Spiral Arm and Galactic Bar Formation Mechanisms

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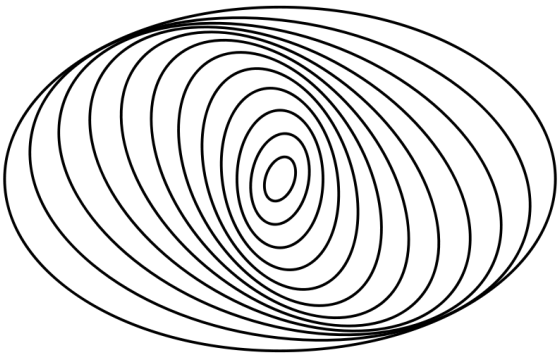
Abstract: *The universe does NOT have an instruction manual to use on itself. The way things work can only be very simple and automatic. Spiral arms and or galactic bars are no exception, they are formed by 4 simple mechanisms: Group mass, Orbit lag, Star lag, and Triple focus.*

How are galactic spiral arms formed?



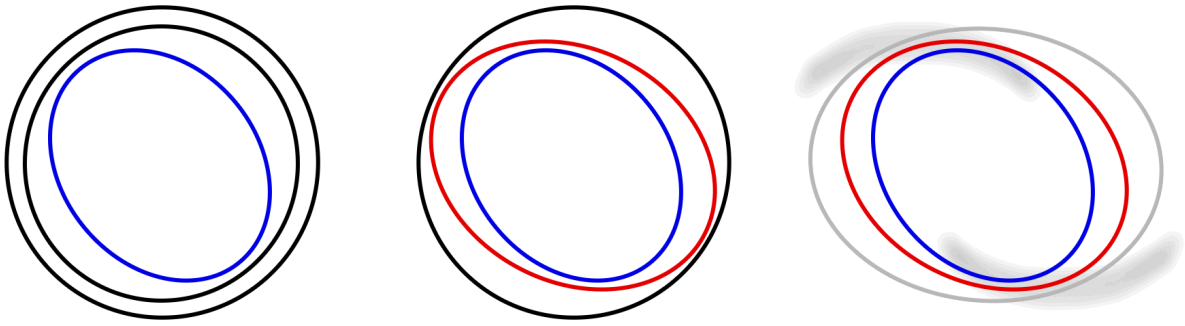
Stars orbit around the galactic center in elliptical orbits.
The stars in the central bulge are also revolving and stars further away from center lag behind in their orbital position.
The result is concentric ellipses that are rotated in relation to each other.

It is easy to see the orbits of nearby stars within a certain distance from center will intersect, that creates an higher density region of stars - the spiral arm
Notice the spiral arm cannot "wind-up" because it is only an emergent property of star intersections, all stars stay basically in their own orbits.

Note: the stars are of course orbiting but the orbits are actually not being rotated.
The "lag" is caused by the spiral arms. The spiral arms are a mechanism the changes the speed and path of stars in a galaxy.

The Spiral Arm Build

All you need is one star in an elliptical orbit to start a chain reaction and an entire spiral galaxy will form.
Notice the stars in the blue elliptical orbits can affect the black circular orbits by changing their speed and direction.
That will form a spiral arm form near the vertices of the ellipses.
The black inner stars are orbiting clockwise and when they intersect with the blue elliptical orbit (near the vertex) they get sped up and pulled towards the spiral arm. That changes the speed and path of the inner black circular orbit into the red elliptical orbit.



The red orbit is now elliptical and its shape has changed so its vertex now reaches to the outer black circular orbit.
As a result the stars in the black outer orbit are also sped up and pulled toward the red elliptical vertex as they approach it. That creates another section of spiral arm by adding more stars to it.
This same process happens over and over and over until the spiral arms encompass the entire outer reaches of the galaxy.

Notice the red and blue orbits are completely different and independent of each other but during the intersection the orbits overlap and they affect each other

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Outer Rotation Speeds
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Stars in a galaxy (outside of the bulge) in the spiral arms travel at basically the same speed. But it takes the stars out at the furthest reaches of the galaxy a lot longer to make an orbit than those right near the bulge (but only because the stars have to travel a much greater distance).
It is easy to see in the infinite train loop video. The railroad cars are all traveling at the same speed but the outer cars have further to travel.

