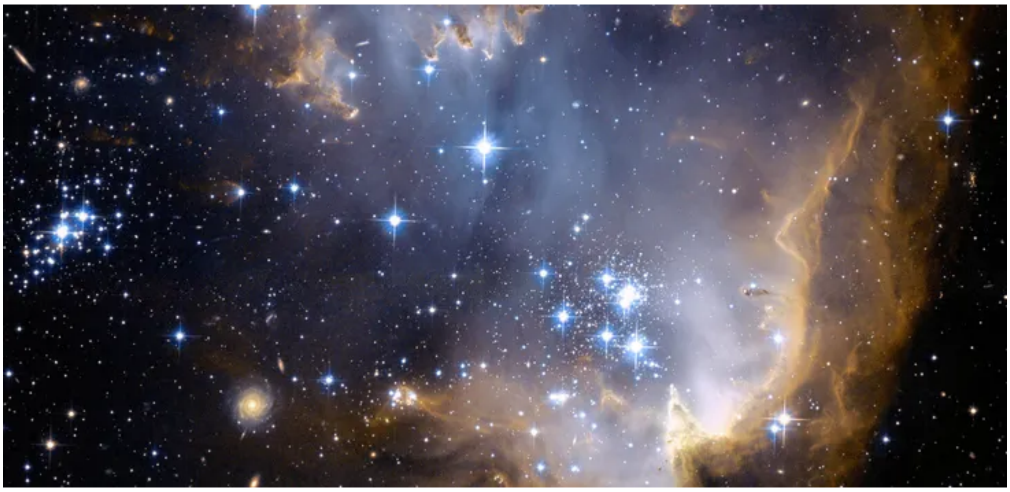
Dark matter up for debate

20-9-2023 Author: Victor Estrada Diaz

Introduction

Since time immemorial, humanity has observed the vast and infinite starry sky with admiration. Curiosity about celestial objects has led us to develop coordinate systems that allow us to precisely locate stars, planets, galaxies and other bodies in the sky. In this document,we explore celestial coordinates and how astronomers measure distances in space, a monumental challenge that allows us to better understand our place in the



universe.

Thatwe can notice?

The sky presents us with a diversity of celestial objects, including asteroids, comets, planets, stars, star clusters, galaxies and quasars. However, the way we perceive these objects varies depending on their distance and movement.

> Asteroids, comets and planets are distinguishable by their apparent movement in the sky due to their proximity. While asteroids and comets can change position quickly, planets also move, but at a slower rate compared to the background stars.
>
> The stars, despite their apparent immobility, exhibit a slight displacement in the sky at the end of the year due to stellar parallax, observable when comparing their position at different times of the year, although this is small due to their enormous distance, it is sufficient to calculate this.
>
> The galaxies are so far away that their movement cannot be distinguished from the background, so parallax can no longer be used even forfurther next to us which is the galaxy ofAndromeda, its distance presents a challenge that we can only face under theoretical assumptions of what we believe the structure of the universe to be like.

Stellar coordinates

Well, we have the situation in the sky of a star or galaxy and we know that how muchfurther The further it is, the smaller its apparent motion will be, so right ascension and declination for stars and galaxies is enough to locate them in the sky, but we need to know howthat distance they are.

At distances from the galaxy we can use parallax as distance, at greater distances like other galaxies parallax does not work because the object will be in the same position on the background, we will measure a parallax that will be null for all purposes, we have to devise then an effective way to measure distance and therefore resort to other methods.

Understanding the sky, stellar coordinates

When we observe the sky from the ground or from a space telescope we need to accurately determine the object, it is important to deposit this information in a good database and we must prepare precise references to identify the stellar object without ambiguity.

To do this, it is necessary to establish coordinates for the sky

The standardized coordinates for observing the sky are angular measurements.

Celestial Coordinates: Marking the Sky

When observing the sky from Earth or through space telescopes, it is essential to establish precise coordinates to identify celestial objects unambiguously. These coordinates are expressed in angular measurements, which means that they are not subject to specific units, as they represent viewing angles determined by our location on Earth.

Straight Ascension (AR): Right ascension is an angular measurement taken from the celestial equator to locate an object perpendicular to this plane. This coordinate resembles longitude on Earth and is used to define the position of objects in the equatorial plane.

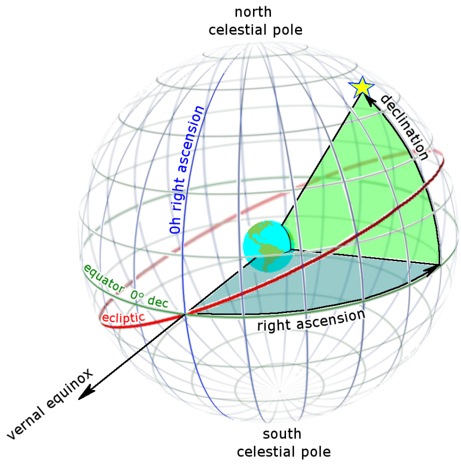
It is the measurement set from the equator to see the star or galaxy from perpendicular to it, hence the name right ascension.

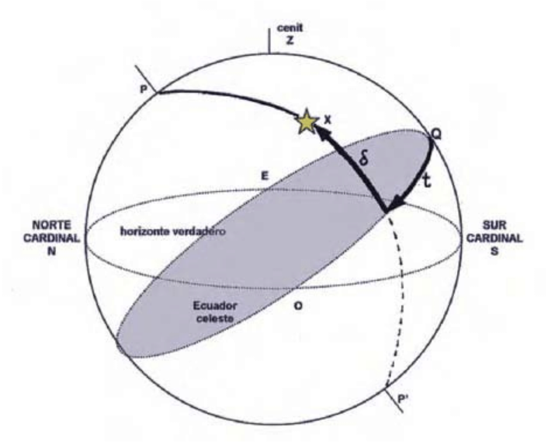
Declension (DEC): Declination is an angular measurement from the celestial equator up in the sky. Determines the height of an object in the sky. Combined with right ascension, declination uniquely defines position in the sky for stars and galaxies.

It is the height in the sky from the equator.

These measurements fix the location in the sky for a star or galaxy, they do not tellthat distance at which they are found but they are sufficient in most cases to identify them in the sky.

- RA: Straight Ancestry, DEC: Declination.



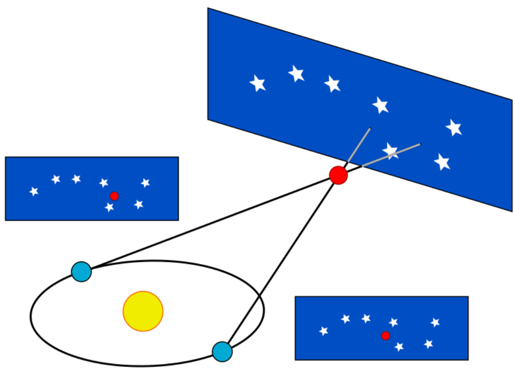


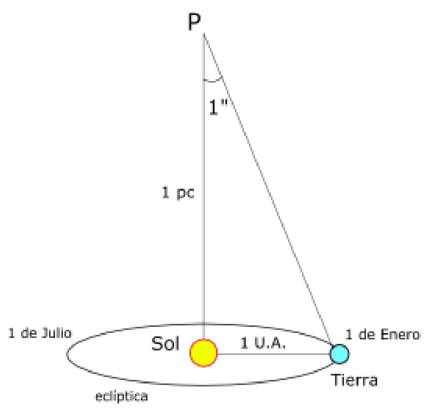
What can we see?

Asteroids, comets, planets, stars, clusters, galaxies, quasars.

The first three: asteroids, comets and planets are clearly distinguishable because when they are close, their position in the sky constantly changes, in the same way that we see a close person moving relative to us and, on the contrary, we see someone who is very far away. as a point always on the same apparent position.

The stars always seem to be in the same area of the sky, but if we observe them at two diametrically opposite times of the year, due to the binocular view provided by the distance of our distant observations, which is the orbit around the Sun, we will be able to observe a certain difference. On the much more distant background, this way of measuring is known as “parallax”, it is an angular measurement.





https://en.wikipedia.org/wiki/Cosmic_distance_ladder#/media/File:Extragalactic_Distance_Ladder_en.svg

Measure Distance

For stars within the galaxy we use “parallax”.

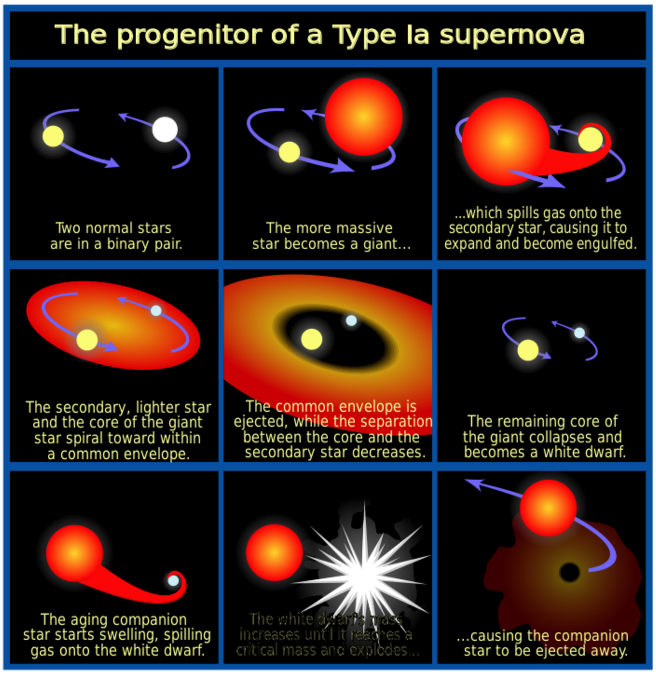
If the stars are too far away we will not be able totell the difference of position with respect to the background, which makes the idea ofparallax for starscumulus very distant galaxies or quasars is not possible.

For stars in our galaxy PARALLAX (parallax) is a possible measurement andvalid, butfurther There it is not a measurement that can be used because the position of the object does not change over the course of the year, so it gives an angular value of 0.

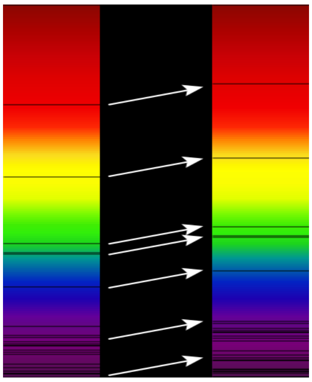
Of all the methods for calculating distances at the galactic level where parallax cannot be used, thefurther used, is that of Z (redshift of the spectrum) but this method has some drawbacks, despite this it is the methodfurther used in catalogs as variable zwhy besides of the angular measurements RA (rise straight line) and DEC (declination) are variables that can normally be measured.

As an alternative to parallax for enormous distances we can use some methods:

1. **Standard Candlestick Method (Cepheids and Type Ia Supernovae):** Variable stars such as Cepheids and Type Ia supernovae have a well-known relationship between their intrinsic luminosity and their period of variation. By observing its apparent brightness from Earth, astronomers can estimate its distance.
    - These supernovae occur because, by consuming mass from a neighboring companion star, there comes a time when they reach the critical mass to become a nova star. The important thing is that this critical mass ensures that the new nova star has a mass and brightness conditions. standardized which makes it very appropriate as a standard candle for measuring distances.
    - [Progenitor IA supernova - Type Ia supernova - SpeedyLook encyclopedia]



2. **Hubble-Lemaître Lay Method:** The expansion of the universe, discovered by Lemaître in 1927 and proposed by Edwin Hubble in 1929 established a relationship between the recession speed of galaxies and their distance. By measuring the redshift of the light emitted by a galaxy, its distance can be estimated.
    - [Hubble-Lemaître law - SpeedyLook encyclopedia]
    - With distance it is assumed due to the belief that we are in an expanding universe that distant galaxies have an increasingly redshiftfurther pronounced, this redshift can be determined by thestripes hydrogen spectra that are known.



