Spiral galaxies – explanation for their shape and the velocity curve flattening

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Abstract

Spiral galaxies pose two profound conundrums that the current cosmology has no clear answers to. I claim that the observations of the velocity curve flattening and the spiral shape of galaxies emerge from the velocity of a star in a galaxy. The star velocity is the superposition of velocities exerted on a star by the Pivot, the black hole at the center of the galaxy, and the distributed mass of the galaxy.

Problem description

Spiral galaxies pose two profound conundrums that the current cosmology has no clear answers to.

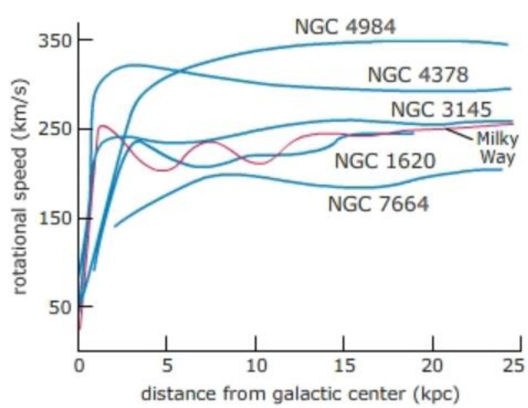

Fig. A – curve flattening

Fig. A is the velocity curve flattening of stars in galaxies. Vera Rubin and her team observed in 1970 that the velocity of stars in a galaxy does not behave as expected by Kepler's law that has been verified in the solar system. Instead of curving down after a certain peak, it stays flat. It is shown that the graph of the velocities is quite chaotic and each galaxy behaves uniquely. Physicists suggested a theory that the reason for this phenomenon can be due to the presence of an un-visible mass inside or around the galaxy. They called it dark matter and calculated its mass to be approximately 5.5 times the mass of the galaxy's visible mass. Despite an extensive search for dark matter, it was not observed anywhere in the universe and its nature is not known.

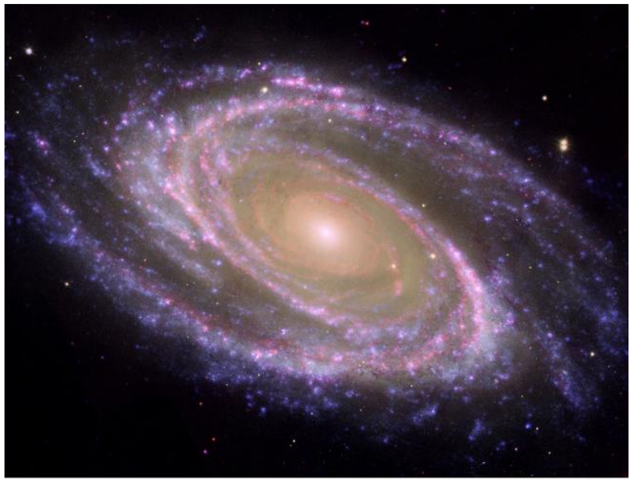

Fig. B – Spiral galaxy

Fig. B shows the spiral arms of a Galaxy. The first question is, what is the origin of the spirals and how spirals can be created in a universe that, according to the Big Bang, is expanding radially in all directions? Second, why are the arms stable after billions of years? The arms of a galaxy would become more and more tightly wound, since the matter nearer to the center of the galaxy rotates faster than the matter at the edge of the galaxy. The arms would become indistinguishable from the rest of the galaxy after only a few orbits. But galaxies performed already many orbits, for example, our Sun located 26Kly from the center of the Milky Way has completed more than 50 orbits since its creation. Other stars located closer to the center of the Milky way have completed more than 50 orbits. This is called the winding problem. In addition, observations show that each galaxy has its specific shape. It is possible to arrange the galaxies in several categories, namely, Elliptical, Irregular, Peculiar, and Spiral galaxies. In this paper, I relate to the sub-categories of spiral galaxies which are: Spiral, Barred, and Lenticular spiral galaxies. Current cosmology has no clear explanation for the various shapes of spiral galaxies.

To answer these two profound conundrums, I divide my paper into two parts. In the first part, I describe the entire structure of the universe. In the second part which is based on part 1, I relate specifically to the spiral galaxies.

Part 1- Structure of the Pivot universe.

I claim that both the phenomena of spiral galaxies emerge from the structure of the universe, which I designate the Pivot universe. I hypothesize that the Pivot universe is composed of two distinct parts: At the center of our universe resides a massive spinning black hole I designate the Pivot. Orbiting the Pivot is the visible universe in the shape of a flat disk. While spinning the Pivot, according to general relativity, drags space around it. It will be shown that the shape of dragged space is not entirely flat. However, an observer located in the visible universe can see only the flat part of the universe. The flatness of the visible universe is verified by observation. A quote from reference [1]: "….experimental data from various independent sources (WMAP, BOOMERanG, and Planck for example) confirm that the universe is flat with only a 0.4% margin of error".

It is important to note that the Pivot structure explains additional cosmological observations that current cosmology has no clear explanations for, e.g., the Michelson Morley experiment and the origin of celestial bodies spinning.

It was noted above that the Pivot is a spinning (or Kerr) black hole, therefore general relativity theory is used for the description of the universe. One of the results of general relativity is the frame-dragging of space around any spinning celestial body. This phenomenon was first predicted by Lense-Thirring in 1918 and later in 1963, it was derived from solving the Kerr metric. This prediction was verified by the Gravity Probe B experiment. Gravity Probe B measured the frame-dragging by Earth and it was found to be minuscule. However, when general relativity is used for massive celestial bodies the influence of frame-dragging is significant. In the following paragraph, I will show the influence of the Pivot on space.