This means there are two different types of lag in a spiral arm.
● The Star Lag: Individual stars in an outer orbit lag behind inner stars as they travel. i.e. the inner cars are continually passing the outer cars even though they are traveling at the same speed.
● The Orbit Lag: The outer orbits (as a whole) lag behind the inner orbits, but the positions do not change. i.e. the train tracks stay in the same place.
Note: the train tracks are circular and spiraling inward. In a galaxy the orbits (the tracks) would be elliptical and individual closed loops.

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Inner Rotation Speeds
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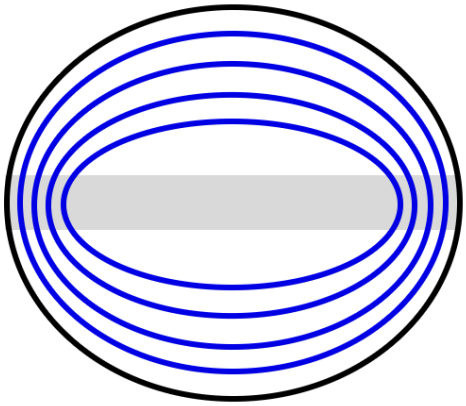

The stars in the central bulge are a different story. They rotate as if it were a solid object, like a disc.
Example: the outer edge of a Frisbee is spinning faster than the center.
So, as you move away from the galactic center - the speed of the stars keeps increasing. But that process stops right at the edge of the bulge.
The edge of the bulge is called the corotation circle, it is the circle around the galactic center of a spiral galaxy where the stars move at the same speed as the spiral arms.
The outer edge of the bulge is where the spiral arms start to form and from there on out all of the stars travel at about the same speed.
Notice in the central bulge there is NO star lag NOR orbit lag. So, the elliptical orbit paths and the high density region of stars are lined up.

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A Spiral Arm and a Bar are The Same Thing?

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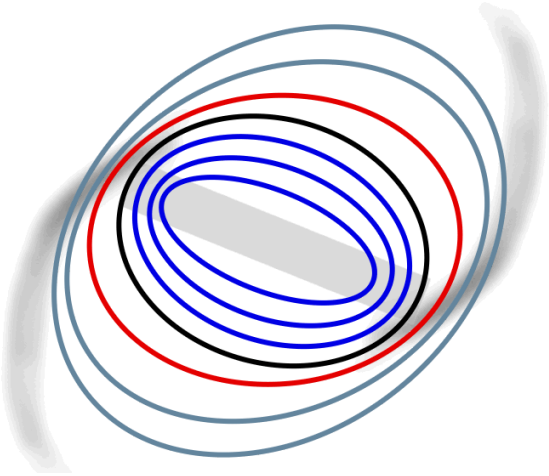
Yes, the only difference is the speed of the stars.
When stars are traveling at the same speed: the spiral arm changes the trajectory of the orbits so they lag. That is the orbit lag.
Stars form spiral arms because of star lag and orbit lag.
In the central bulge there is NO orbit lag NOR star lag.
The stars in the bulge are traveling as if they were a solid object.
So, the spiral arm is straightened out into the galactic bar shape.
The high density region (the bar) is now near the vertices of the elliptical orbits.



The same thing goes for any other star orbits passing through the bar - they will be converted into high speed elliptical.
The bar started to form in the center of the galaxy then keeps building outward.