    - They are based on theoretical models of the expansion of the universe, so it depends on the degree of accuracy with which the actual measurement of the observed shift adapts to the theoretical model.
3. **Gravitational Lenses:** The gravity of massive objects, such as galaxy clusters, can distort the light from objects behind them. This can be used to estimate the distance to the distorted light source using gravitational lensing models.
4. **Color-Magnitude Diagram:** In star clusters or groups of galaxies, stars or galaxies can be related so that their apparent luminosity and relative color are correlated. This can be used to estimate their distances.
5. **The Stefan-Boltzmann law:** The luminosity of an object is proportional to its temperature raised to the fourth power. By measuring the luminosity and temperature of celestial objects (such as stars), their distance can be estimated.
6. **Stellar Evolution Models:** By studying stellar evolution and the intrinsic characteristics of stars, such as their mass, temperature, and luminosity, astronomers can estimate distances to stars and star clusters.
7. **Radial Velocity Method:** By measuring the Doppler shift of spectral lines in the light emitted by a source, such as a galaxy, its radial velocity can be determined. If the radial velocity and orbital velocity are known, the distance can be estimated.
8. **Indirect Geometric Estimates:** In some cases, indirect geometric observations, such as the relationship between an object's apparent size and its distance, can be used to estimate distances.
9. **Methods Based on Relativistic Effects:** In extreme astrophysical systems, such as binary pulsars or black holes, relativistic effects in the orbit can provide information about masses and distances.
10. **Observations of Distant Supernovae:** Distant supernovae, such as type Ia supernovae, can be used as cosmic beacons to measure distances in the distant

universe by the relationship between their intrinsic brightness and their apparent brightness.

These methods and techniques allow astronomers to estimate distances in the universe even when the parallax method is not applicable due to observational limitations. Each of these approaches is used depending on the situation and the distance scale to be measured.

But it has some drawbacks:

Each of the mentioned methods for measuring distances in space has its own drawbacks and limitations.

Here is a list of some of the drawbacks associated with each method:

1. **Standard Candlestick Method (Cepheids and Type Ia Supernovae):**

    It requires the identification of specific variable stars or supernovae in the observed field.
    Accurate calibration of these relationships requires detailed observations and can be difficult for very distant objects.

2. **Hubble-Lemaître Lay Method:**

    It depends on accurate redshift measurements, which can be difficult for very distant objects or at small redshifts.
    The linear relationship is a simplified approximation and is not accurate on all cosmic scales.

3. **Gravitational Lenses:**

    It depends on the presence of massive objects acting as lenses, which may not always be available.
    It requires complex modeling and can be sensitive to the underlying mass distribution.

4. **Color-Magnitude Diagram:**

    It is not applicable to all situations and depends on the availability of high-quality data.
    The presence of interstellar dust can affect color and luminosity measurements.

5. **The Stefan-Boltzmann law:**

    It requires precise measurements of luminosity and temperature, which can be difficult to obtain for distant objects.
    Interstellar dust can also affect luminosity measurements.

6. **Stellar Evolution Models:**

    It requires precise information about the intrinsic properties of stars, such as their mass and composition, which can be difficult to determine.

7. **Radial Velocity Method:**

It depends on precise measurements of the Doppler shift, which can be affected by non-gravitational effects.
Requires knowledge of orbital velocity, which may be uncertain in some cases.

8. **Indirect Geometric Estimates:**

   The precision of geometric estimates depends on the quality of the observations and the specific geometry of the system in question.
   It may not be applicable to extremely large cosmic scales.

9. **Methods Based on Relativistic Effects:**

   They require very precise observations of extreme systems and can be difficult to obtain.
   Interpreting relativistic effects can be complicated.

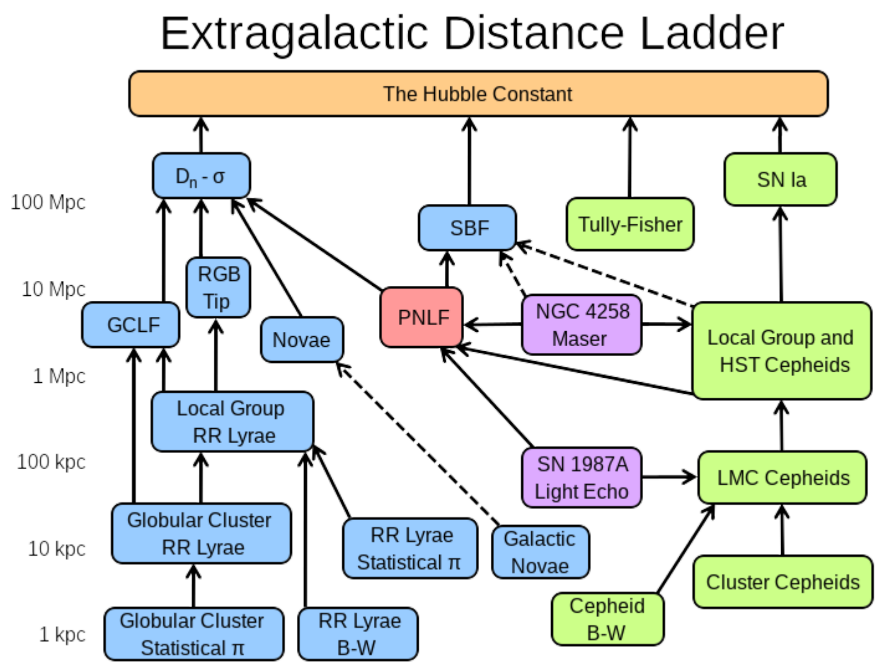
10. **Observations of Distant Supernovae:**

    It requires the identification of specific supernovae and precise measurements of their brightness.
    There may be uncertainties in the nature of the supernova and extinction due to dust.

Problems with distance measurements outside our galaxy

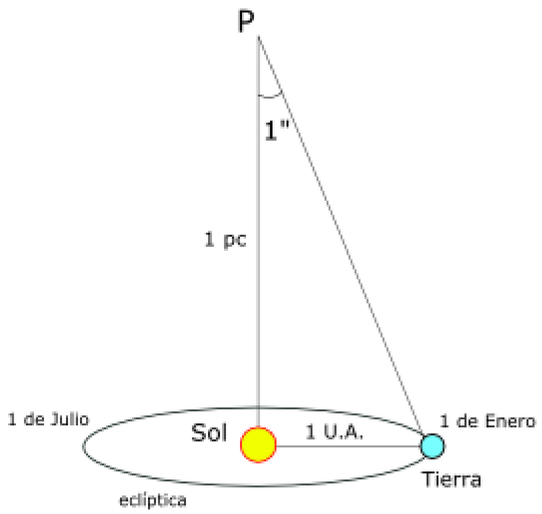
These methods of measuring distances make them strongly dependent on models of the universe and our idea of the curvature it may have; they cannot give us a precise measurement of distance. For example, if we use the redshift as distance we are bringing together the same concepts and this gives rise to two variables that are not independent, but one defines the other, this greatly conditions us to knowas We can determine distances by redshift.

Here we can see the complexity of the methods used to calculate distances.



Galactic units

To measure distances we use:



The astronomical unit UA

- Your unityd is the distance from the Sun to the Earth

The light year

- Its unit is the distance that light travels in a vacuum after one year.

The parsec and the Kpc

- They are unit is the distance at which a star or stellar object would be that had a parallax with an angular measurement of one second.

How much is 1 AU in km?

- The International Astronomical Union defines 1 au as a length equal to exactly 149,597,870,700 meters. As can be seen, 1 AU is approximately**150 million kilometers**, something a little less than the Sun-Earth distance.

How many km are equivalent to a light year?

- Its value can be found by multiplying the speed of light in a vacuum (c =**299792.458 km/s**) for 365.25 days (duration of a year) and for 86,400 (seconds in a day). If this definition of year is used, the result is 9,460,730,472,581 kilometers.

What is the distance of a parsec?

- Equivalent to 3.26 light years
- Unit of distance measurement equivalent to about**3.26 light years**, the 3.086×10^{16} meters. A parsec (or parsec) is defined as the distance from which the Solar System would have to be observed so that the Earth's orbit could be seen in the distance as an angle of one arc second.
- The kpc is 1000 parsec
- The distance of the closest star to the sun (Proxima Centauri) is at a parallax of 0.76 arc seconds. Therefore, it is 1.32 parsec away, or**4.29 light years,**It is part of the Alpha Centauri triple star system.

How can you determine the motion of a star?

This is only possible within the galaxy, objectsfurther distant objects will not show apparent movement so calculating their speed cannot be determined by the change in coordinates RA and DEC

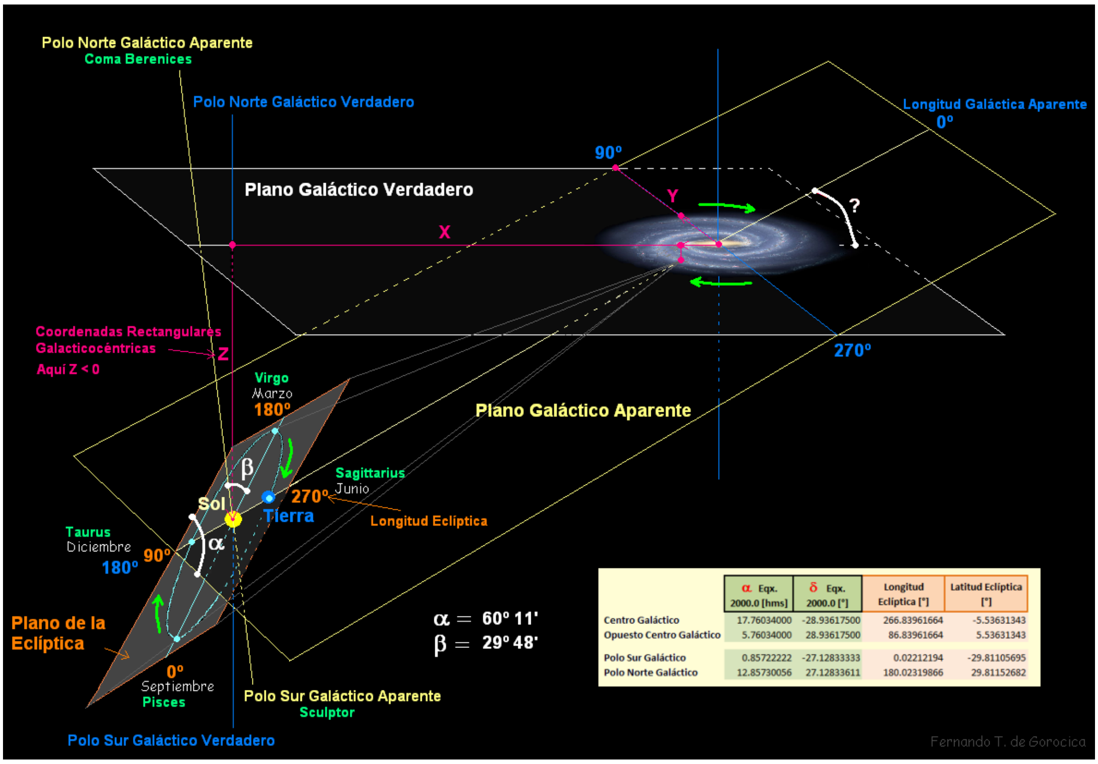
A star's speed and direction can be determined by its apparent motion. If we can see that its observed position in the sky changes over time from those changes in coordinates, we can deduce its speed and direction.

