A. M.; Schödel, R.; Meyer, L.; Yelda, S.; Albers, S.; Martínez, G. D.; Becklin, E. E.; Do, T.; Lu, J. R.; Matthews, K.; Morris, M. R.; Sitarski, B.; Witze, G. (October 3, 2016). “An Improved Distance and Mass Estimate for SGR A* from a Multistar Orbit Analysis” (PDF). The Astrophysical Journal. 830 (1): 17.

[6] David Freeman (May 25, 2018). “The Milky Way galaxy may be much bigger than we thought” (Press release). CNBC. Archived from the original on August 13, 2018. Retrieved August 13, 2018.

[7] Staff (July 27, 2017). “Milky Way's origins are not what they seem”. Phys.org. Archived from the original on July 27, 2017. Retrieved July 27, 2017.

[8] Yin, J.; Hou, J.L; Prantzos, N.; Boissier, S.; et al. (2009). “Milky Way versus Andromeda: a tale of two disks”. Astronomy and Astrophysics. 505 (2): 497-508.

[9] Gillessen, Stefan; Plewa, Philipp; Eisenhauer, Frank; Sari, Re'em; Waisberg, Idel; Habibi, Maryam; Pfuhl, Oliver; George, Elizabeth; Dexter, Jason; von Fellenberg, Sebastiano; Ott, Thomas; Genzel,
Reinhard (November 28, 2016). “An Update on Monitoring Stellar Orbits in the Galactic Center”. The Astrophysical Journal. 837 (1): 30.

[10] Croswell, Ken (March 23, 2020). “Astronomers have found the edge of the Milky Way at last”. ScienceNews. Archived from the original on March 24, 2020. Retrieved March 27, 2020.

[11] Taylor, J.H., “Binary Pulsars and Relativistic Gravity”, Rev. Mod. Phys., 66, 711-719, (1994).

[12] Shappee, Benjamin; Stanek, Kris (June 2011). “A New Cepheid Distance to the Giant Spiral M101 Based on Image Subtraction of Hubble Space Telescope/Advanced Camera for Surveys Observations”. Astrophysical Journal. 733 (2): 124.

[13] Armando, Gil de Paz; Boissier; Madore; Seibert; et al. (2007). “The GALEX Ultraviolet Atlas of Nearby Galaxies”. Astrophysical Journal Supplement. 173 (2): 185-255.

[14] Francis, Matthew (22 March 2013). “First Planck results: the Universe is still weird and interesting”. Ars Technica.

[15] Kuijken, K.; Gilmore, G. (July 1989). “The Mass Distribution in the Galactic Disc - Part III - the Local Volume Mass Density” (PDF). Monthly Notices of the Royal Astronomical Society. 239 (2): 651-664.

[16] Babcock, Horace W. (1939). “The rotation of the Andromeda Nebula”. Lick Observatory Bulletin. 19: 41-51.

[17] Stonebraker, Alan (3 January 2014). “Synopsis: Dark-Matter Wind Sways through the Seasons”. Physics - Synopses. American Physical Society.

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