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The Group Mass

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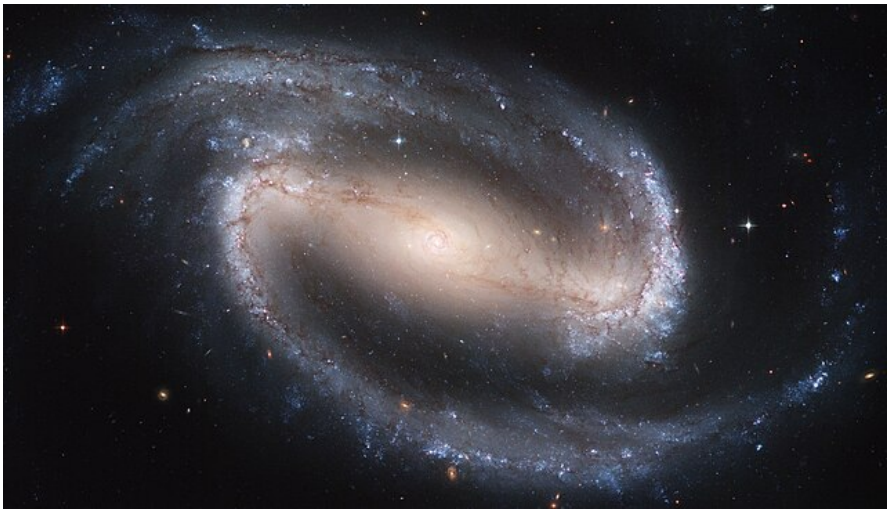
Galactic Bar

If you have one stacked deck of playing cards: there are 52 cards lined-up.
If we call that a group mass, the group mass would be 1 x 52.
One more card placed on the end would only feel the gravitational effect of 1 x 52 cards.

With 12 decks the group mass is of course 12 x 52.
A single card placed on the end would feel a massive 12 x 52 group mass or force of gravity.
That is the way the group mass in a galactic bar works.
There would be a black hole in the center of a galaxy, then as you move out and away from the center: there is an ever increasing number of stars in the bar. Stars with a greater distance away from the center will cut through the galactic bar at different distances.
The further away a star is from the center: the more force and thereby orbital speed it will experience in its orbit due to the group mass.
i.e. the force created by the bar type group mass increases with distance.

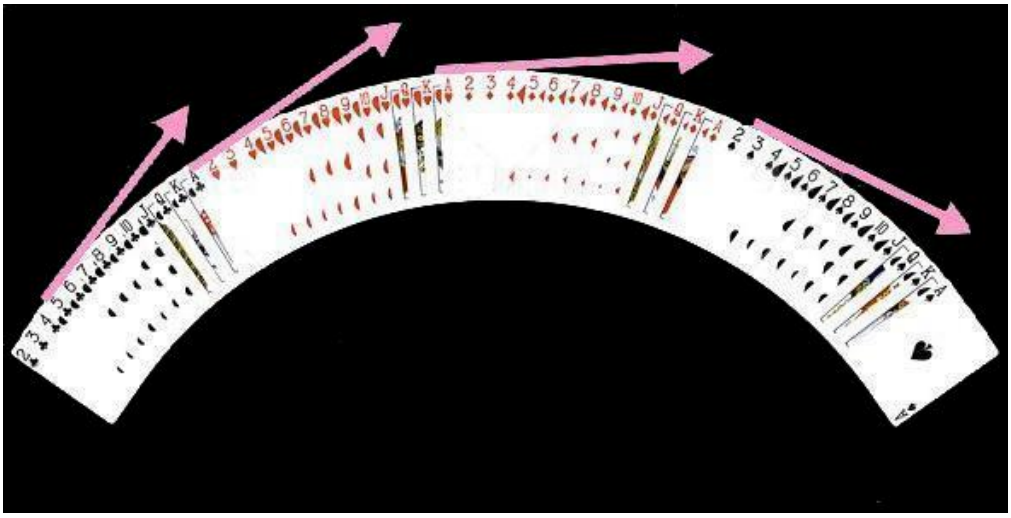


Barred spiral galaxy NGC 1300 photographed by Hubble telescope.

If you zoom in you can actually see everything happening: orbit shapes, spiral arm being straightened out into a bar, gas being trapped on one side, etc.