To do this, we can use the observed values of its apparent movement in the direction of straight ascent and movement in the direction of declination. These two values, being angular, have no other units than the measurement of the angle that we observe, which is why they are They usually call MRA for apparent movement in subtraction ascendancy and MDEC for movement in declension.

The movement in the other direction that we are missing, in parallax, the direction towards us cannot be taken directly but can be calculated, by other methods such as cyclical redshift through year., In some database catalogs data from observations is known as radial velocity.

Visual references in the galaxy

This image by Fernando de Gorocica can give us an idea of the visual references of the stars in the galaxy.



THREE PLANES:

1°) The plan of the**Ecliptic** or plane of the Earth's orbit, it passes through the center of the Earth and the center of the Sun, it is inclined 23º 47' with respect to the Celestial Equator. The point of Aries (today Pisces) is the origin of the

System ofcoordinates Geocentric Ecliptics, that is, the ecliptic longitude and latitude.

2°) The plandenominated **Apparent Galactic**, goes from the center of the Sun to the center of the Galaxy. The Apparent Galactic Coordinate System is used, simply called Galactic Coordinates today, with its galactic longitude and latitude.

3°) Hecalled plane **True Galactic** that passes through the galactic equator centered in the galactic bulge, origin of the Rectangular Coordinate SystemGalactic-XYZ centric.

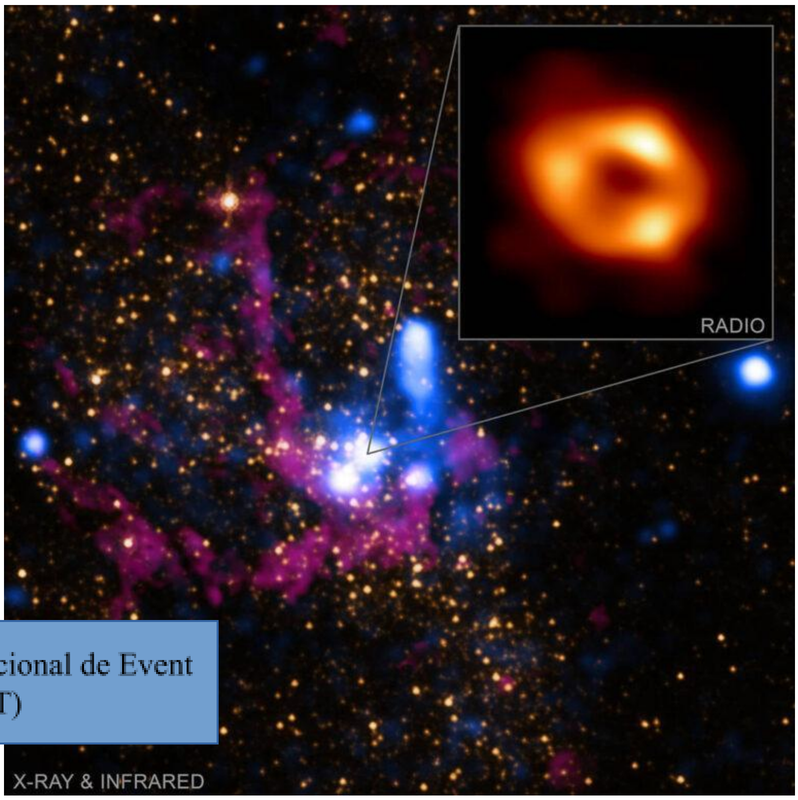
The angle or inclination between the Apparent Galactic plane and the True Galactic plane is not yet defined (? in white). This is why our star, the Sun, can have a positive or negative Z value, depending on which side of the True Galactic plane it is on.

To see:**Apparent Galactic Coordinates**.

Date	30 April 2014, 08:40:12
Source	Fernando Gorocica's own work https://commons.wikimedia.org/wiki/File:Plano_Gal%C3%A1ctico_y_la_Ecl%C3%ADptica.png
Author	Fernando de Gorocica

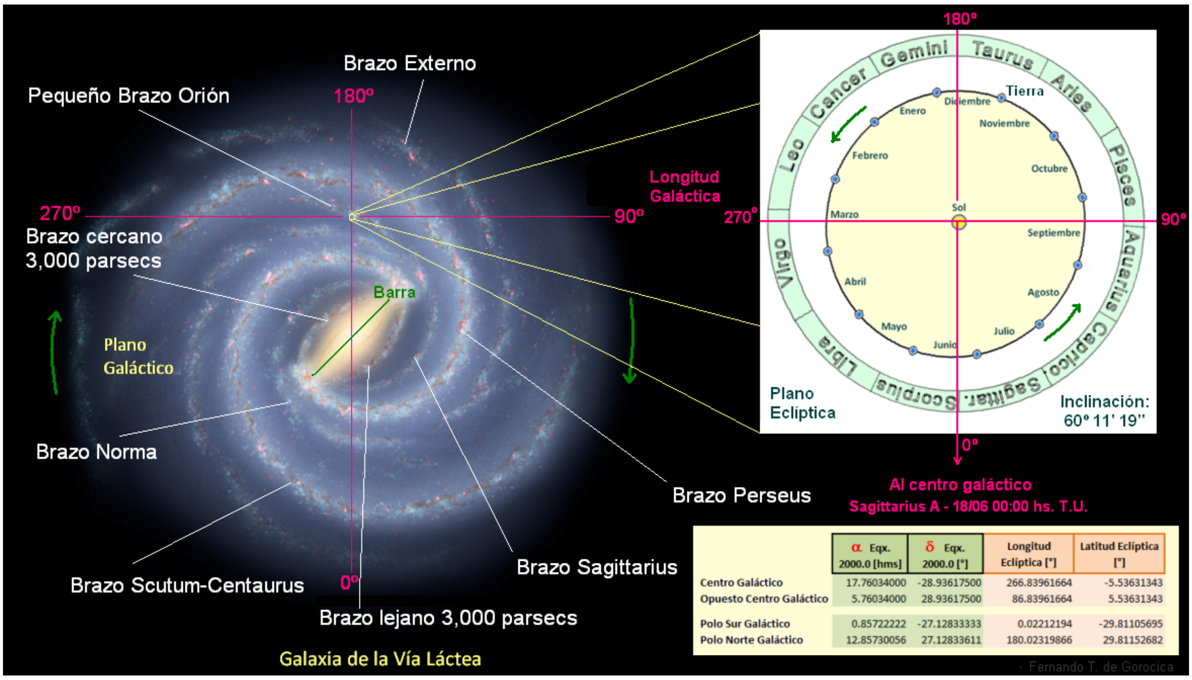
Galactic coordinates

The RA, DEC and PARALLAX values mentioned above, being angular observation values used directly, do not help us to study the movement of stars in the galaxy, which is why we need a system of Cartesian coordinates X and Z, fixed at the galactic center.



a de Internacional de Event
escope (EHT)

Point (x,y,z) = (0,0,0) Set in Sagittarius A where EHT has managed to use a set of antennas around the world to form, through interferometry, a radio telescope the size of the Earth by synchronizing the antennas.



The Milky Way is an SBbc-type galaxy, a barred spiral with moderately open arms. Here you can see the armsfurther important and the solar system is located in a smaller one called Orion that contains the stars of said constellation. Also in the graph on the right it can be determinedthat zodiacal constellation is observed throughout the year as well as which arm of the disk or edge of the galaxy, this at midnight.

For example, when the Earth is in its orbit around the Sun and in the month of June (06/18) at midnight you can see a more relevant whitish cloudiness and in the constellation of Sagittarius, it is then the galactic bulge or center and such band runs from the geographic South to the North.

When the Earth is in the month of December, cloud cover with lower luminosity compared to June will be observed at midnight and corresponds to the stars that make up the disk or band of the Milky Way galaxy and the direction of observation is towards the outer arms. of the same where the constellations of Gemini and Cancer are located, then the intergalactic space.

To see:**Galactic Plane and the Ecliptic**

Date	30 April 2014, 08:40:32
Source	Fernando Gorocica's own work https://commons.wikimedia.org/wiki/File:Coordenadas_Gal%C3%A1cticas_Aparentes.png
Author	Fernando de Gorocica

A privileged place for observation

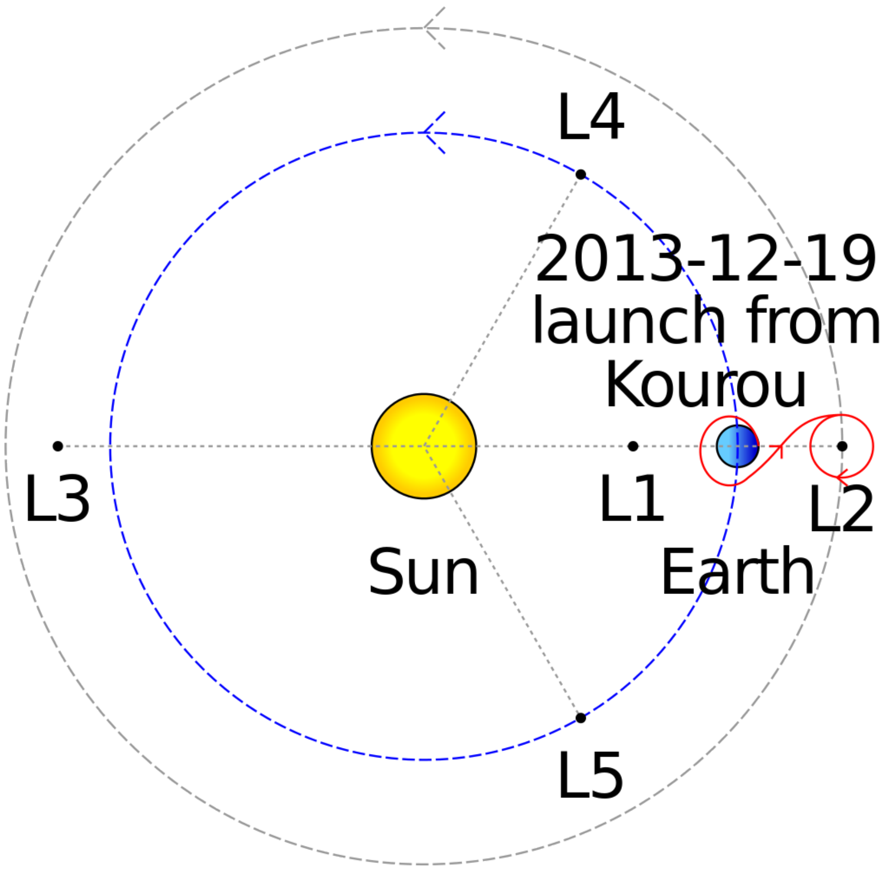
With the aim of obtaining data on the stars of the galaxy, the European Space Agency or ESA, an organization of the European Union, created the GAIA project.

