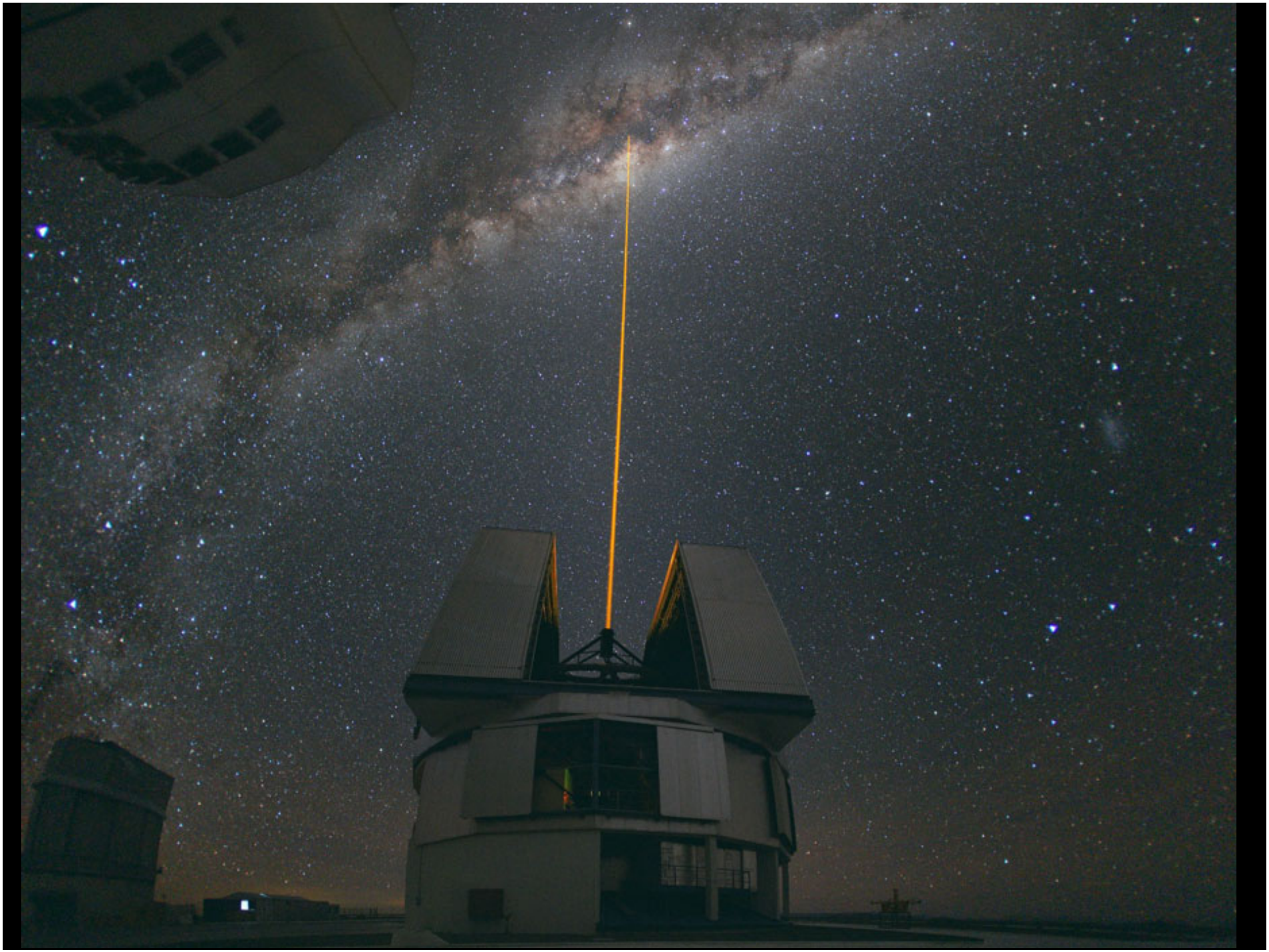
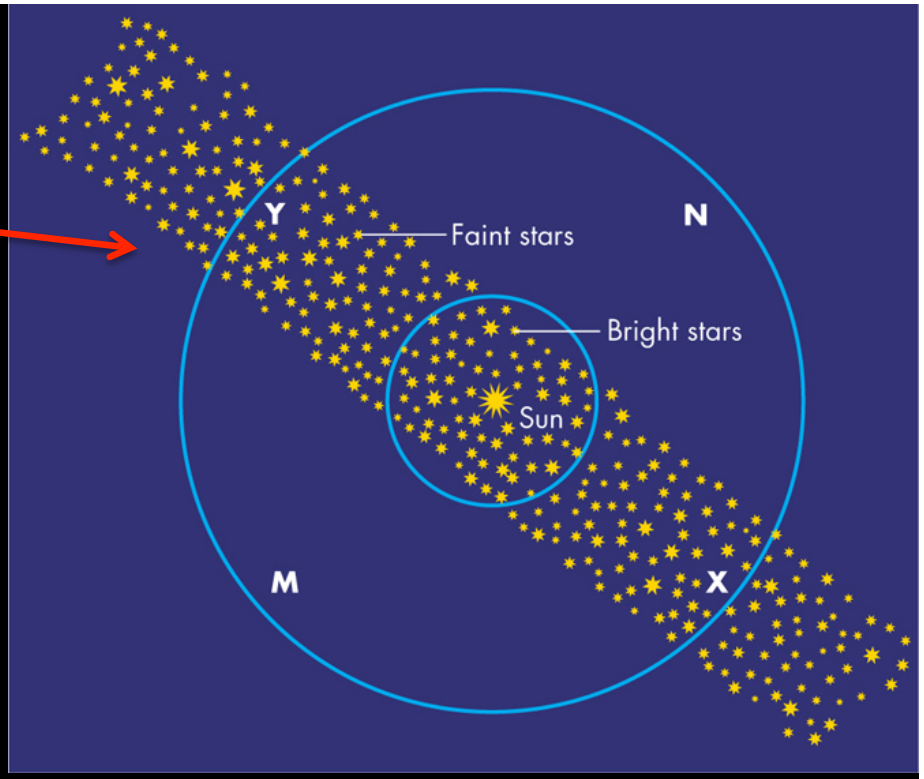
The Milky Way Galaxy