Spiral Arm

The spiral arm works exactly like the bar except it is spread out.
When a star is being pulled toward and then passing through a spiral arm the amount of group mass stays basically the same regardless of distance from center of galaxy.
Notice when the cards are spread out: the thickness through the deck is only about 3 or 4 cards and it stays the same.
So, the effect the group mass has on a passing star at any distance from center of galaxy would be the same and the stars in a spiral arm would all have basically the same speed.



The spiral arm pulls stars in then spits them out at the same speed but in different directions because of the different curvature at different distances.
Now it is easy to see where orbit lag comes from.
i.e. the force created by the spiral arm type group mass stays the same with distance.

Galaxy M101 (Messier 101, The Pinwheel Galaxy), 25 million light years away.
Has a beautiful mathematical curve known as a logarithmic spiral.

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Triple Focus - The Trifecta

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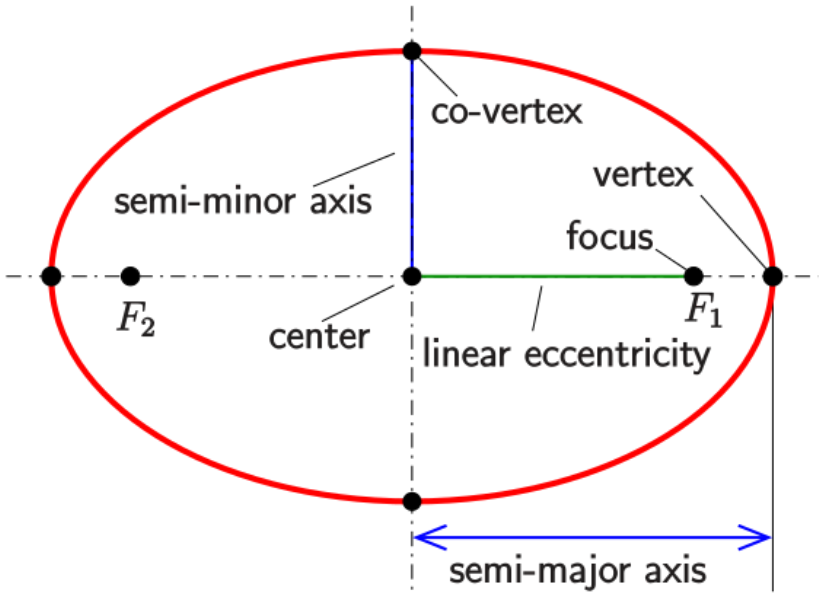
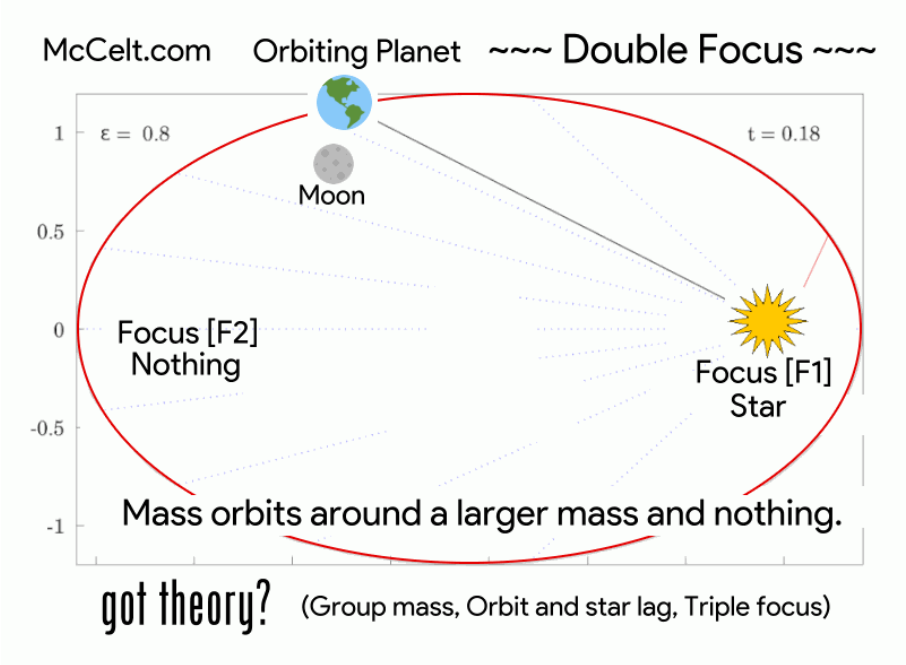
In the 17th century, Johannes Kepler discovered that the orbits along which the planets travel around the Sun are ellipses with the Sun at one focus, and described this in his first law of planetary motion. Later, Isaac Newton explained this as a corollary of his law of universal gravitation.