According to general relativity, the angular speed $\Omega(r,\theta)$ of the co-rotating reference frame is given in Eq. 1. The angular speed is dependent on both the radius and the colatitude θ. Note: The angular speed is not dependent on an azimuthal angle because the solution is axis-symmetric. See reference [2]

$$\Omega(r,\theta)=\frac{R_H\cdot\alpha\cdot r\cdot C}{(r^2+\alpha^2\cdot\cos^2\theta)(\mathrm{r}^2+\alpha^2)+R_H\cdot\alpha^2\cdot r\cdot\sin^2\theta} \qquad \text{(Eq. 1)}$$

The velocity of space about the Pivot is:

$$V_{pivot}(r,\theta)=\Omega(r,\theta)\cdot \mathrm{r} \qquad \text{(Eq. 2)}$$

In this paper, the following constants and variables are used. The derivation of these parameters is given in [3]:

$M_{pivot}=7.82\cdot 10^{53}kg$ ...Mass of the Pivot

$J_{total}=2.13\cdot 10^{87}J\cdot\mathrm{s}$ ...Total angular momentum of the universe

$\alpha=\frac{J_{total}}{M_{pivot}\cdot C}=0.96\cdot Gly$

$R_H=122.75\cdot Gly$ ...Schwarzschild radius of the Pivot

$R_{in}=122.88\cdot Gly$ ... Inner radius of visible universe disk

$R_{mw}=123.36\cdot Gly$ ... Milky Way radius

$R_{out}=175.57\cdot Gly$ ... Outer radius of visible universe disk

Fig. 1 shows the velocities of space about the Pivot (Eq. 2) for two cases:

1) Colatitude angle $\theta=0\deg$ i.e., on the axis of rotation

2) Colatitude angle $\theta=90\deg$,i.e., on the equatorial plane of the Pivot.

From the graph, it is shown that the velocities near the Pivot reach 32C for $\theta=0\deg$, and 2.5C at $\theta=90\deg$. At a distance near the inner radius of the disk (~123Gly) space velocity drops substantially to ~2300km/s.

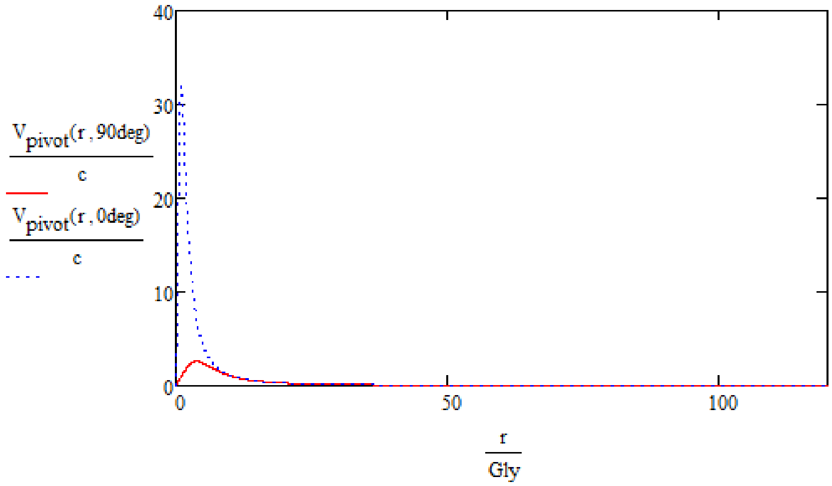

Fig. 1 – Velocity of space about the Pivot

Fig. 2 is a schematic cross-section of the entire universe based on Fig. 1. The event horizon sphere is also shown. The visible universe is the flat disk that is located outside the event horizon. The approximate location of the Milky Way is shown. My main claim is that the Milky Way, like all other celestial bodies, is dragged by space at the velocity that is calculated by general relativity V_{mw_gr}, but simultaneously this velocity must be equal to the velocity $V_{mw-Newton}$ that is calculated by Newton's gravitation law.

This claim solves the ongoing dispute raised by Michelson and Morley's experiment (MME). There exists a stationary vacuum space (or aether), but around the Pivot space is dragged. Celestial bodies located in the dragged space move at the same velocity as space. There is no relative velocity between them and space. This explains the MME results that there is no relative velocity between Earth and space. On the other hand, the situation differs for a celestial body 1 that is located at the same distance from the Pivot as the Milky Way, but, in the stationary space, rather than in dragged space. Calculating the velocity of body 1 according to Newton's law gives: $V_{cb1} = \sqrt{\frac{G \cdot M_{pivot}}{R_{mw}}} = 0.7C$. At such a velocity the friction between space and celestial body 1 is such that it will spiral into the Pivot. This result applies to any other celestial body that is located in the stationary space. In other words, no celestial body can exist, for a long time outside the region of dragged space. A celestial body will be attracted by the gravity of the Pivot. While approaching the Pivot the velocity of space becomes bigger than the speed of light, thus the matter of any celestial body that approaches the Pivot will be transformed into radiation and will be ejected through the poles of the Pivot. A similar phenomenon has been observed in many black holes.