Reading: Chapter 22



What we see as a band of many stars is actually a disk, viewed edge on



Shape and Size

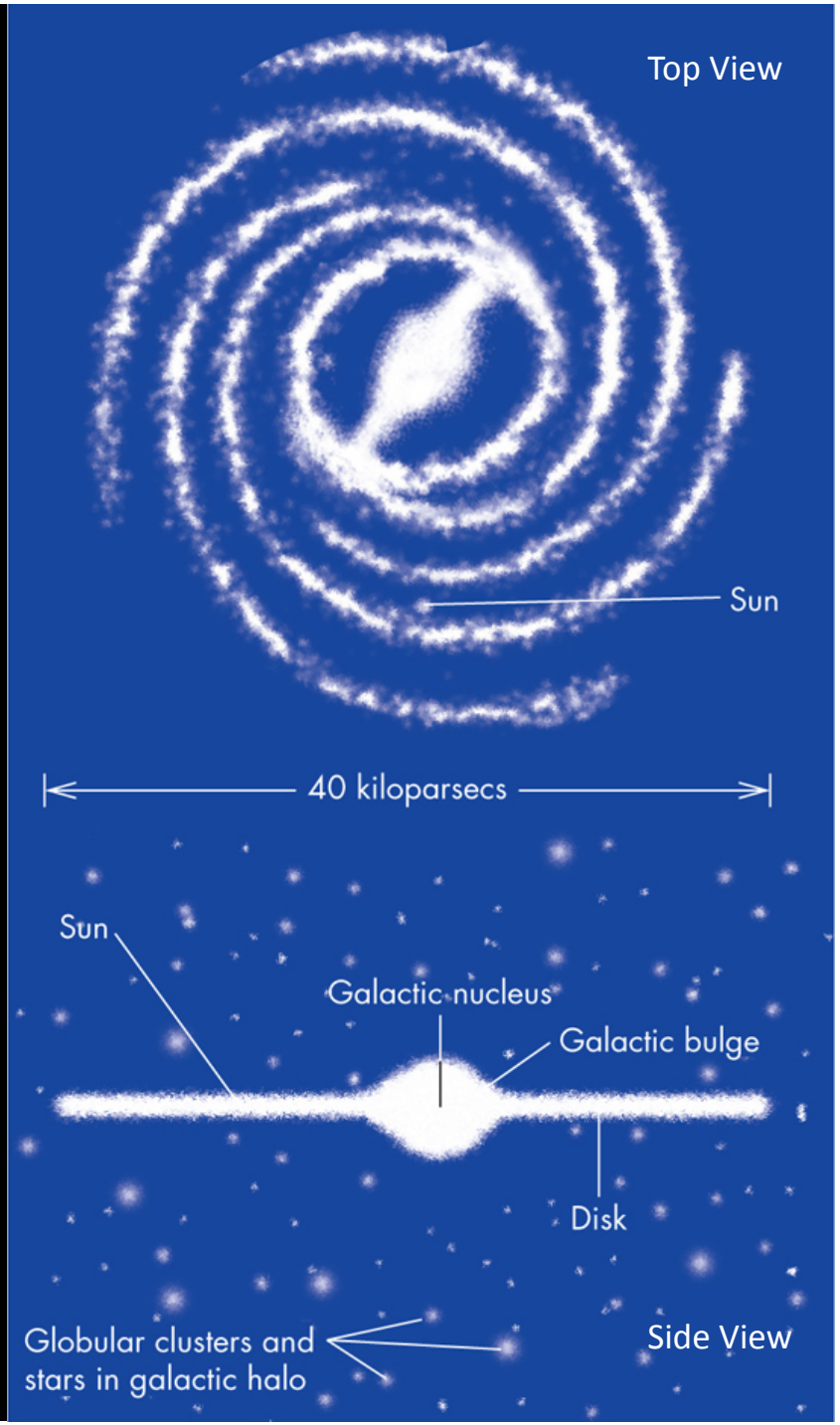
The Milky Way is a collection of some 200 to 400 billion stars ($\approx 10^{12} M_{\odot}$) rotating around a common center.