The Gaia space mission was launched on December 19, 2013 from the Kourou Space Center in French Guiana towards the second Lagrange point (L2) of the Sun-Earth system. Gaia was established in an orbit around Earth's L2 point, which is located about 1.5 million kilometers (approximately 930,000 million

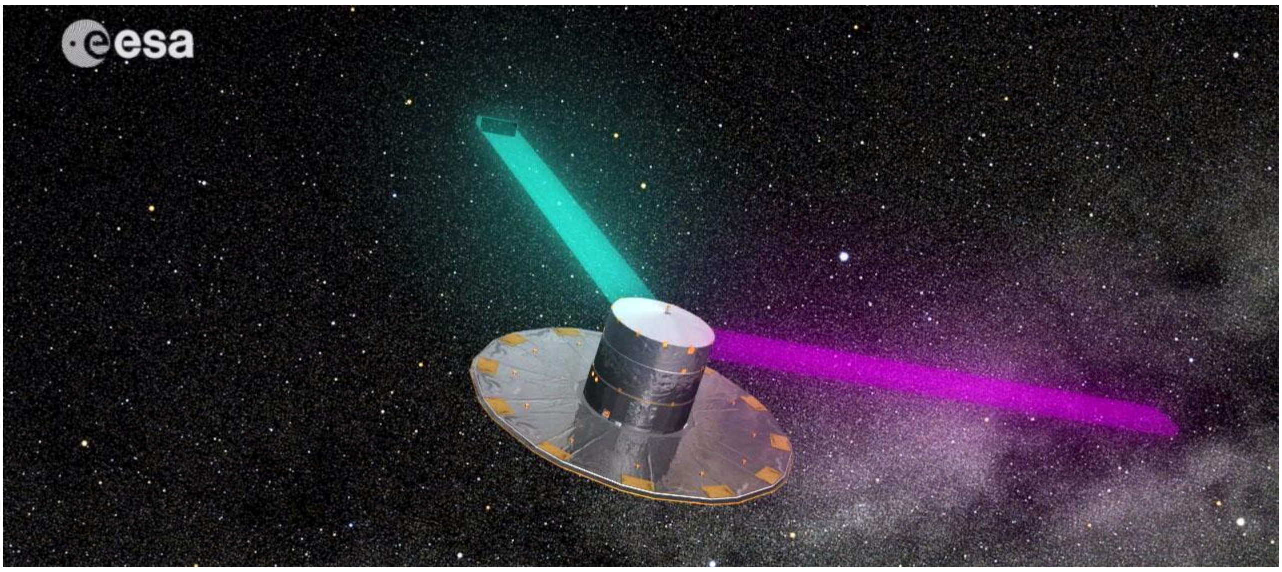
Gaia was designed to carry out an ambitious stellar mapping project, which involved observing the position, movement and characteristics of more than a billion stars in our Milky Way galaxy. Settling at the L2 point allowed Gaia to have an uninterrupted view of the sky without interference from sunlight, the moon, and Earth's atmosphere, allowing for extremely precise measurements of the stars.

Since its launch, Gaia has been collecting astronomical data and providing aLots of information valuable to astronomy, helping to improve our understanding of the structure and evolution of the Milky Way and the distribution of stars in our galaxy.

The important thing about this project is that anyone with programming knowledge and research interest can have access to its public data, which offers exceptional help to science.



The satellite collects position, movement and other data on objects in our galaxy in order to generate cartography asfurther complete possible.



This exceptional open scientific project has allowed me to carry out this work on stellar movements that show me interesting and new concepts.
The above figures are the result of my query to the GAIA database.
The first is a sample within the radius of 40 kiloparsec, about 130 thousand light years from the center of the galaxy, we are about 8.3 kiloparsec (kpc) about 27 thousand light years from the galactic center.

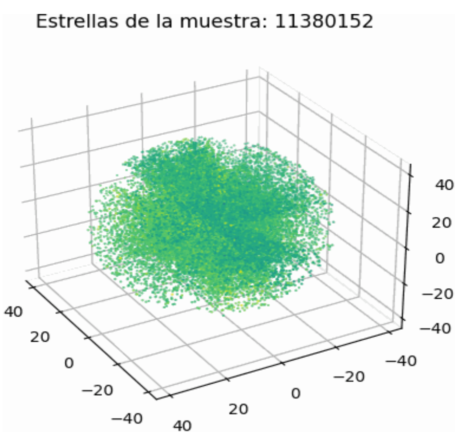
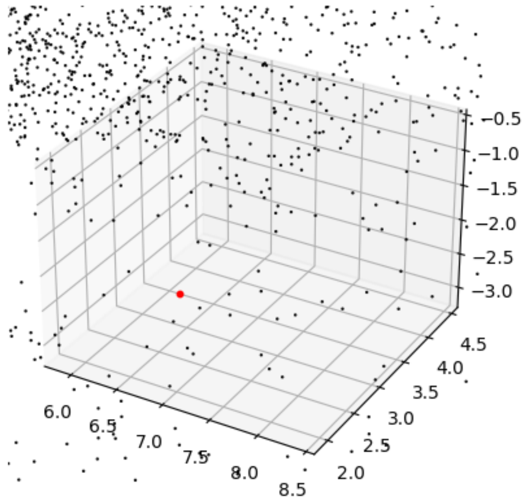


Figura -1
Situacion de la muestra del grafo



The figure below shows the Sun and its neighboring companions in its surroundings, the Sun is marked in red.

Where we are?

The situation of the Sun in the galaxy and therefore that of the solar system is:

x0 = 8.3 # kpc
y0 = 0 # kpc
z0 = 0.027 # kpc

Kpc is inkiloparsec

This situation corresponds to approximately 27 thousand light years from the galactic center and approximately 88 light years above the galactic plane, the y coordinate is set in the direction of the Sun to the center, which is why it is worth 0.

Y: The y coordinate is set to zero in the direction from the sun to the galactic center, it is radial to the circular movement of the sun in the galaxy.
X: The x coordinate is set perpendicular to the Y coordinate from the galactic center
Z: this coordinate is fixed on the axis of rotation of the galaxy.

The lines of the X and Y planes that pass through the galactic center are in orthogonal planes (90º) and coincide with the galactic plane.

Importance of Stellar Speed

In astronomy, we use angular measurements, such as parallax (PARALLAX), to determine distances, and celestial coordinates, such as right ascension (RA) and declination (DEC), to locate objects in the sky. These measurements provide information about the position of the stars relative to our Earth's perspective.

When we want to know the speed of a star, we observe the variations in its RA and DEC coordinates throughout the year. This gives us measurements of their relative angular motion, which are known as relative motion with respect to right ascension (MRA) and relative motion with respect to declination (MDEC).

However, it is important to note that these measurements only provide us with information about the apparent motion of the star in the sky, but do not tell us anything about its motion in our line of sight or regarding parallax. Typically, the motion value in the parallax direction is close to zero or very small.

In some cases, due to redshift and other factors, the Gaia project and other observatories can calculate and provide this velocity, which is assumed to be zero by default. This velocity is calculated under the concept of radial velocity, which is the component of the velocity of a star in the observer's line of sight, that is, towards or away from us.

This information is essential to fully understand the movement of stars in space and how they relate to our solar system and the Milky Way as a whole.

Thus, a movement of the sun with respect to the galactic center is observed in the coordinates that we have set:

vx0 = -11.1 # km/s
vy0 = 232.24 # km/s
vz0 = 7.25 # km/s

Now what about the speeds we observe?

They are apparent velocities, velocities from our perspective, but as we have seen the Sun and therefore the entire solar system moves with it, therefore the real velocity of the stars is not what we observe in MRA MDEC and Radial velocity since we are measuring them. from an object that also moves like the sun and withhe, the solar system.

The actual speed is the result of composing the two speed vectors.

Any study must be done taking this into account.

Real speed of a star

"Galactic speed" or "GSM speed" refers to the actual speed of a star relative to the center of the Milky Way. To calculate it, a vector composition is made of the speed of the star's own motion (MRA and MDEC) and the speed of the Sun in the galaxy.

The speed of the Sun in the galaxy is known as the "galactic speed of the Sun" or "peculiar speed of the Sun." This speed is due to the Sun's orbit around the galactic center and can be approximately 232.24 kilometers per second (km/s).

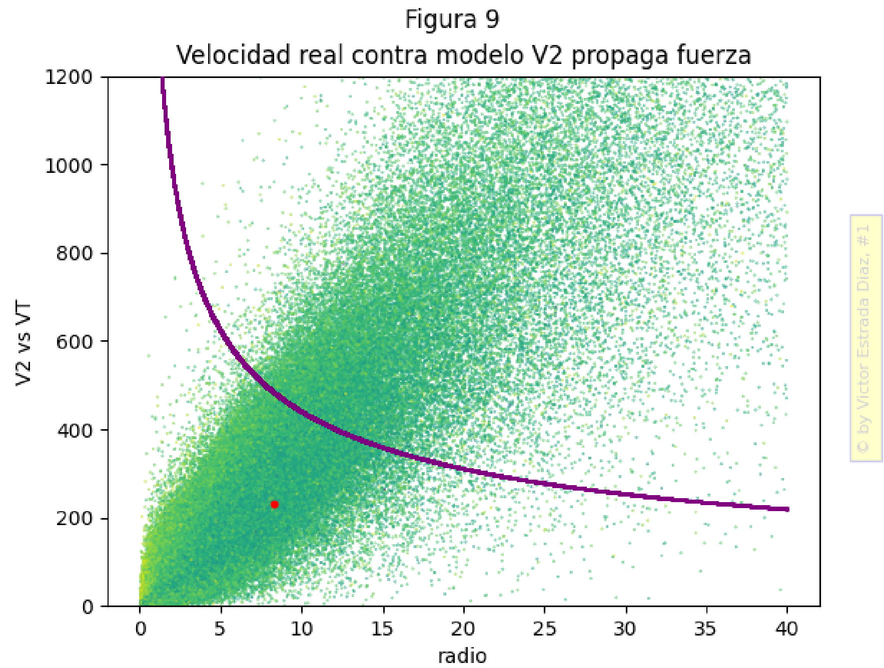
The galactic velocity is calculated by vector adding the star's own velocity and the Sun's peculiar velocity. This information is essential to understanding the motion and dynamics of stars in the Milky Way, especially when studying stellar motions on galactic scales.

Apparent motion of stars

Note that these are real data that I have obtained by directly consulting the GAIA database through a query inlanguage SQL. I have stored the data on my computer for this study, all the graphs of my work have a mark.

These values are apparent velocities, that is, they are those that the GAIA satellite observes directly, an increasing trend can be seen but they are not real velocities since they are measured from the Solar system that is moving with the Sun, therefore a composition is needed. between the observed velocity and that of the Sun to extract the actual velocity of the stars in the galaxy.
The mauve curve is the velocity that is calculated for each star if we apply Newton's laws. Being an apparent speed, it is conditioned by the Sun's own speed.

Note that the Sun is marked in red.



Real Speeds

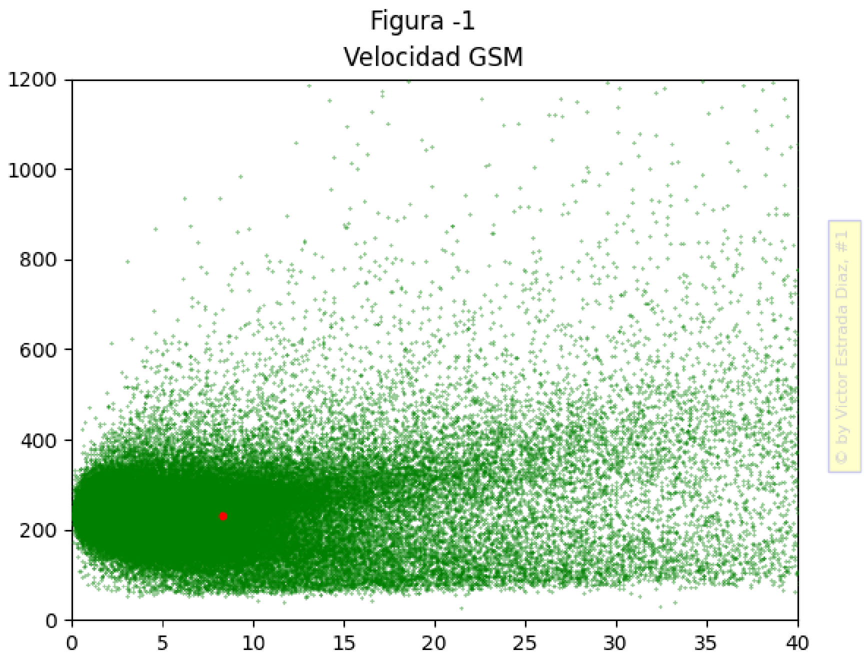
Note: the term GSM

- In this work, we will use the acronym GSM, it refers to the 'Galactic Standard of Rest' (Galactic Standard of Rest in English).
- This GSM system allows us to study the velocities of stars because what GSM means is that we have to convert the motion values that we observe, which imply that we are measuring them with respect to a moving system that has its own velocity. as is the one that the solar system has in the galaxy to fix it on a fixed galactic coordinate system.