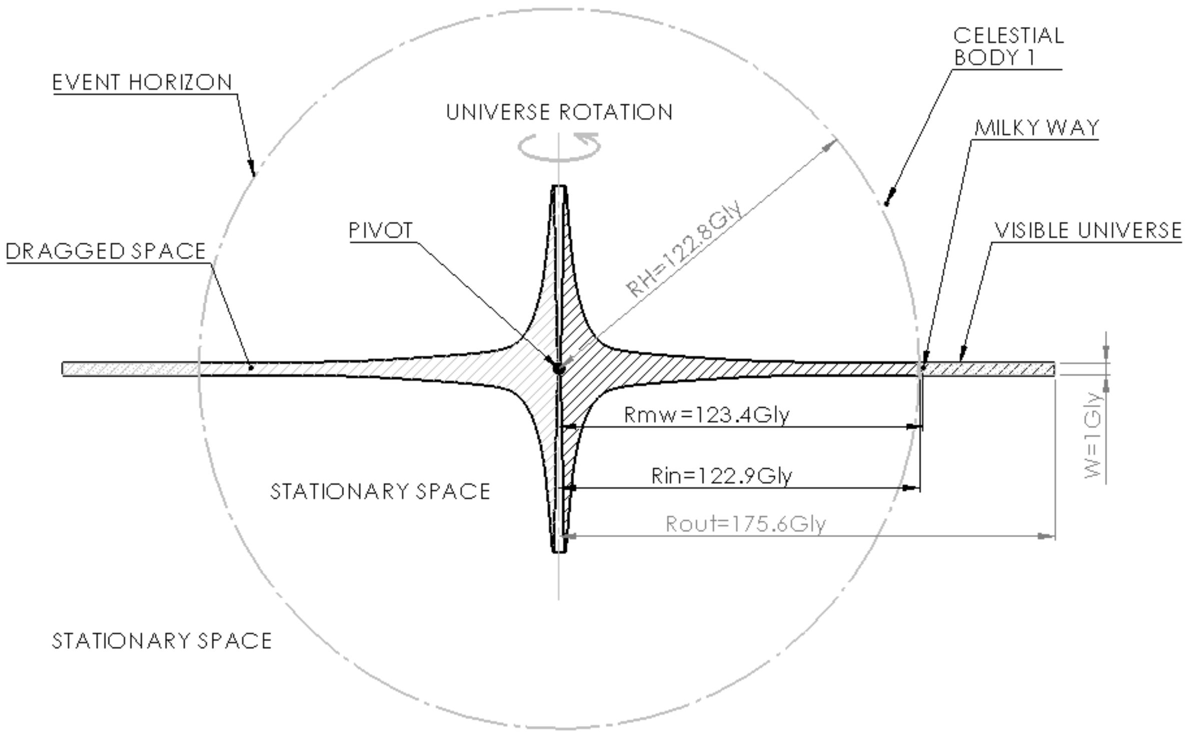

Fig. 2 – Shape of the entire Pivot universe

The region of the sphere with a radius smaller than R_H (i.e., the event horizon) cannot be seen by an observer located in the visible universe e.g., the Milky Way. Therefore, we can simplify (Eq.1) by substituting $\theta = 90\,\deg$. This gives:

$$\Omega(r) = \frac{R_H \cdot \alpha \cdot C}{r^3 + \alpha^2 \cdot r + R_H \cdot \alpha^2} \quad \text{(Eq. 3)}$$

Fig. 3 is the plot of (Eq. 3). It shows that space in the Pivot's equatorial plane has a spiral shape. I postulate that the gravity force that attracts the Milky Way to the Pivot, propagates along the geodesic presented by the spiral, rather than the straight line connecting the centers of the Pivot and the Milky Way. To equate the velocity of dragged space and the velocity of the Milky Way according to Newton's gravitational law, the distance according to Newton's gravitational law between the Pivot and the Milky Way (R_{mw}) must be replaced with the length of the spiral (L_{mw}), shown in the figure.

The reader is referred to [4], where these concepts of geodesics are used for the solar system and a neutron star.

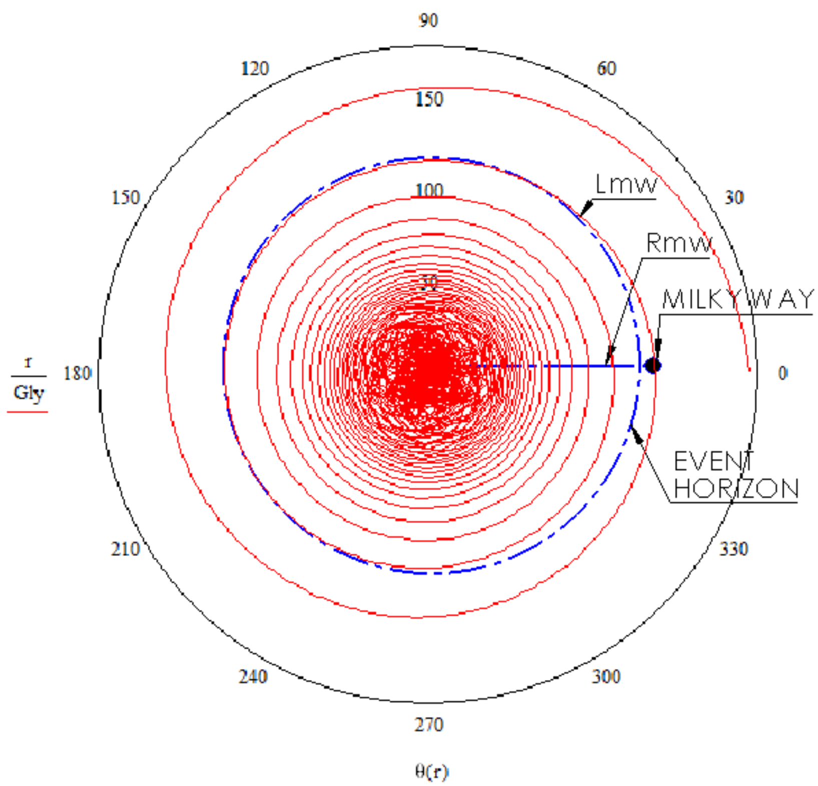

Fig. 3 – dragged space on the Pivot's equatorial plane

$$\text{Calculation of GR frame} - \text{dragging Vs. Newton's gravitational law of Milky Way around the Pivot}$$