In our solar system the sun would be at one focus and a planet like the earth would be following the red elliptical orbit.

Solar Orbits

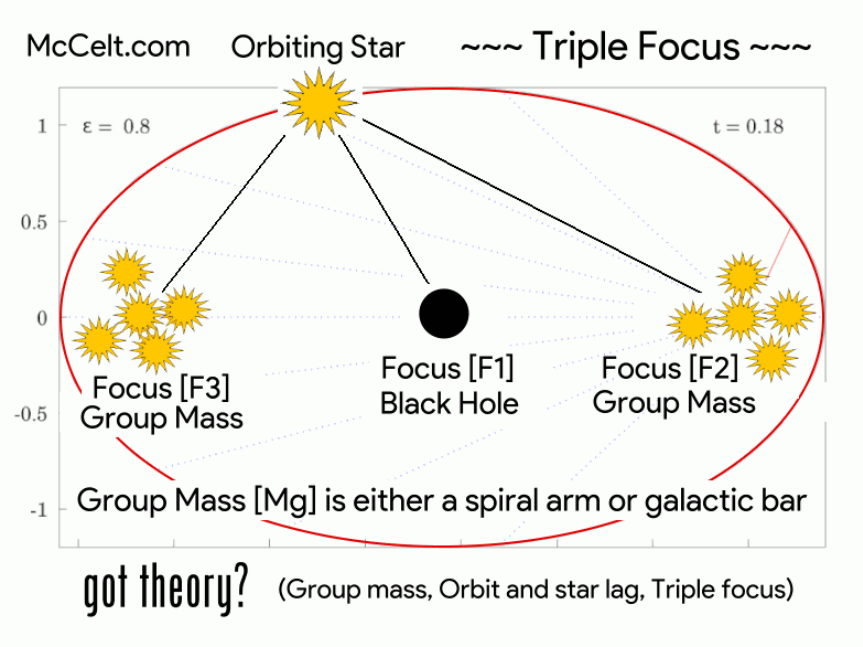
Here is an animation from wiki that shows the sun and a planet (click for animation).
This is one mass (earth) orbiting around a larger mass (sun).



Kepler and Newton orbits are one-to-one elliptical with one star (like the sun) at one focus and one planet tracing out the elliptical path. The other focus is an empty spot in space with no effect on the orbit.

Galactic Orbits

This is the equivalent of one mass (a star) orbiting around three masses.
The central black hole is the original focus (but after a certain distance the gravitational effects of the black hole becomes negligible).



The two additional foci are created by the spiral arms and or the bar.
If a star passes through a spiral arm or the bar during its orbit it will have a triple focus.
Note: The double or triple focus ellipse with mass at every focus is a game changer.
Kepler and Newton are in the clear because they didn't even know about galaxies, everyone else missed the boat.

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Orbital Rotation Bulk Intersection Theory

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Stars are NOT slowed down as they enter a dense star region "like a traffic jam" from density wave theory.
Any star that enters a density wave will be sped up to the speed of the wave.
It is something like a river with all of the water flowing at the same speed, anything that enters the river will assume the same speed as the river.

Every star in a galaxy will interact with neighboring stars from inner and outer orbits during the journey.
The intersection wave forms a continuous spiral but it is made from billions and billions of individual and overlapping orbit intersections.
Notice this is also a way for a galaxy to form and keep building into larger size.
The orbital intersections force all stars into the same speed and create the spiral arms.