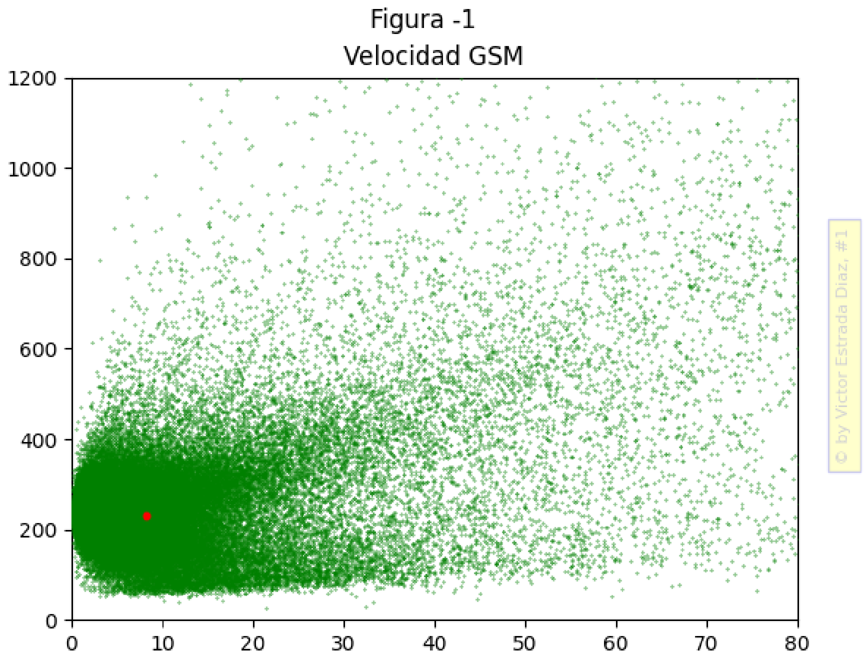
Also known as GSM, this system determines the real velocities of the stars by transforming the apparent velocities by means of vector subtraction from the real velocity of the Sun.

Note then that these are the real speeds as they are not influenced by our own speed as observers.

This simple mathematical transformation will result in a completely accurate view of the actual velocities of the sample, not being a theoretical velocity model but actual velocities.

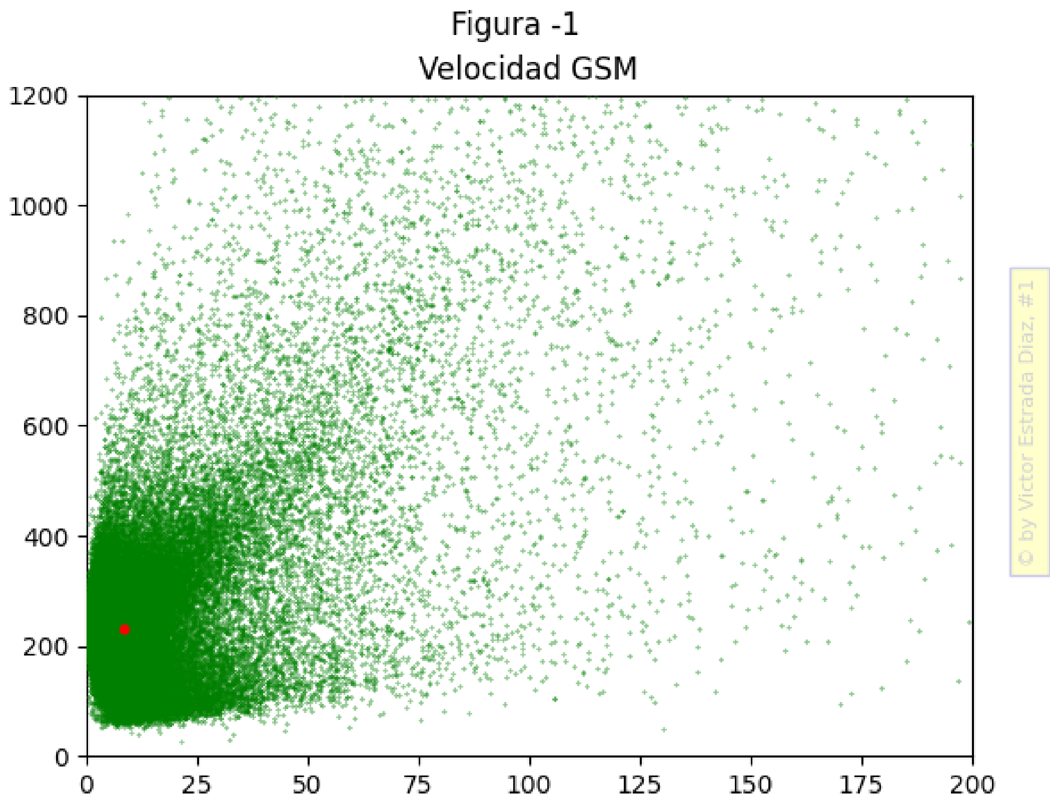


Here speeds up to 40 kiloparsec from the galactic center



Here speeds up to 80 kiloparsec from the galactic center.

Here up to distances of 400 kiloparsec from the galactic center.



AND WELL, How to interpret the movement of the stars?

In a vacuum, any pair of points that are separated by a distance will maintain this distance if they are not subject to a force, or what is equivalent, they will be subjected to an acceleration proportional to their mass.

An object will maintain its speed in a vacuum or its momentum if it is not subjected to a force.

There are 4 known forces in nature but only gravity, which is the weakest of them, is significant at astronomical distances.

weak force

strong force

electromagnetic force

Gravity

The movement of stars and the dynamics of objects in the universe are governed mainly by the laws of physics, in particular, by the law of gravity according to Einstein's theory of relativity. Here are some key considerations for how to interpret the movement of stars:

1. **Law of Universal Gravitation**: The law of universal gravitation states that any object with mass exerts a gravitational force on other objects with mass. This force depends on the mass of the objects and the distance between them. In the context of stars, this law explains how stars interact gravitationally with each other.
2. **Orbital Motion**: Stars in star systems (such as binary systems or planetary systems) move in orbits around a common center of mass due to the influence of gravity. This movement is governed by Kepler's laws, which describe how objects move in space under the influence of gravity.
3. **External Forces**: Stars can also experience external forces in addition to gravity, such as forces exerted by interstellar gas and dust, electromagnetic radiation, and other factors. These forces can affect its movement and evolution.
4. **Dark matter**: Dark matter is a hypothetical form of matter that, if it exists (something not yet proven), does not emit light or interact directly with electromagnetic radiation, but exerts a significant gravitational influence. Its existence is postulated to explain the observed movement of galaxies and the formation of large-scale structures in the universe.Although Now this concept is generalized,sIts origin was to find an explanation for the movement of stars in the galaxy.
5. **Dark energy**: Dark energy is another mysterious component that is believed to be causing an acceleration in the expansion of the universe. But notthey interact gravitationally at small distances, its effect at cosmological scales is conjectured to be important and is being investigated to understand its nature.
6. **theories ofgravity modified and String Theory**: Some physical theories beyond the Standard Model propose modifications in the laws of gravity or unification of

fundamental forces on cosmic scales. These theories are explored as possible explanations of cosmic phenomena without resorting to dark matter or dark energy.

7. **Active Research**: Astronomy and theoretical physics continue to actively investigate the motion of stars and other cosmic phenomena. The search for exotic particles, understanding gravity at extremely large and small scales, and exploring new theories are constantly evolving areas of scientific research.
8. **String Theory**: String theory is a theoretical framework that seeks to unify fundamental physics by considering that elementary particles are actually vibrating strings in dimensions additional to the space-time we know. Although this theory is very complex and has not yet been demonstrated experimentally, it could have implications for gravity on cosmic scales.

In short, the motion of stars is mainly interpreted through the law of gravity and astronomical observations. However, the existence of phenomena such as dark matter and dark energy suggests that there is still much to learn about the fundamental nature of the universe and its influence on stellar motion. Continued research is essential to resolve these puzzles and advance our understanding of the cosmos.

Until now, it has not been possible to find a particle that can justify acting on the stars to give them speed or acceleration.let it not bethe force of gravity.

Particles currently sought to justify the expansion of the universe, or stellar velocities observed beyond explanation by Newton or Einstein, include a new type of neutrino called a 'sterile neutrino', another class of particles called 'axions', or even primordial black holes, formed just after the Big Bang. In addition to dark matter, a type of new fundamental particle that we do not yet understand, it would represent 25% of the universe. The third parameter is the cosmological constant, the mysterious dark energy that is at the root of the accelerated expansion of the universe that is believed to be observed. This would represent 70% of the universe's total matter and energy budget.

Motion according to Newton (Model_VN)

As massive objects, stars are subject to the laws of gravitation, we owe Newton hiscalculation.

$$F = G\frac{M_1 M_2}{R^2}$$

F	gravitational force
M_1	primary meal
M_2	secondary mass
R	distance
G	Newtonian gravitational constant:$6.67430(15) \times 10^{-11} N \times mkg^2$
	With a relative uncertainty of$2,2 \times 10^{-5}$

When using G the units must correspond in thecalculation, the masses must be in***kilograms*** and the distances in meters, to calculate these forces that will be in***Newton units*** You have to convert the mass of the stars into its equivalent in Kg.

Another consideration is the distance between the masses of the stars, this distance is obviously not measured in meters.

The calculations must therefore respect the units that we can measure.

We must therefore work consistently with the units

$Length \Rightarrow kiloparsec \Rightarrow Light\ years \Rightarrow meters$

$Weight \Rightarrow solar\ masses \Rightarrow Kg$

Newton's laws were first used to calculate planetary velocities in the 17th century. Isaac Newton, in his work "Philosophiæ Naturalis Principia Mathematica" (commonly known as the "Principia"), published in 1687, formulated his three laws of motion and the law of universal gravitation. These laws provided a solid theoretical basis for understanding and calculating the movements of planets and other objects in the solar system.

Newton's law of universal gravitation states that every particle in the universe attracts every other particle with a gravitational force directly proportional to the product of their masses and inversely proportional to the square of the distance between them. This law allowed scientists to calculate the orbits and velocities of the planets relative to the Sun.

One of the first notable successes in the application of Newton's laws to astronomy was the work of Johannes Kepler, who developed his laws of planetary motion in the 17th century before the publication of Newton's "Principia." Kepler formulated empirical laws thatdescribe planetary orbits, and these laws were later combined with Newton's laws to provide a more complete understanding of planetary motions.