According to general relativity:

$\Omega(\mathrm{R}_{mw}) = 6.28 \cdot 10^{-14} \cdot \frac{rad}{yr}$ ....The angular velocity of Milky Way around the Pivot - From (Eq. 3)

$V_{mw\_gr} = \Omega(R_{mw}) \cdot R_{mw} = 2321 \cdot \frac{km}{s}$ ....The velocity of Milky Way around the Pivot

$T(R_{mw}) = \frac{2 \cdot \pi}{\Omega(\mathrm{R}_{mw})}$ ....The rotation time of Milky Way around the Pivot

Finding the length of a geodesic L_{mw} is done by using the formula of spiral length:

$$L_{mw} = \int_0^{R_{mw}} \sqrt{\left[1 + \left(\tfrac{d}{dr}\left(r \cdot \Omega(r) \cdot T(R_{mw})\right)\right)^2\right]} \cdot \mathrm{dr} = 5.22 \cdot 10^5 \cdot \mathrm{G} \text{ ....Length of geodesic - Pivot to Milky Way}$$

Newton's gravitational law:

$V_{mw-Newton} = \sqrt{\frac{G \cdot M_{pivot}}{L_{mw}}} = 3250 \cdot \frac{km}{s}$ ....The velocity of Milky Way according to Newton's law

Comparing the two calculated velocities gives: $\frac{V_{mw-Newton}}{V_{mw\_gr}} = 1.4$

There is a discripancy between the two velocities. I do not know yet, what are the reasons for this discripancy. It should be noted that in reference [3] , I used parameters that are based on observations that are not firmly verified. For example: what is the maximum acceleration posible in the universe? and how accurate is Birch's estimation on the angular velocity of the universe?

The origin of the spinning of celestial bodies

An additional observation that is explained by the Pivot structure is that all celestial bodies spin. I postulate that space has viscosity. On the surface of the Pivot, the viscosity is enormous. That makes the dragging of space possible. However, in the visible universe, far away from the Pivot, the viscosity is reduced substantially. Nevertheless, the viscosity is still sufficient to cause the spin of celestial bodies. It is shown in Fig. 4 that all celestial bodies spin in the same direction CW, which is opposite to the Pivot and the entire universe rotation

CCW. A detail of a celestial body in the right part of Fig. 4, shows that the velocity $V_2 < V_1$, therefore the celestial body must rotate CW.

I claim that the frame-dragging of space resembles the viscous fluid flow. An experimental proof that a rigid body that is submerged in a viscous fluid spins and rotates is given by Prof. Taylor in the video [5], starting at 3:38 minutes. The theory of this experiment is the Stokes flow that describes a low Reynolds number flow, i.e., a flow where the inertial forces are small compared to the viscous flow. It can be shown that the inertial forces in the Pivot universe are small compared to the viscous forces. I claim, without verification, that it is possible to derive the shape of dragged space around the Pivot by using Stokes equations, however, for this end, one must define the viscosity of space as a function of gravity. Using general relativity equations is simpler because it is not required to define the viscosity of space. Please note in the experiment that the motion of the rigid ring submerged in the viscous fluid stops immediately as the cylinder stops rotating. Returning to the Pivot universe - I claim that all celestial bodies in the universe that are located in the dragged vacuum space will spin and rotate as long as the Pivot spins. As the Pivot is composed of nucleons that have an intrinsic spin, most probably the Pivot will spin forever. Therefore, I claim that the visible universe will also exist forever.

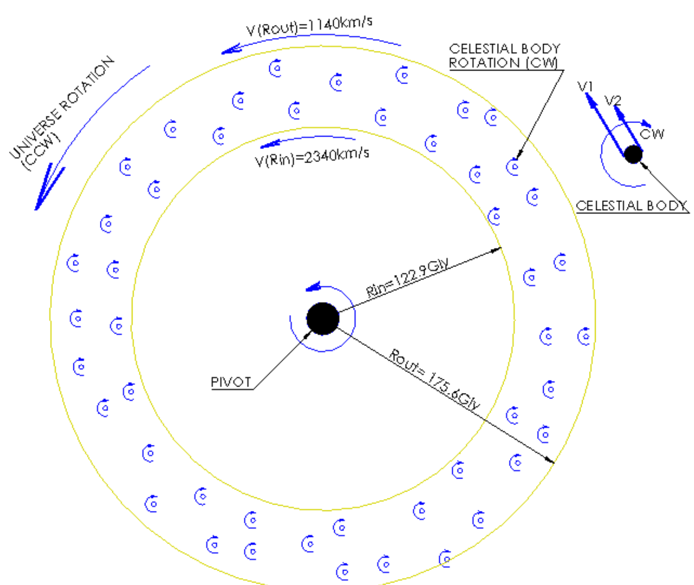

Fig. 4 – Spinning of celestial bodies

Part 2- Spiral galaxies.

Galaxies formation

After the explosion of the primeval nucleus, the disk-shaped visible Universe contained a very hot soup of nucleons that orbited the Pivot. It took the visible Universe 380,000 years to cool down. When this happened, ordinary atoms were formed.