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Cosmic Sweep

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The spiral arms are NOT slowing down stars in a density wave. A star is sped up by an area of higher gravity. A star can also blast right through an area of dense gas, but the gas the star is dragging will definitely be trapped and or stopped by another area of dense gas (like the spiral arm).

The spiral arms make a clean sweep of the gas being dragged around by the orbing stars then funnel it into the center of the galaxy. That continuously adds more and more material into the central bulge.
More material in the bulge means greater gravitational tug and more drag. That enables the bulge to rotate as if it were a solid object. That means no star lag nor orbit lag and that allows a bar to start forming.
Then the bar formation can continue via group mass.
Spirals arms form first, then the bar. The radius where they meet is called the corotation circle. It is the circle around the galactic center of a spiral galaxy . It's the radius where the concentration of material / mass in the central bulge decreases enough to a point where it loses its strong grasp on outer stars.
So, the stars revert back to star lag and orbit lag, that's the spiral arm.

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Self Regulation
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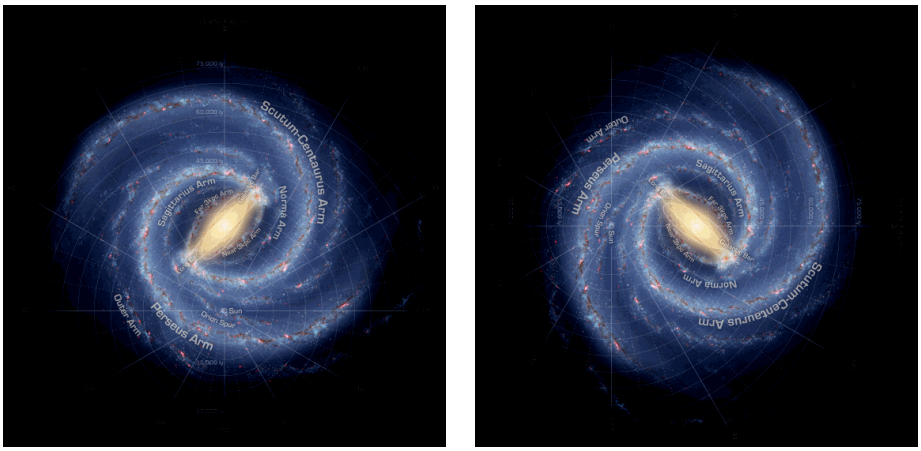
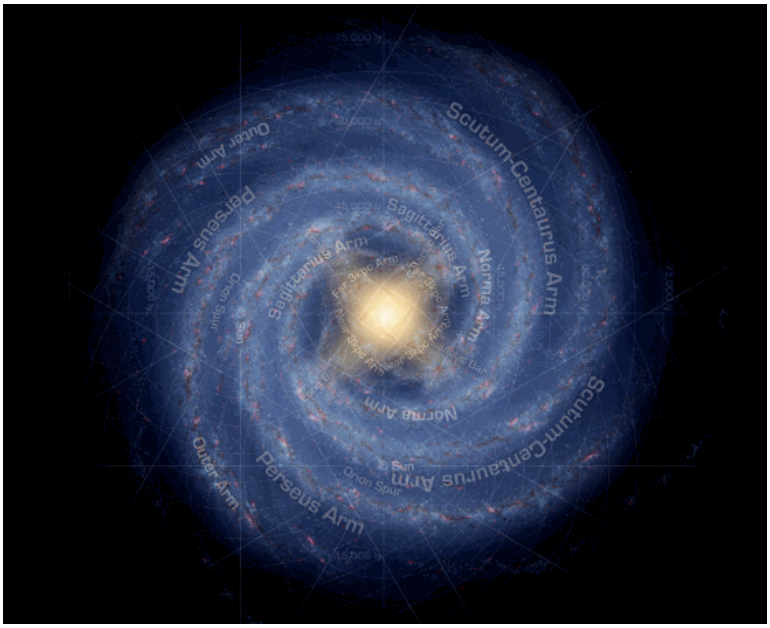
Notice a spiral arm has about the same amount of stars at any distance from the center of a galaxy? That causes the same amount of group mass force and therefore same amount of star speed and vector direction (orbit lag) relative to the spiral curvature at any distance.
If any orbit level or radius has a larger amount of stars: the mass increase will fling the stars out into an higher orbit radius level with greater distance from center of galaxy (it's almost like an atom the way an high energy electron can jump to an new higher orbit shell level).
That is how the spiral arm can regulate its own star density (thickness) and size, and the galaxy can also build into a larger size.