The Milky Way is a "*barred spiral*" galaxy

The Milky Way consists of a thin disk with a diameter of 30 to 40 kpc and thickness about 0.3 kpc, with a central bulge which is elongated into a bar about 5 to 6 kpc long.

1 kpc = 1000 pc = 3,262 light years

The disk is surrounded by a spherical halo of globular clusters and "low metalicity" stars. The halo has a radius of 30 to 40 kpc



Globular Clusters

Spherical cluster of thousands or even hundreds of thousands of stars, tightly bound by gravity.

Stars in a globular cluster are all old, about the same age, and have low amounts of elements beyond hydrogen

Messier 54

Over 150 globular clusters in/around the Milky Way, probably more

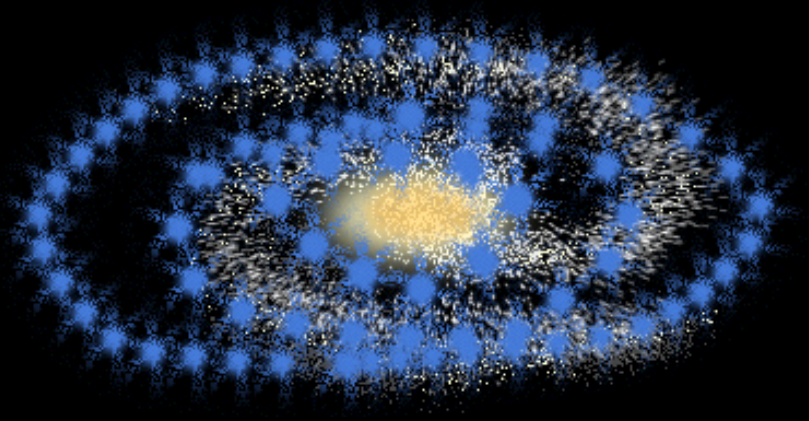
Bad Astronomy Blog: The massive massiveness of M54

http://blogs.discovermagazine.com/badastronomy/2012/03/28/desktop-project-part-3-the-massive-massiveness-of-m54

Stellar Populations

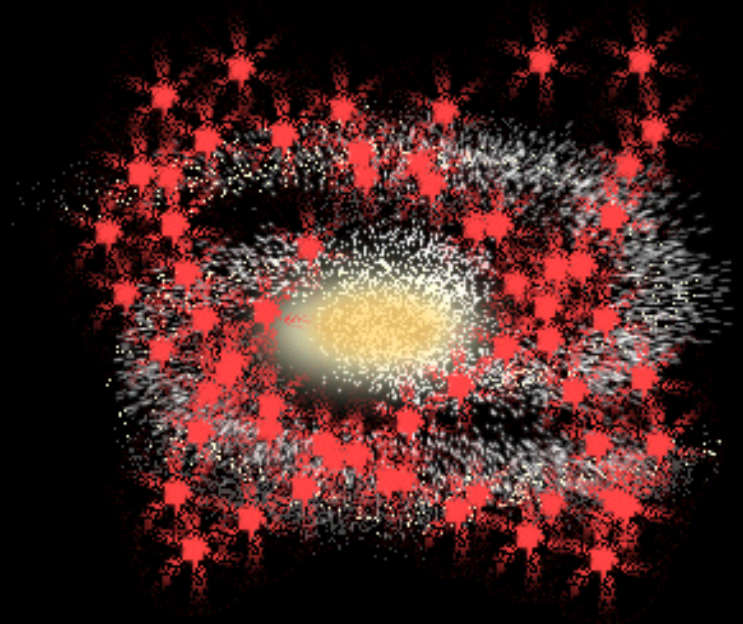
Population I stars

Younger, blue stars, with high heavy element content, they are found primarily in the disk and arms. They have more or less circular orbits in the disk.