The celestial bodies were created as a result of atoms attracting each other by gravity. The local density of the visible Universe was the cause of the variety of celestial bodies, i.e., dust, stars, neutron stars, and galaxies. If the density of atoms at a particular region in the visible universe ring was too low to enable significant attraction between them, they remained as a cloud of gas that orbits the Pivot. However, if the density of atoms was sufficient for interaction between them, stars were created. Sometimes it happened that stars were born far from the gravitation of other stars and therefore they continue to orbit the Pivot as "lonely" or intergalactic stars. The variety of celestial bodies is dependent on the mass of the born star. Some stars had enough mass to collapse into neutron stars. Galaxies were formed if the density in a certain location was big enough it collapsed into a black hole. In any case, the galaxy formation started with a seed black hole. This black hole forced other stars to orbit it. New stars were attracted to the young galaxy by the gravity of the distributed mass of the new galaxy, rather than the gravity caused by the seed black hole. The size and shape of a galaxy were dictated by how much matter was in the vicinity of the galaxy. The mass of the seed black hole may vary from several Sun masses to a supermassive black hole. For example, the black hole of the M101 (Pinwheel) galaxy is estimated to be 20 to 30 Sun-masses, whereas the Milky Way black hole is 4.1 million Sun-masses.

To sum up, the shape of a galaxy (spiral, barred, and Lenticular) is dependent on the mass of the black seed hole, and the mass of the entire galaxy. In the next paragraph, I calculate the shape of a spiral galaxy depending on these parameters.

Model of a galaxy

Fig. 5 describes schematically the velocities of a star in a galaxy. The star velocity is a superposition of the star velocity around the Pivot and the black hole at the center of the galaxy. The Milky Way is also shown as the observer location.

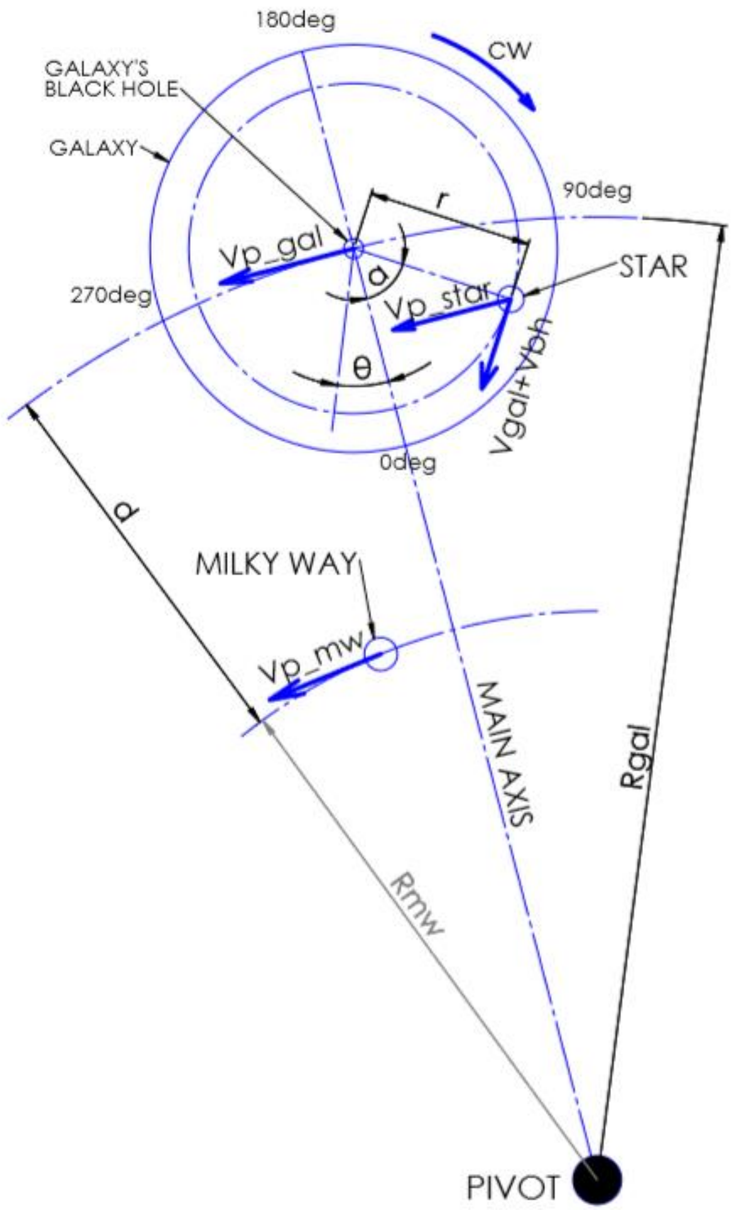

Fig. 5 – Velocities of a star in a galaxy

The velocities on a star in a galaxy are caused by:

a) Distributed mass of the galaxy.

b) The Blackhole in the center of a galaxy.

c) The Pivot.

Three cases that present the sub-groups of spiral galaxies are analyzed:

a) PinWheel Spiral galaxy NGC5457 (M101)

For calculating the stars velocities, the following parameters are used:

$M_{gal} = 100 \cdot 10^9 \cdot M_{sun}$ … is the mass of a galaxy

$M_{bh} = 20 \cdot \mathrm{M}_{sun}$ ...is the mass of the galaxy black hole

$d = 21Mly$ ... distance Milky Way to the galaxy

$R_{gal} = R_{mw} + d$ ...is the distance between the galaxy and the Pivot.

$r = 0...85\,\mathrm{Kly}$ ...is the distance from the star to the black hole of the galaxy

$r_0 = 85\,\mathrm{Kly}$ ...is an assumed characteristic radius of the distributed mass in the galaxy.