This is an artists rendition of the Milky Way and a similar but 90° degree rotated Milky Way

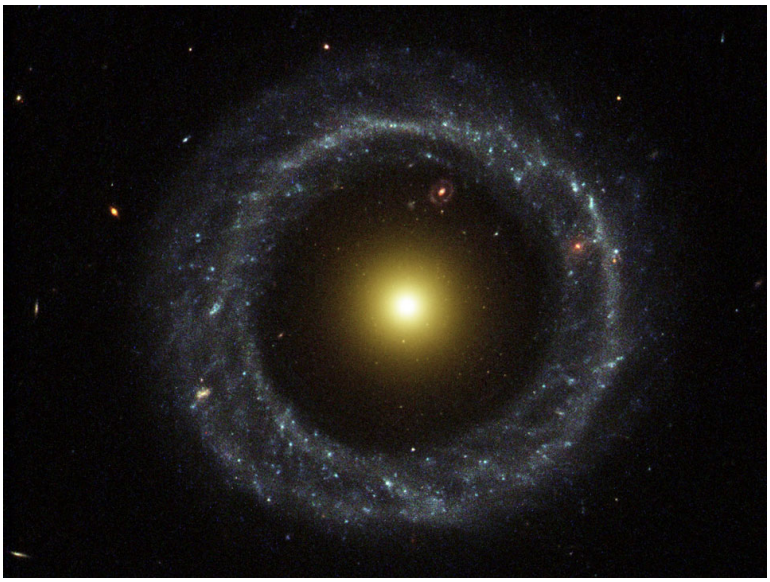
If two similar barred galaxies pass through each other in the same manner as plates stack: while they are together there will be twice as much mass at every orbit level in the galaxy combo.
If they are at a 90° degree rotation from each other the combo will be almost entirely spiral arms.
If they have the same orientation: every point in the galaxy will have double mass (star) density.
That completely disrupts the bar formation and turns them into a ball without any form



This is the two Milky Way type galaxies as they are passing through each other. One is rotated 90° degrees from the other so the combo galaxy has become almost completely filled with spiral arms.

The stars in the spiral arms get flung out into a larger orbit level. There is twice as much mass and if each galaxy had two spiral arms that would mean there are temporarily four spiral arms with four foci - that's a quad focus.

Remember: at the distance of the spiral arms the black hole has already lost its grasp on stars and everything is regulated and controlled by the spiral arms. So, a triple focus actually only has two usable foci.
That's why the opposite of what would normally be expected is happening. The black hole is NOT pulling the excess mass inward, the black hole is being ghosted and the spiral arms are in complete control.