Population II stars

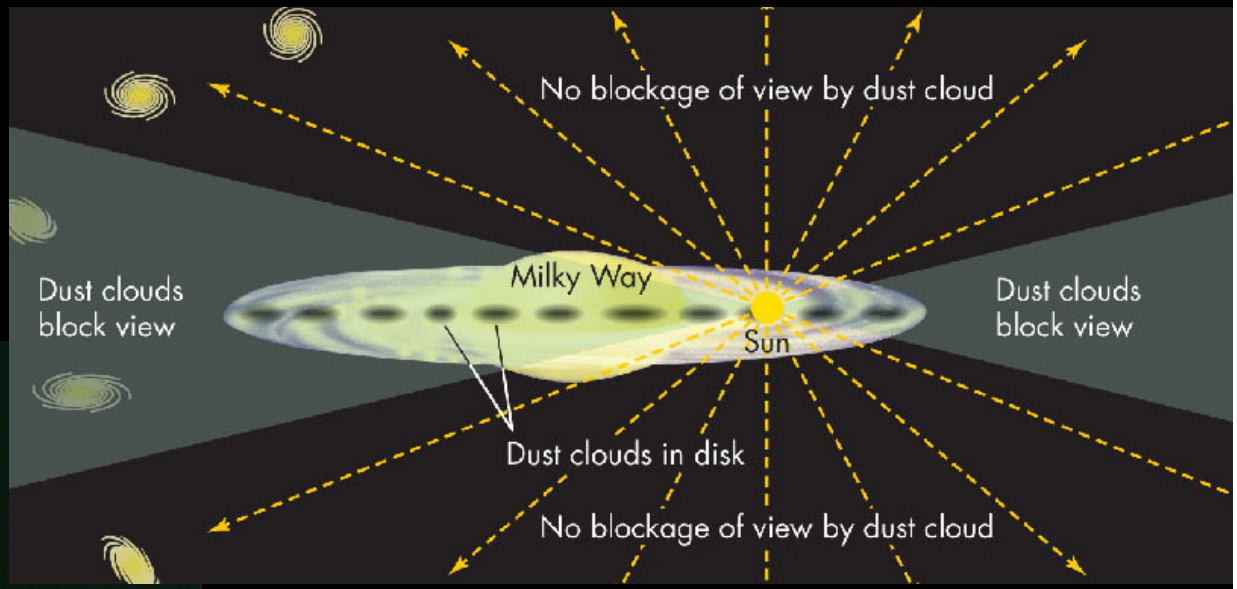
Older, red stars, with lower heavy element content, they are found primarily in the halo and bulge. Their orbits plunge through the disk .

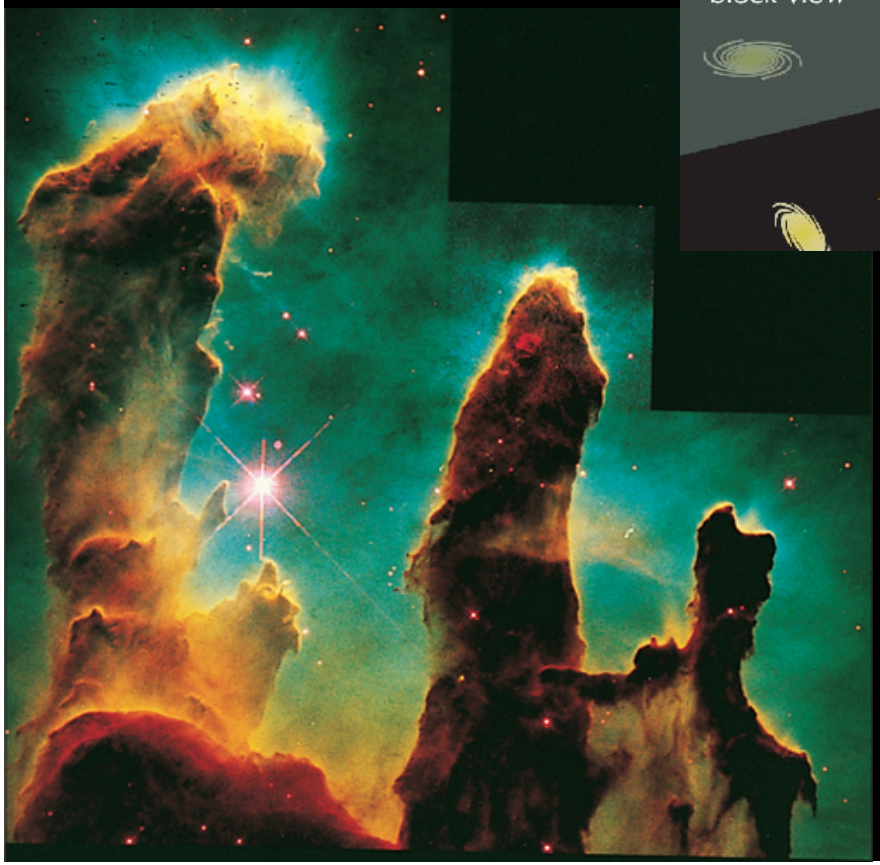


(Hypothetical Population III stars would be even older and composed of just Hydrogen and Helium, but they have not been observed.)