$V_{sun\_bh} = 230 \cdot km/s$ ...is the velocity of the Sun around the Milky Way black hole

$\alpha = 0 \cdot Deg..360 \cdot Deg$ ...Angle, see Fig. 5

b) NGC2787 lenticular galaxy

For calculating the stars velocities, the following parameters are used:

$M_{gal} = 5.5 \cdot 10^8 \cdot M_{sun}$ … is the mass of the galaxy.

$M_{bh} = 4.1 \cdot 10^7 \cdot \mathrm{M}_{sun}$ ...is the mass of the galaxy black hole.

$d = 25Mly$ ... distance Milky Way to the galaxy

$R_{gal} = R_{mw} + d$ ...is the distance between the galaxy and the Pivot.

$r = 0...9\,\mathrm{Kly}$ ...is the distance from the star to the black hole of the galaxy

$r_0 = 8\,\mathrm{Kly}$ ...is an assumed characteristic radius of the distributed mass in the galaxy.

$V_{sun\_bh} = 230 \cdot km / s$ ...is the velocity of the Sun around the Milky Way black hole

$\alpha = 0 \cdot Deg..360 \cdot Deg$ ...Angle, see Fig. 5

c) Milky Way - barred spiral galaxy

For calculating the stars velocities, the following parameters are used:

$M_{gal} = 5.5 \cdot 10^8 M_{sun}$ … is the mass of the Milky Way

$M_{bh} = 4.1 \cdot 10^6 \cdot \mathrm{M}_{sun}$ ...is the mass of the Milky Way black hole

$d = 0 \cdot Mly$ ... distance Milky Way to itself

$R_{gal} = R_{mw} + d$ ...is the distance between the galaxy and the Pivot.

$r = 0...60\,\mathrm{Kly}$ ...is the distance from the star to the Milky Way black hole.

$r_0 = 20\,\mathrm{Kly}$ ...is an assumed characteristic radius of the Milky Way.

$V_{sun\_bh} = 230 \cdot km / s$ ...is the velocity of the Sun around the Milky Way black hole

$\alpha = 0 \cdot Deg..360 \cdot Deg$ ...Angle, see Fig. 5

a) The velocity of a star is due to the distributed mass of the galaxy.

Note: This calculation is according to the Newtonian shell theorem. This is an approximation because the Newton shell theorem relates to a sphere and a galaxy has a thin-disk shape. However, the measurements of a galactic rotation curve of spiral galaxies reveal that the rotation velocity $V_{gal}(r)$ is similar to a sphere. It rises linearly from the galactic center to a characteristic radius r_0 and then bends down to reach an approximately constant value extending to the galactic periphery. The problem in this approach is that the value of r_0 is estimated. More accurate mathematical solutions were suggested for the thin-disk shape galaxy. For example, see [6]

$$V_{gal}(r) := \begin{cases} \left(\dfrac{G \cdot M_{gal}}{r_0}\right)^{0.5} \cdot \dfrac{r}{r_0} & \text{if } 0 \cdot Kly < r \le r_0 \\ \left(\dfrac{G \cdot M_{gal}}{r}\right)^{0.5} & \text{else} \end{cases}$$

b) The velocity of a star around the galaxy's black hole

$$V_{bh}(r) = \left(\frac{G \cdot M_{bh}}{r}\right)^{0.5}$$

Note - Although the central black hole of a galaxy is massive it influences only the near region around it. Its influence on the entire galaxy is negligible. Newton’s law is applicable here because frame-dragging is only near the black hole of the galaxy.

c) The velocity of a star in a galaxy orbiting the Pivot:

$$V_{p\_star}(r,\alpha) = \Omega\ (R_{gal}) \cdot (R_{gal} - r \cdot \cos(\alpha))$$

<u>Summation of the three velocities on the star gives:</u>

$$V_{sum}(r,\alpha) = V_{p\_star}(r,\alpha) + (V_{gal}(r) + V_{bh}(\mathrm{r})) \cdot \cos(\alpha)$$

Orbital velocity of Milky Way around the Pivot:

$$V_{p\_mw} = \Omega(R_m) \cdot R_{mw} = 2320 \frac{km}{s}$$

The velocity of a star in a galaxy as seen by an Earth observer is given by:

$$V_{star}(r,\alpha) = V_{p\_mw} - V_{sum}(r,\alpha) + V_{sun\_bh} \qquad \text{(Eq. 4)}$$

Eq. 4 explains the curve flattening and the shape of a spiral galaxy.

The velocity flattening of a spiral galaxy

Fig. 6a, Fig. 6b, and Fig. 6c are the curves of a star velocity in a galaxy. It is shown that each galaxy behaves differently. But in all graphs, the velocity curve is flattened out as r becomes bigger. The curve is also dependent on α. The closer α to 90deg or 270deg the curve is flattened out. In any case, all the velocity curves are confined between the two extreme curves of the graph (the red and the dotted blue).