In short, Newton's laws were first used in the 17th century and later applied to calculate the velocities and orbits of planets, revolutionizing our understanding of physics and astronomy.

The discrepancy between predictions based on Newton's laws and actual observations of Mercury's orbit was a major problem in the history of astronomy and physics. Observation of Mercury's orbit showed a precession in its orbit, that is, that the point closest to the Sun (perihelion) was gradually advancing with time faster than the predictions of Newton's laws predicted. This discrepancy was a mystery for some time.

The discrepancy in Mercury's orbit became apparent in the mid-19th century and became a problem known as the "Mercury precession anomaly." Various explanations and theories were proposed to resolve this discrepancy, but none of them were completely satisfactory.

Einstein's field equations

These equations describe the relationship between the geometry of space-time and the distribution of mass and energy in the universe. Einstein's field equations are:

$$G_{note}= 8\pi G T_{note}$$

Where:

G_{note} Einstein tensor, which describes the curvature of space-time.

T_{note} energy-momentum tensor, which describes the distribution of mass and energy in space-time.

G the gravitational constant.

m n They are indices that vary from 0 to 3

They represent the four dimensions of space-time (t, x, y, z).

Hecalculation It is complex and depends on what the structure of space-time in the galaxy really is, which is a direct relationship of the masses and their location in it.

But Einstein's main idea is that matter curves space and that is the cause of movement, it is not really that something pulls on matterbut that it is space itself with its curvature that causes movement.

This equation expresses the relationship between the geometry of space-time (the left side, $G_{\mu\nu}$) and the distribution of mass and energy (on the right side, $T_{\mu\nu}$).

Motion according to Einstein

The solution to the problem finally to the problem of precession inthe Mercury's orbit arrived with Albert Einstein's theory of general relativity, published in 1915. In general relativity, Einstein proposed a new theory of gravity thatreplace to Newton's law of universal gravitation. general relativitypredict the precession of orbits differently from Newton's laws and, crucially, the predictionsmatch with the observations of theorbit of Mercury.

In 1915, during a solar eclipse, observations were made that confirmed Einstein's prediction. British astronomer Arthur Eddington led an expedition to Príncipe and Sobral in Africa to measure the curvature of light from stars close to the Sun during a solar eclipse. These measurements confirmed the deviation of light predicted by general relativity and were thereforeanother support for Einstein's new theory.

LThe anomaly in Mercury's orbit was one of the firstsuccesses important observations of Einstein's general relativity and showed that this theory was a more accurate description of gravity compared to Newton's laws.

In Albert Einstein's theory of general relativity, the equivalent of the gravitational force is the geometry of space-time itself. This theoryrevolutionized our understanding of gravity by proposing that massive objects, such as planets and stars, curve spacetime around them, and this curvature is what causes the appearance of a gravitational force andthe cause of the movements of the planets and any mass object in space.

The main difference between the theory of general relativity and Newton's law of universal gravitation isThe next:

1. **Newton's Law of Universal Gravitation**: According to this law, gravity is an attractive force that acts instantaneously between two masses. The gravitational force is described by an equation that includes the mass of the objects and the distance between them. This law describes gravity as an action at a distance.
2. **Einstein's Theory of General Relativity**: Instead of an attractive force acting at a distance, Einstein proposed that massive objects curve space-time around them. Moving objects follow trajectories called geodesics, which are straight lines in curved space-time. The curvature of spacetime around a massive object is what causes other objects to move toward it, giving the impression of a gravitational force. In this theory, gravity is a manifestation of the geometry of space-time itself.

The main essential difference lies in how gravity is conceptualized. While in Newton's theory, gravity is interpreted as an instantaneous force acting at a distance, in general relativity, gravity is interpreted as the geometry of space-time that guides the motion of objects. General relativity has been shown to be more accurate than Newton's law under extreme conditions, such as near massive objects or in strong gravitational fields, and has been confirmed by numerous experiments and observations.

All this seems very GOOD, but I do not knowmanaged to explain why the movement of the planets in the solar system is not the same as the speed and trajectory of the stars in the galaxy. INin turnfurther we found a discrepancyWhen we go to analyze the movement of stars in the galaxy that we will explain..

Einstein's theory of general relativity despite being thefurther accurate to date, it does not fully explain some astronomical observations, especially regarding the motion of stars in galaxies. In general, general relativity may not provide a complete or approximate description of galactic dynamics. In these cases, the existence of dark matter has been postulated as a possible explanation for this discrepancy.

But we must clarify that dark matter is a medium that has been introduced to explain that the calculationsmatch with the observations, withoutembargo It's a hypothesiswhich still does not have a convincing explanation and we need to do science not based on conjectures but on evidence..

Dark matter, which despite current efforts has not yet been detected, is a form of matter that does not emit, absorb or reflect electromagnetic light, so it cannot be detected directly through optical observations or other types of radiation. electromagnetic. Its existence is inferred through its gravitational influence on the speed and distribution of visible matter, such as stars in galaxies.

The dark matter hypothesis arose to explain phenomena such as the rotation of galaxies, where stars in the outer regions of galaxies move at higher speeds than would be expected according to the laws of gravity based on the visible mass of galaxies. the Galaxy. The idea of current science is that dark matter, which we cannot see, is exerting an additional gravitational influence that keeps stars in stable orbits at these speeds.

Dark matter has also been invoked to explain the formation and dynamics of large-scale structures in the universe, such as galaxy clusters. While it has not yet been directly detected, there is believed to be observational evidence of its existence due to its gravitational effects.

In summary, while Einstein's theory of general relativity is an accurate description of gravity in many situations, it cannot fully explain certain large-scale astronomical phenomena, such as the motion of stars in galaxies, which has led to the introduction of the dark matter hypothesis as a potential solution to these observational discrepancies. The search for and study of dark matter continue to be active areas of research in astronomy and physics.

BUT WE CAN NOTSTILL CLAIM THAT DARK MATTER EXISTS

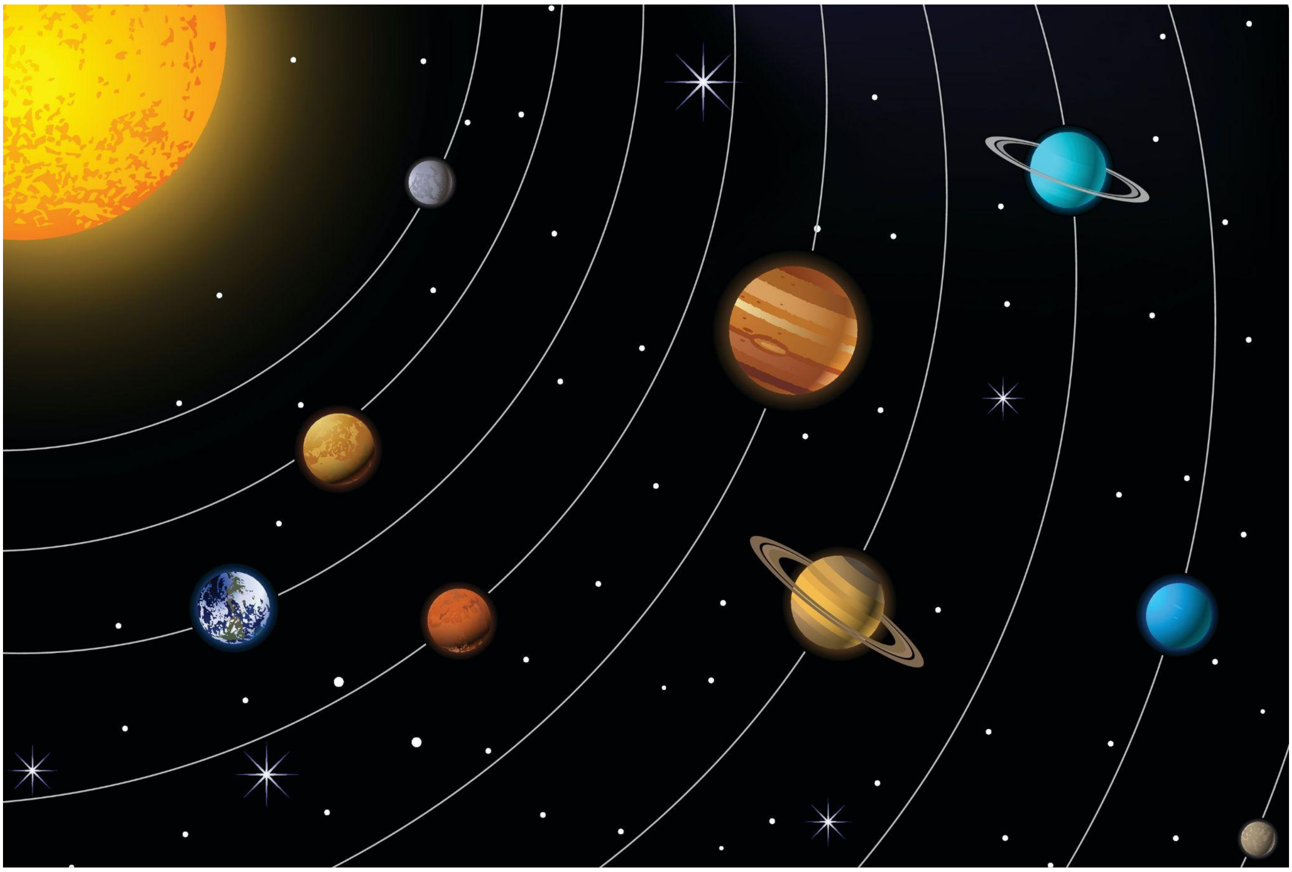
Although the existence of dark matter is notquestioned Generally, due to current science, I do not want this concept, that of dark matter, to contaminate my work, which will show other explanations for the speed of stars in the galaxy without the need to introduce concepts.that today are only conjectures.

The real speed of the planets in the solar system

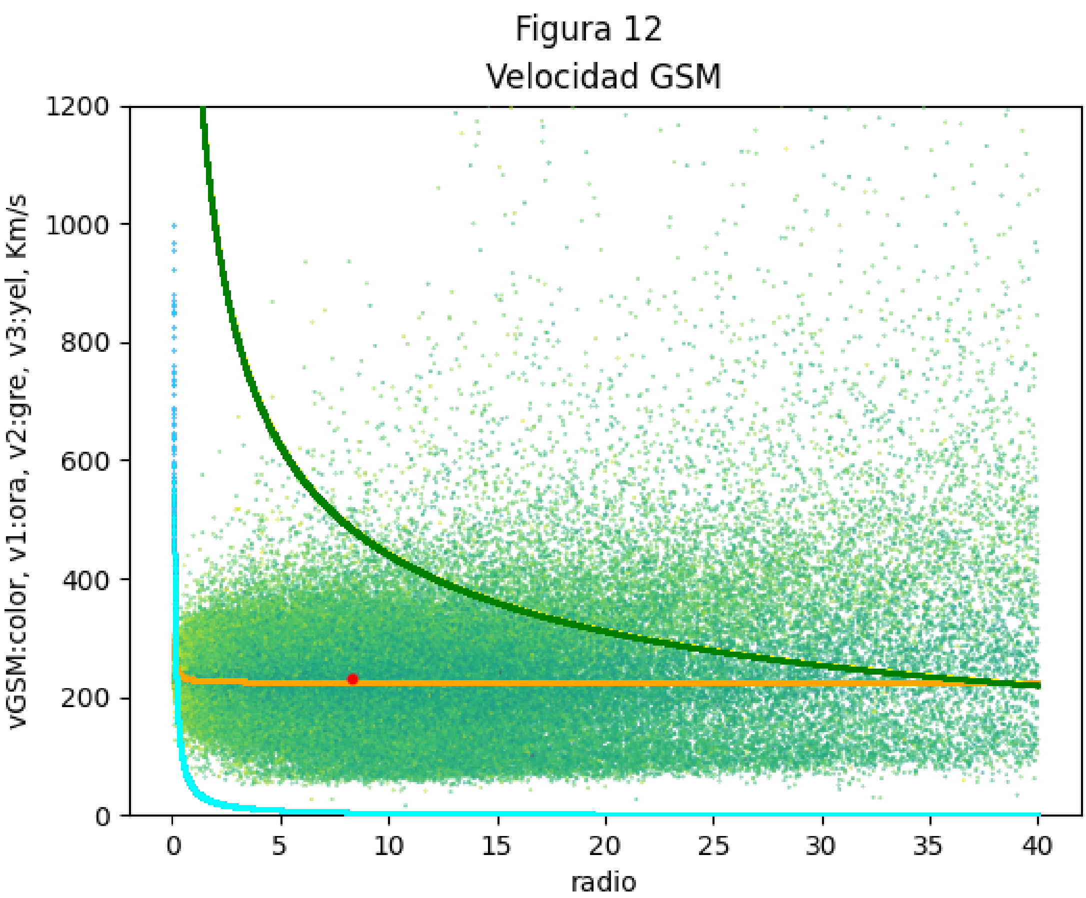
It can be seen that with distance the speed of the planets decreases, for the observed speed calculations the data coincide with the theoretical results of applying Newton and Einstein, only thislast explain itorbit of Mercury as we have said.