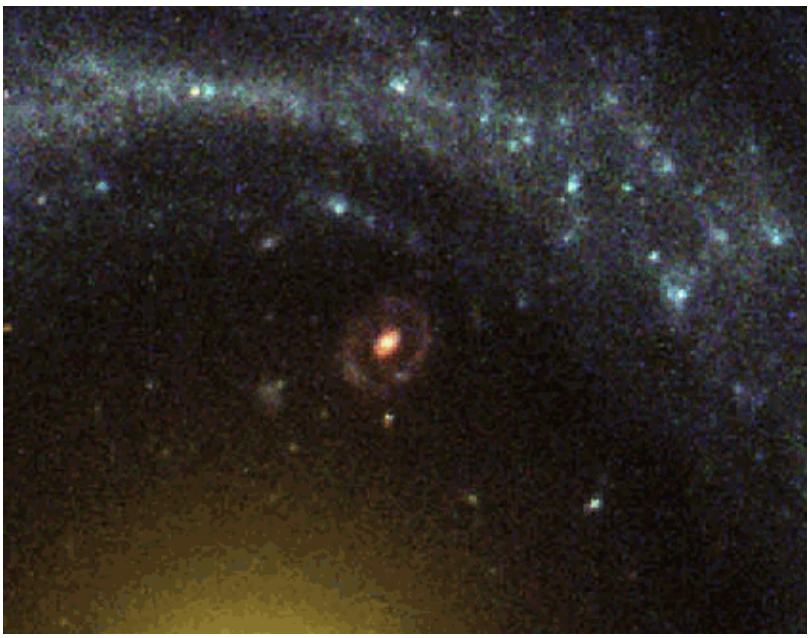


"Hoag's Object is a non-typical galaxy of the type known as a ring galaxy.[4] The galaxy is named after Arthur Hoag who discovered it in 1950 and identified it as either a planetary nebula or a peculiar galaxy[5] with eight billion stars, spanning roughly 100,000 light years.[6]" - Wiki

Hoag's Object has another Hoag's Object at the one o'clock position inside the ring.
- The galaxies passed through each other.
- The bars were completely disrupted.
- The stars in the spiral arms were flung out to a greater distance but everything was done evenly because you can still almost see their original shape.
- The exact same processes happened to the other "Hoag."

Notice the stars can get flung out to an higher level because of the excess mass and double focuses but they do NOT drop back down after the pass through is over?
It's more proof the spirals arms are in completel control and the black hole is irrelevant.

Here is a zoom in on the one o'clock...



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## Epilog
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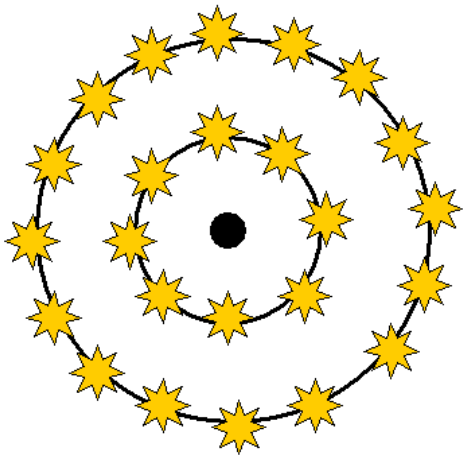
In our solar system there is a one-to-one relationship between the center of mass (sun) and individual planets.
Newton's gravity F = Gm1m2/r^2 works just great.
A galaxy is a completely different story - trillions of stars are tugging on each other.
A galaxy as a whole can be considered a group mass [Mg]. The spiral arms and galactic bars are just higher concentrations of group mass (stars, gas, etc.)

Change m1 into mg (a high concentration group mass (like a section of spiral arm or a galactic bar)), m2 is a lone star, and it explains just about everything.

$$F = G \frac{mgm2}{r^2}$$

It needs to be used on both sides of a stars orbit, that means on both sides of the galaxy.

Now you know how spiral arms and galactic bars form, why the stars are the same speed, and what really happens inside a density wave.



Another reason for same speed stars:

The orbits of stars in galaxies intersect. The speed can be transferred out to the furthest reaches of the galaxy then centrifical force and momentum takes over and keeps them at that speed.
That's another one of Newton's laws that do NOT need modification: F = mv^2/r
Believe it or not it is just like a regular circumference formula. The number of stars (mass) at any particular orbit radius increases with distance but so does the radius.
8 stars at radius 8 equals 16 stars at radius 16, force wise, speed wise, and momentum wise.
Remember: A galaxy as a whole is a group mass [Mg]. Spiral arms and galactic bars are just higher concentrations.

P.S. Energy can also be TL = Tension times Length.
Here is a regular thread tension formula...
Tension = velocity squared x mass / Length.
If we plug in c and rearrange we get the one-inch equation...

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 TL = mc^2
|--inch--|
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Tension [M][L]/[T^2] * Length [L] = mass [M] * speed c^2 [L^2]/[T^2]
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NOTE: T = Tension, inside brackets [T] = Time

http://www.mccelt.com/gravitational-constant.php
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Category: Astro Physics
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