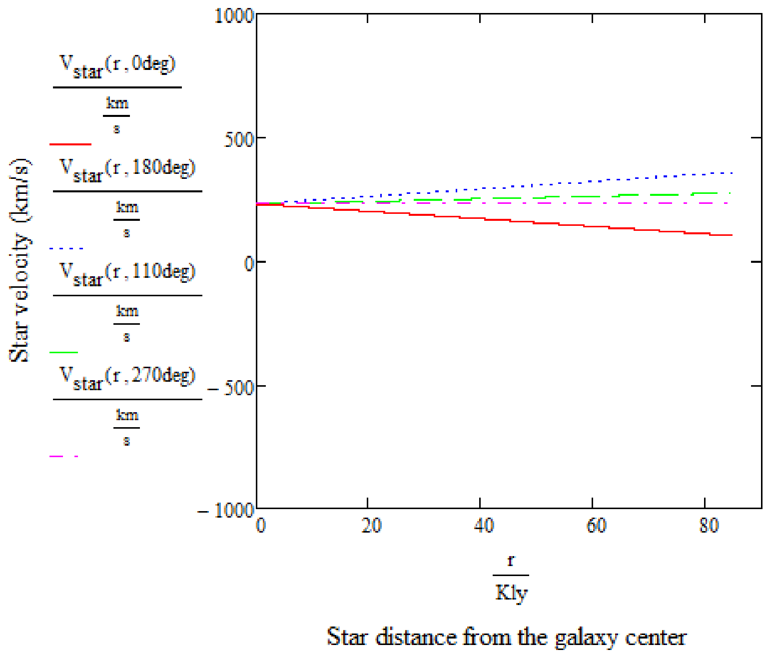

Fig. 6a – PinWheel spiral galaxy NGC5457 (M101)

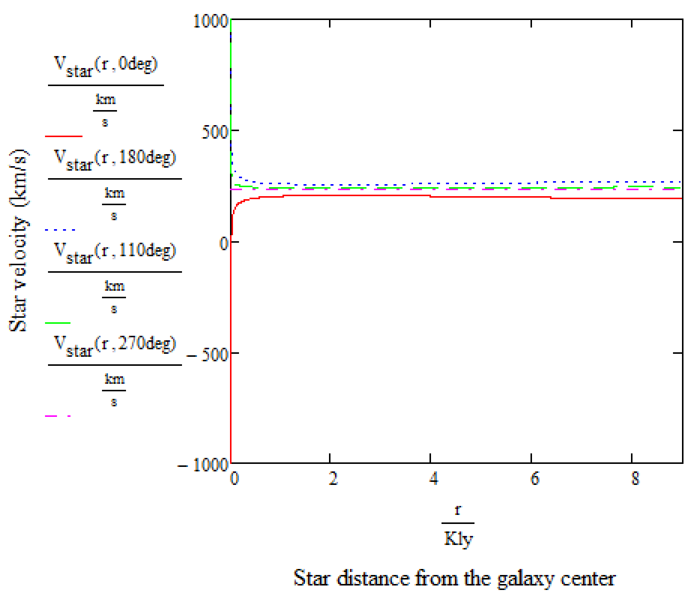

Fig. 6b – NGC2787 lenticular galaxy.

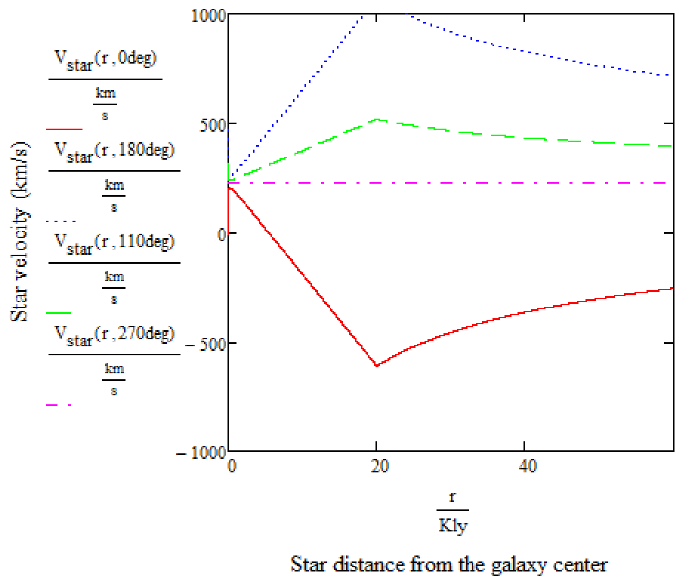

Fig. 6c – Milky Way barred spiral galaxy.

The shape of a spiral galaxy

The angular displacement, during the elapsed time t, of a star orbiting the galaxy's black hole is designated (θ) (See Fig. 5). $\theta(r,\alpha) = \int_0^t \frac{V_{star}(r,\alpha)}{r} dt$, where $V_{star}(r,\alpha)$ is given in (Eq. 4). Fig. 7a, Fig. 7b, and Fig. 7c show the shape of a spiral shape galaxy 13 billion years after its creation. The calculated shape is compared to the picture of the galaxy. (Note: The reason for using the modulo operator in the following equations is that stars in Galaxies have completed by now many full rotations around the galaxy's black hole).

$$\theta_1(r,\alpha) := \mathrm{mod}\left[\left[\int_{0yr}^{t} \frac{V_{star}[r,(\alpha)\cdot deg]}{r}\, dt\right]\cdot deg, 360deg\right]$$

$$\theta_2(r,\alpha) := \mathrm{mod}\left[\left[\int_{0yr}^{t} \frac{V_{star}[r,(\alpha)\cdot deg]}{r}\, dt\right]\cdot deg, 360deg\right] + 180deg$$

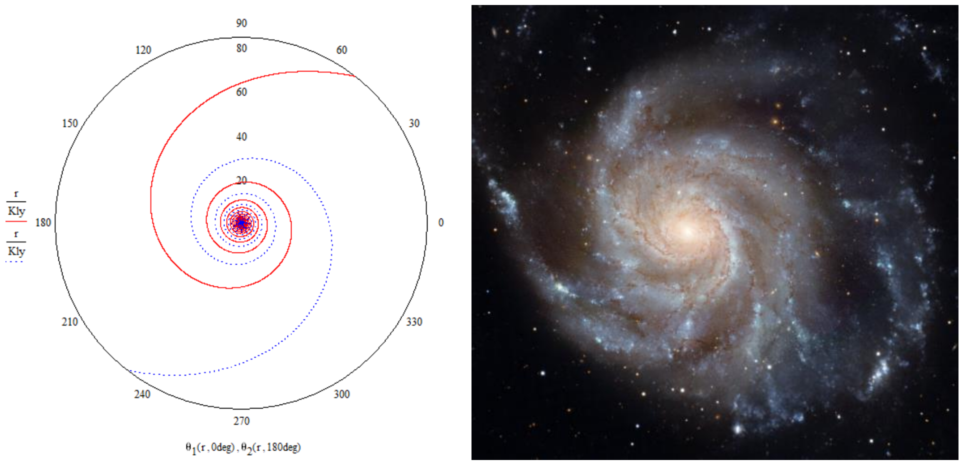

Fig. 7a –Shape of a PinWheel spiral galaxy NGC5457 (M101)