Planet	Average speed (km/s)	Distance to the Sun (AU)
Mercury	47.87	0.39
Venus	35.02	0.72
Land	29.78	1.00
Marte	24.08	1.52
Jupiter	13.07	5.20
Saturn	9.68	9.58
Uranus	6.80	19.22
Neptune	5.43	30.05

These results differ for the velocities of the stars in the galaxy, which with rare exceptions do not decrease as they are further away from the galactic center.



The speed of stars in the galaxy



In the graph I have put the stars of the sample in a color that goes orange.further massive and green the less massive, on the X axis their distance to the galactic center, as a background to contrast with the theoretical values.

For each of the stars I have calculated the speed according to its mass and its distance from the center of mass of the galaxy, the result is the green curve that we see that clearly does not respond to the real observed speed that we see in the point cloud.

I call this result Model_V2

Then I asked myself what results we would have considering the deformation of space by applying Einstein's norms to each star in the sample and I obtained the blue curve, which as can be seen is also in discrepancy, Model_V3.

Finally, I applied a model according to Einstein that included dark matter and the result was the orange curve, Model_V1.

The speed of the Sun and its speed are displayed in the red dot that coincidentally passes through the Einstein-Dark-Matter model Model_ V1

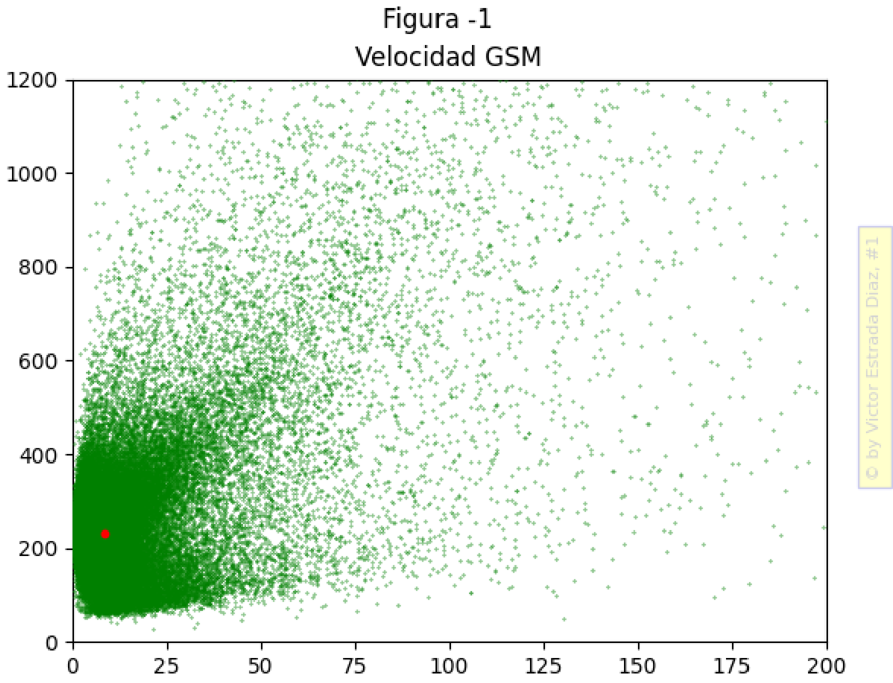
Reasonable doubts to rule out dark matter

It is true that this model, that of dark matter. Model_V1,It seems to be the best fit but there are strong arguments to reject it.

The only value to which the existence of dark matter responds is to justify the speed of the Sun and little else, perhaps the trend in speeds, but even that is of no use to us, because we clearly see that the speed of the stars continues to increase anddispersing evenfurther when we move away from 40kiloparsec of the galactic center as can be seen in the following graph.

It can be seen that there is a dispersion that becomes increasingly greater as we move away from the centergalactic andalthough nicesome stars that maintain a certain trend above 230 km/sec, the dispersion in velocities increases linearly, reaching speed values greater than 1200 km/sec

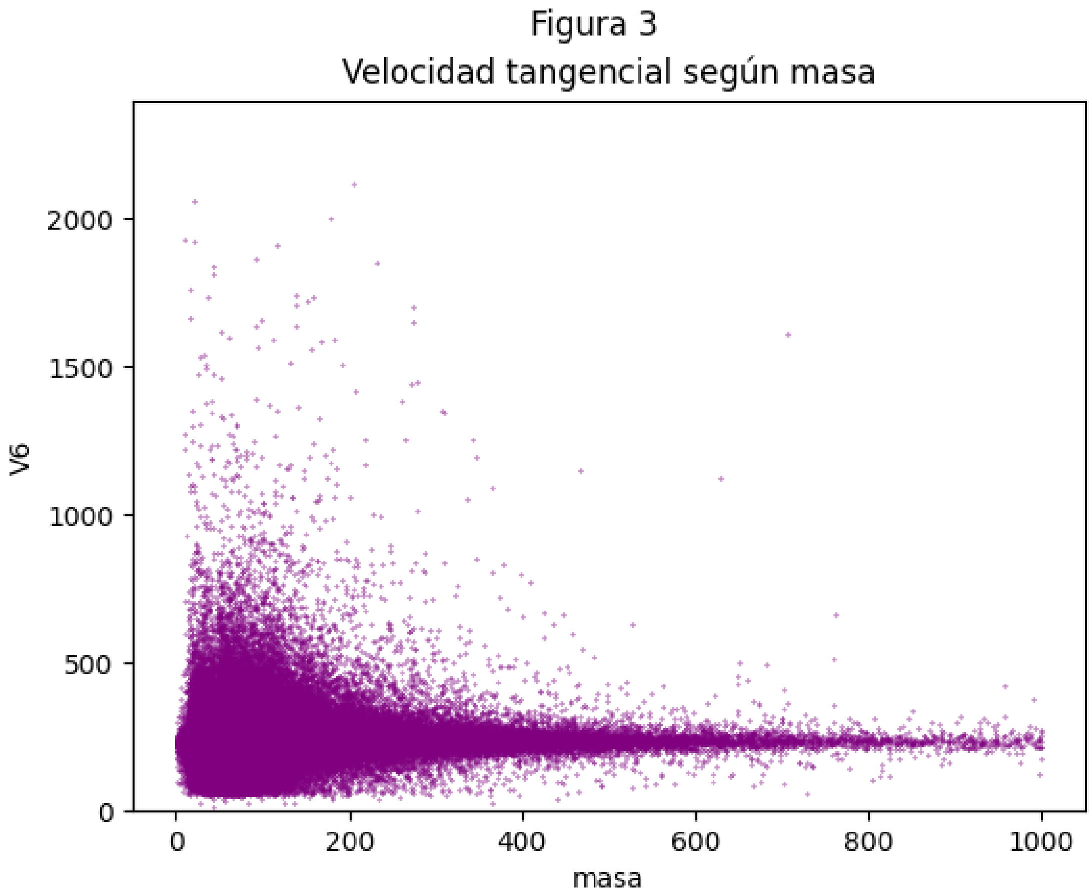
Thedifference It is increasingly pronounced the further we are from the galactic center as can be seen here up to 400 kiloparsec.:



Influence of mass on the speed of the star

The following graph can be seen that as the stars havefurther mass these have a speedfurther stable andpredictable on the other hand understandable since more mass implies more stable inertia.

Sin however, with little mass in a star, Its speed presents a great dispersion of values, thisprint shop It can be used to choose mass values in the distance for calculations that we makecalculations further accurate and avoid small masses of speedsfurther erratic and unpredictable The following figure can give us ideas about this, including finding an appropriate formulation to set thestability in stellar motion..



Why models fail

Everyone assumes, as far as I can understand, that forces are transmitted instantaneously, even with Einstein's ideas spacetime warps are not staticin are transmitted instantly as the models propose or assume.

Not considering propagation that is transmitted at the speed of light is a conceptual error, even Einstein's models omit it.

It is proven that ripples in space-time propagate at the speed of light as has been demonstrated from projects such as LIGO.

That is, none of the current models take into account whether force or deformation of space is considered, thiscarry implies a speed of propagation that is not taken into account and hence the errors that arise when determiningtheoretically the speeds and which must be justified by introducing the subjectdark to give a possible explanation,.

For theoretical purposes, the stars are gravitationally linked, but apart from the fact that their effectiveness decreases with the square of the distance, another effect is produced not contemplated in thetheories current and this is the spread.

Propagation causes adisconnection further beyond gravitational attraction, it is like the effect of a wave or the Olympic hammer that firstit is bound to the launcher and then released each timefurther with the distance.

Personally, I don't think it has anything to do witheffect observed in the stars of the galaxy with or without dark matter.

The galaxy as a graph

Given the strong discrepancy in the models Ihas encouraged this work, afterIt's been a while since I've seen that the best way is treat the sample as a graph since this allows me to create attributes and calculations for each star and relate it to its environment to try to understand what is happening, avoiding performingunnecessary duplicate calculations unless it is our interest to recalculate.

Consider the environment

Seeing or understanding the environment of a star with all the stars or even its neighbors is acalculation monumental and out of my reach,this one would havean order of algorintmico unaffordable.