Interstellar Matter

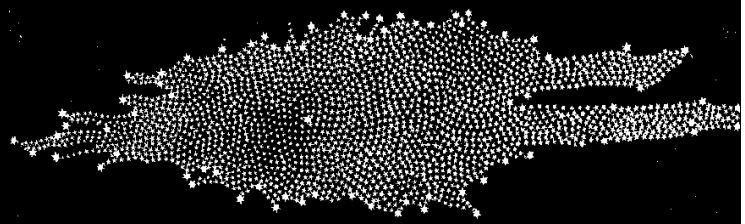
About 20% of the mass of the Milky Way galaxy is gas and dust





The "Pillars of Creation" in the Eagle Nebula

Figuring out the structure of the Milky Way was difficult, because most of it is not visible, due to gas and dust



William Herschel's map of the Milky Way (1784)

Interstellar Gas

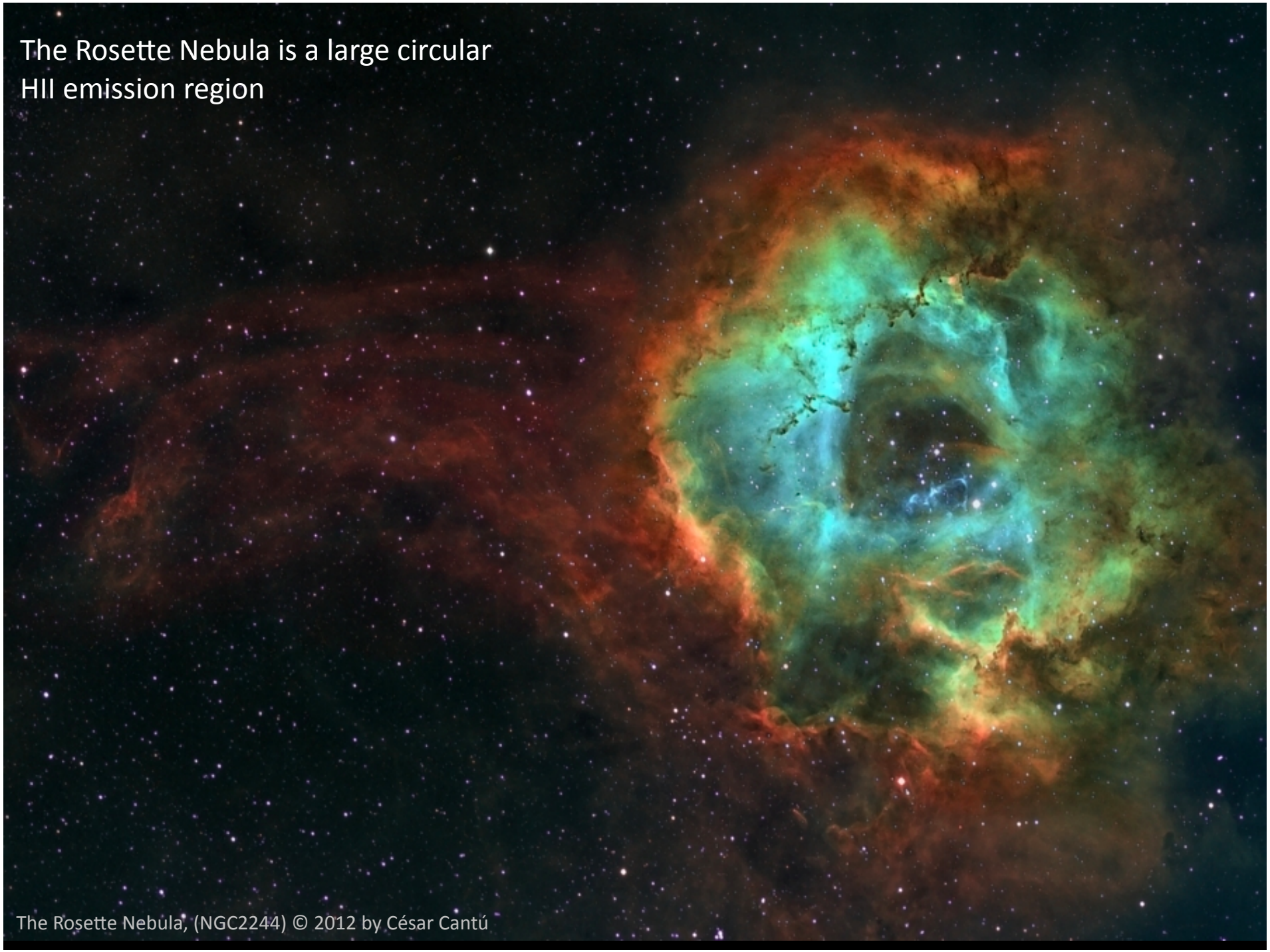
About 99% of interstellar matter is gas, mostly hydrogen and helium

The Orion Nebula

The Trifid Nebula

HII regions are bright emission nebulae lit up by hot O or B stars which ionize hydrogen with UV light.