Note: This galaxy has a clearly defined and well-organized spiral structure.

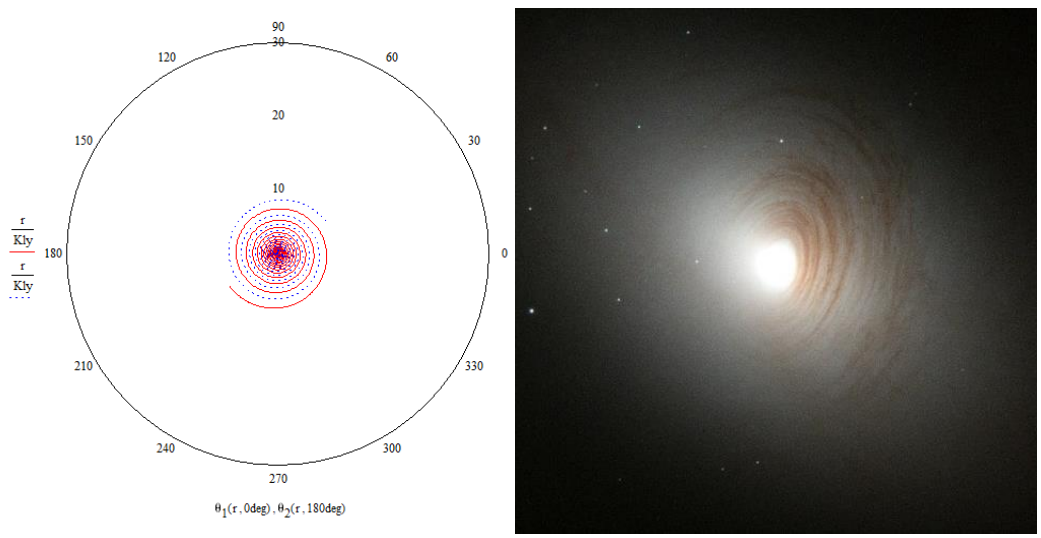

Fig. 7b –Shape of NGC2787 lenticular galaxy

Note: The galaxy contains a large-scale disc but does not have large-scale spiral arms.

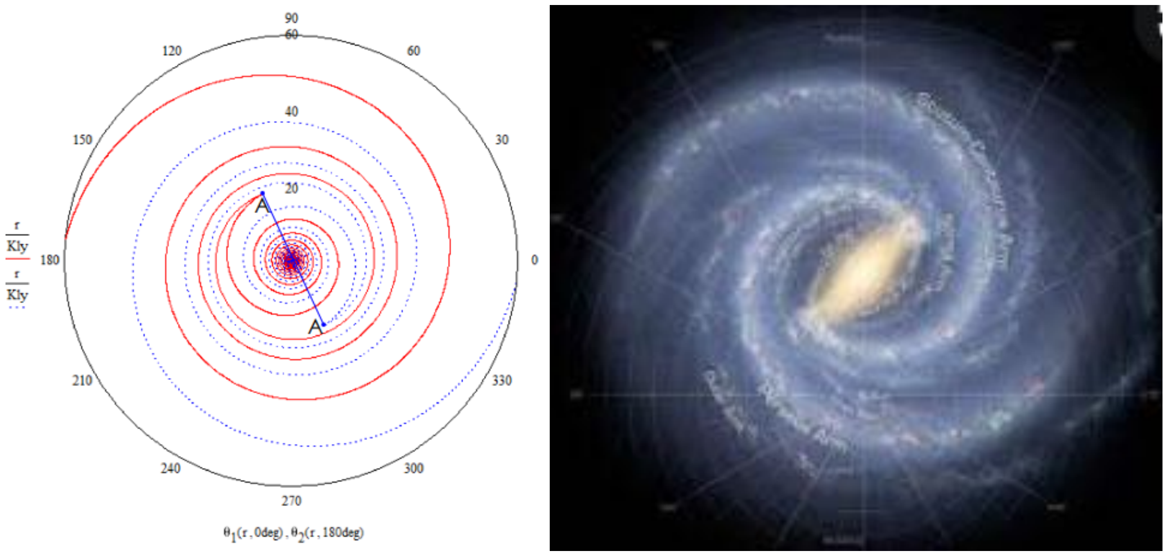

Fig. 7c – Shape of the Milky Way – barred spiral galaxy

Note: The two points A that are shown in this graph are stagnation points where the local velocity of stars is zero. At these points, the velocity caused by the Pivot's frame-dragging is equal to the velocity caused by the galaxy (except for opposite directions). I claim that the line connecting the two points represents the bar of the galaxy.

Conclusion:

The observations of the velocity curve flattening and the spiral shape of galaxies emerge from the velocity of a star in a galaxy. The star velocity is the superposition of velocities exerted on a star by the Pivot, the black hole at the center of the galaxy, and the distributed mass of the galaxy.

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