But we can pose the problem in another way:

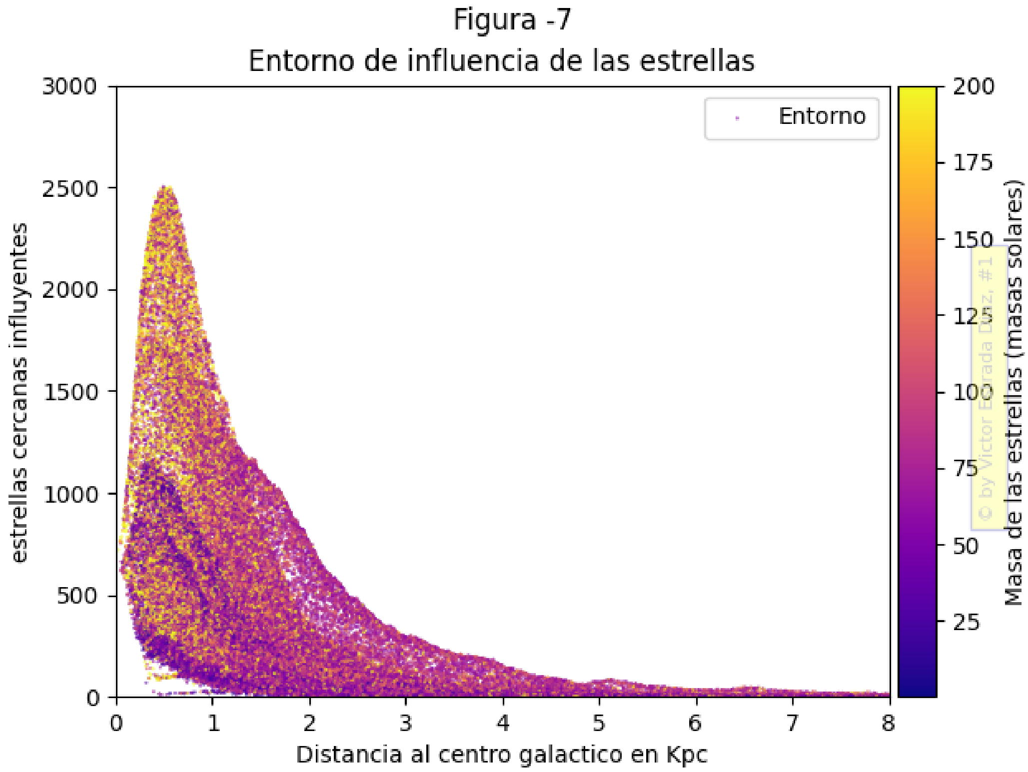
The question is to considerin each star and its speed think what the environment is innumber of stars so that a star of the greatest possible mass is at a distance such that itsattraction gravity begins to slightly have some influence on it.

Thanks to this trick, for each starI have been able to explore your neighbors if they arefurther there or here of that distance mminimal influence.

Then we can obtain for each star thenumber of stars that influence it gravitationally and the use of this criterion makes us observe certain interesting things.

- Gglobally the environment of a star does not significantly influence the speed of its group at the speed it already has, itinfluence on speed is not usually the result ofl close environment unless the stars are very close.
- They are observed as waves in the detected clustersaccording to the mass which suggests that the stars have moved away from the galactic center in stages, have formed in groups of similar masses and at similar times,which suggests a common origin in each wave.

This is thegraphically you can sense what I suggest::



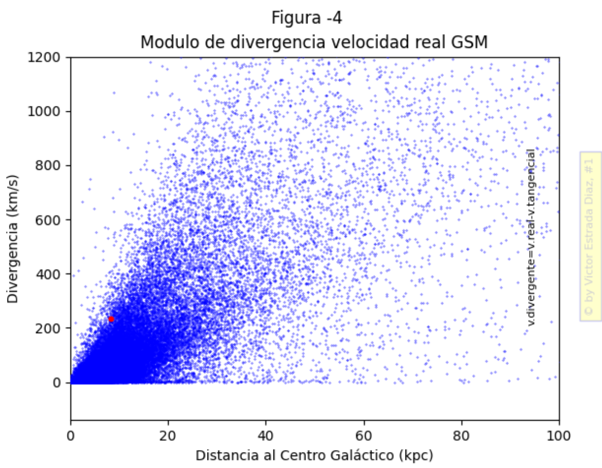
Real speed in the three dimensions of space

In the following figures I have obtained the speed not in the tangential sense but in the three dimensions of space to seethat components of the speed correspond to the rotation or go in another direction, these measurements are summarized in v_t tangential speed and v_m the effective speed in module,So looking at the difference in themodule of speed with respect to the tangente to the galactic spin we can observe whether or not the star deviates from the spin and inthat measure.

Both v_t and v_m are measurements not influenced by the speed of the sun (GSM system)

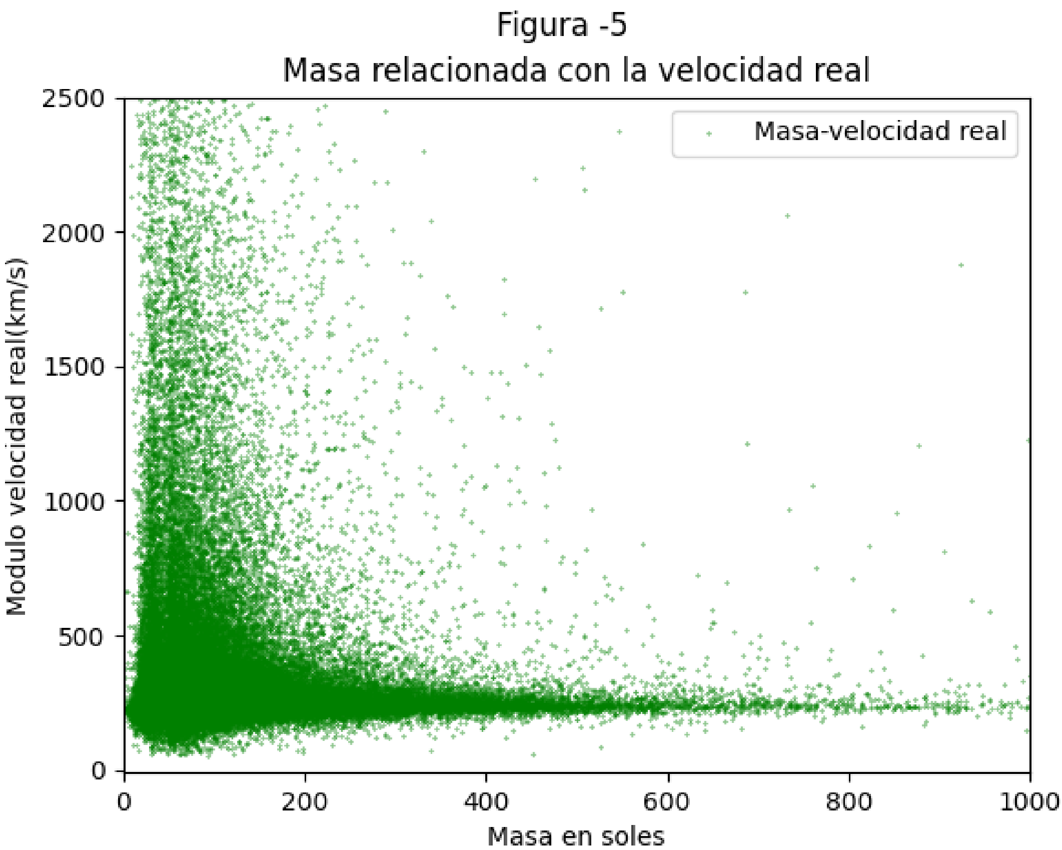
We will consider themodule component of the velocity in three dimensions as the actual velocity (v_m) of the star.

In this graph we see the difference between the magnitude of the real velocity (v_m) and the tangential velocity (v_t)



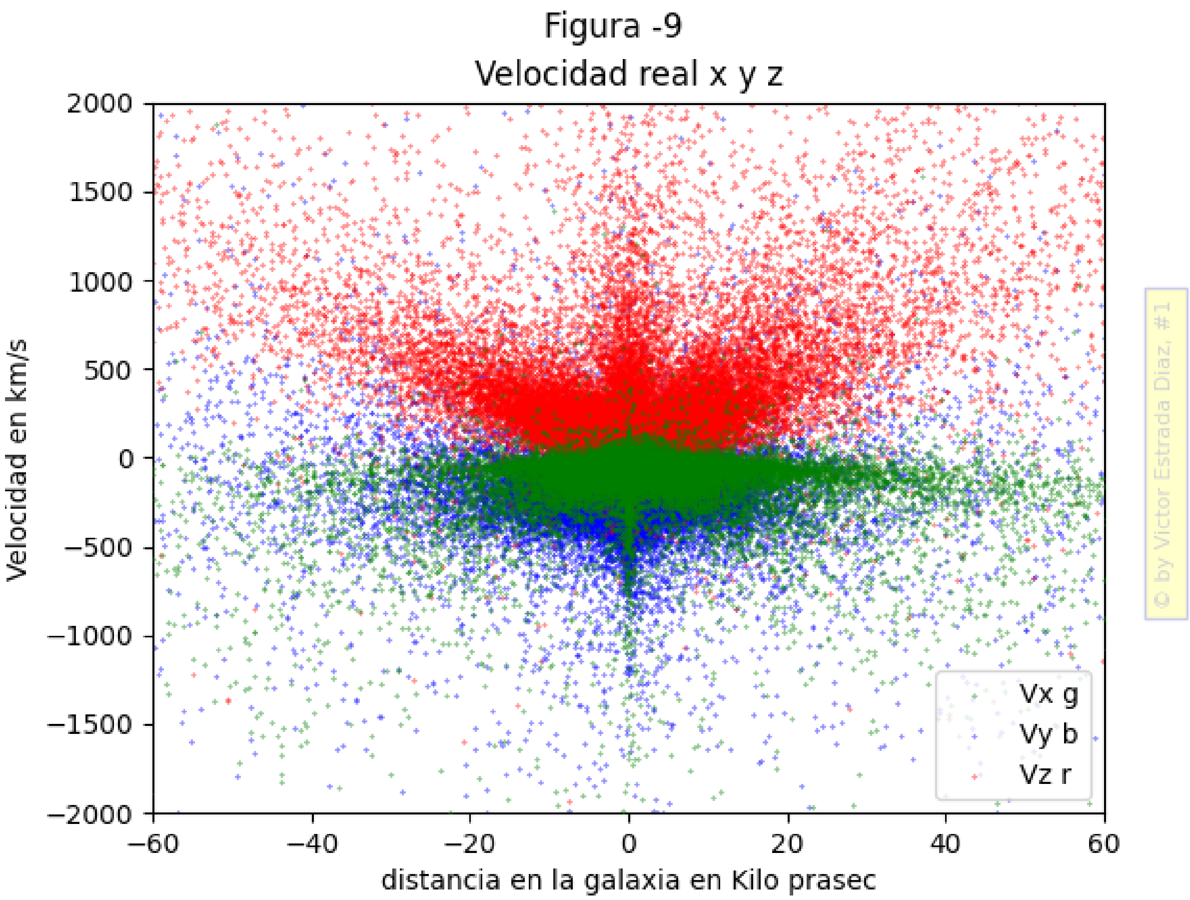
Mass and actual speed

In the following graph we see thatThe mass of the stars with respect to this real speed (v_m) strongly affects low-mass stars, reaching very high speeds while starsfurther massive ones have little speed andthis is more stable, this undoubtedly responds to the inertial moment but the form of this dependence is curious.



The asymmetry in the speed of the galaxy

Viewing the stars in the galactic plane, it is observed that the velocities increase greatly in the northern plane.further than in the southern plane, as if something was pulling on the stars to increase their speed.



Conclusions

Given the measurements provided by the excellent Gaia project, there are well-founded suspicions that the belief in the existence of dark matter to explain the speed of stars in the galaxy is notappropriate or is it an unproven conjecture.

There are reasons to argue that fundamental aspects and while we find other causes that can be proposed andWe can present a reasoned conjecture, it will also be a conjecture like that of dark matter today.

We need to present or discovera verification of our conjectures..

Or at least if this verification did not arriveto andThere are other possible explanations that must be testable, these must be refuted or confirmed..

Let us remember thatan unproven conjecture such as the existence of dark matter is asvalid like any other plausible conjecture.

But we do science with proven facts, not with hypotheses, conjectures show us the way but they are what they are, facts not yet confirmed.

- ***This is the first in a series of works -***