Hydrogen, both molecular and atomic, also emits in radio with wavelength of 21cm


The Rosette Nebula is a large circular
HII emission region
The Rosette Nebula, (NGC2244) © 2012 by César Cantú

Interstellar Dust

Interstellar dust scatters light -- so we see less light from the source (called "extinction")

Dust scatters short wavelengths (blue) more than it does long wavelength (red), so light that does reach us is "reddened"

Only about 1% of interstellar matter is dust, but it scatters visible light so well that we can see only a few thousand light years into the disk of the galaxy.

Horsehead Nebula in Orion

Infrared and radio are less affected by dust, so that is how we have deduced the structure of the Milky way

ALMA - Atacama Large Millimeter/submillimeter Array

Altitude: 16,597 feet (control facility at 9,500 feet)

66 radio antennas

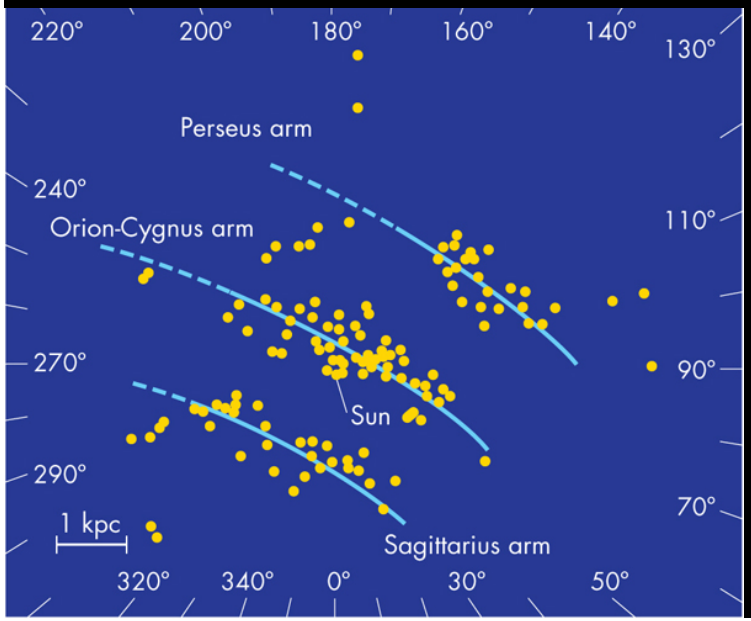
New York Times: At the End of the Earth, Seeking Clues to the Universe (7 April 2012)

Credit: Tomas Munita for The New York Times

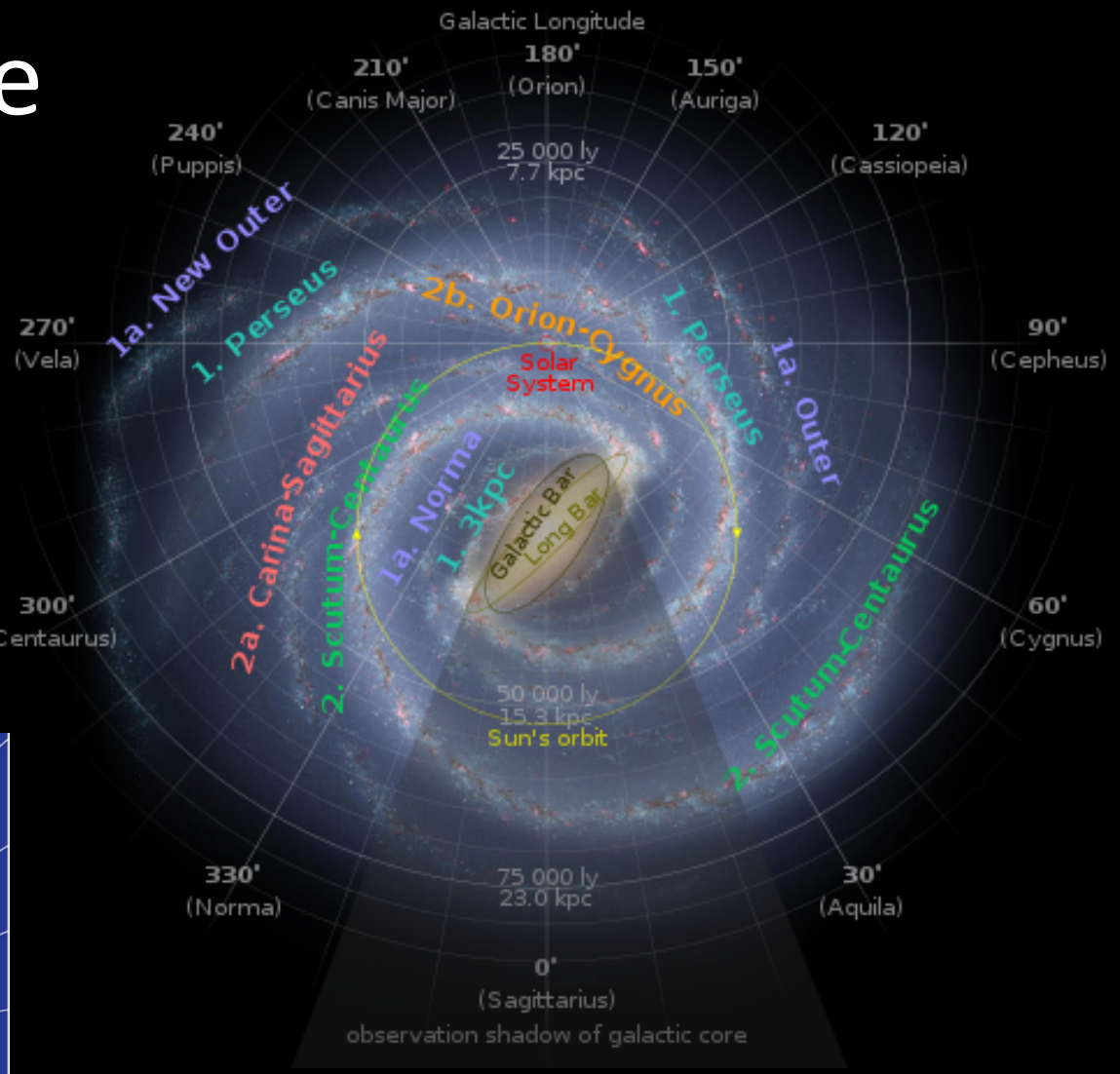
Spiral Structure

Spiral arms have more young objects, such as HII regions and cluster of hot O and B stars

The Sun is in the Orion-Cygnus arm (sometimes called the Orion Spur)

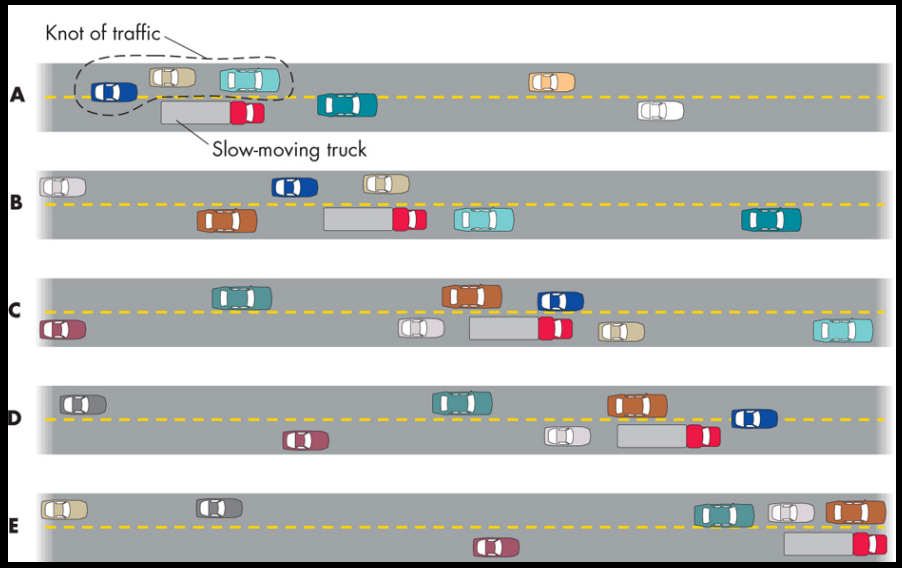


Optical map near our Sun



The spiral arms are now thought to be the crests of *denisty waves*

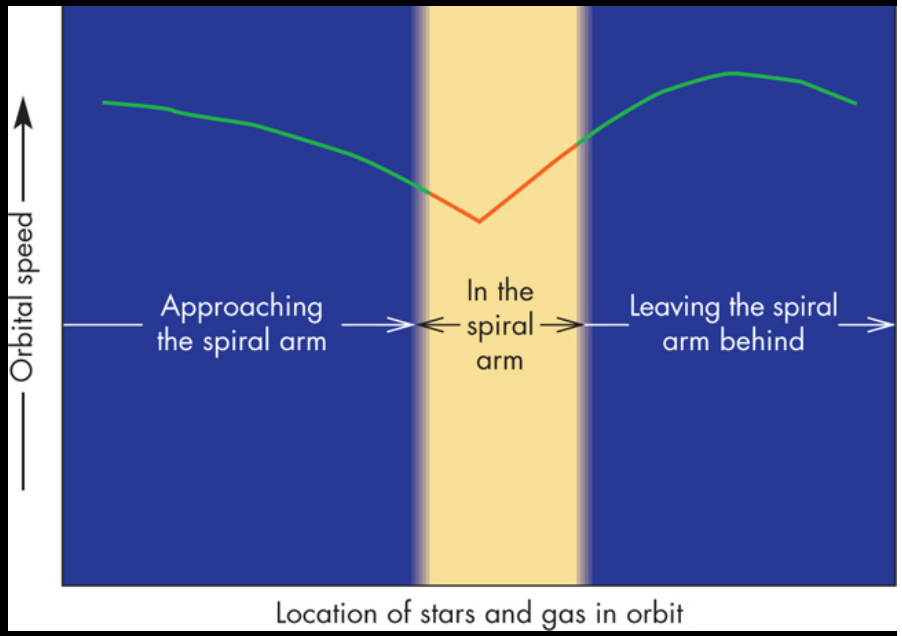
Density waves

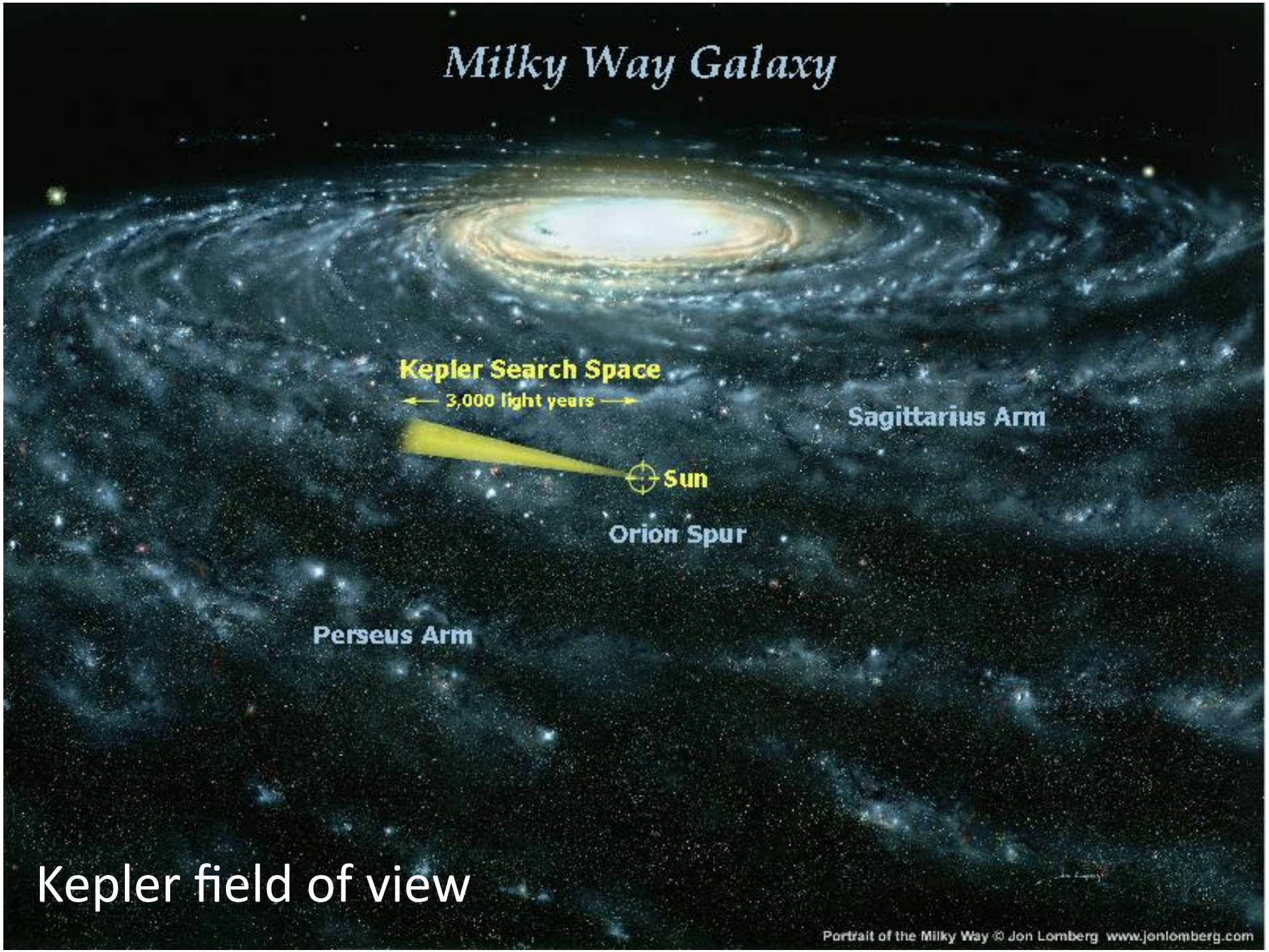


An analogy: traffic builds up behind a slow-moving truck, but over time it's different cars behind the truck

The gravitational attraction of the higher number of stars in the arm can slow down the stars that are just joining the arm, and change their direction

How do spiral arms get started?
Nobody knows (yet)





Kepler field of view

Rotation Curve

The rotation curve is a plot of orbital speed versus distance from the center of the galaxy

- For solid object, like a wheel, speed increases with distance
- For planetary motion about a central mass, speed decreases with distance

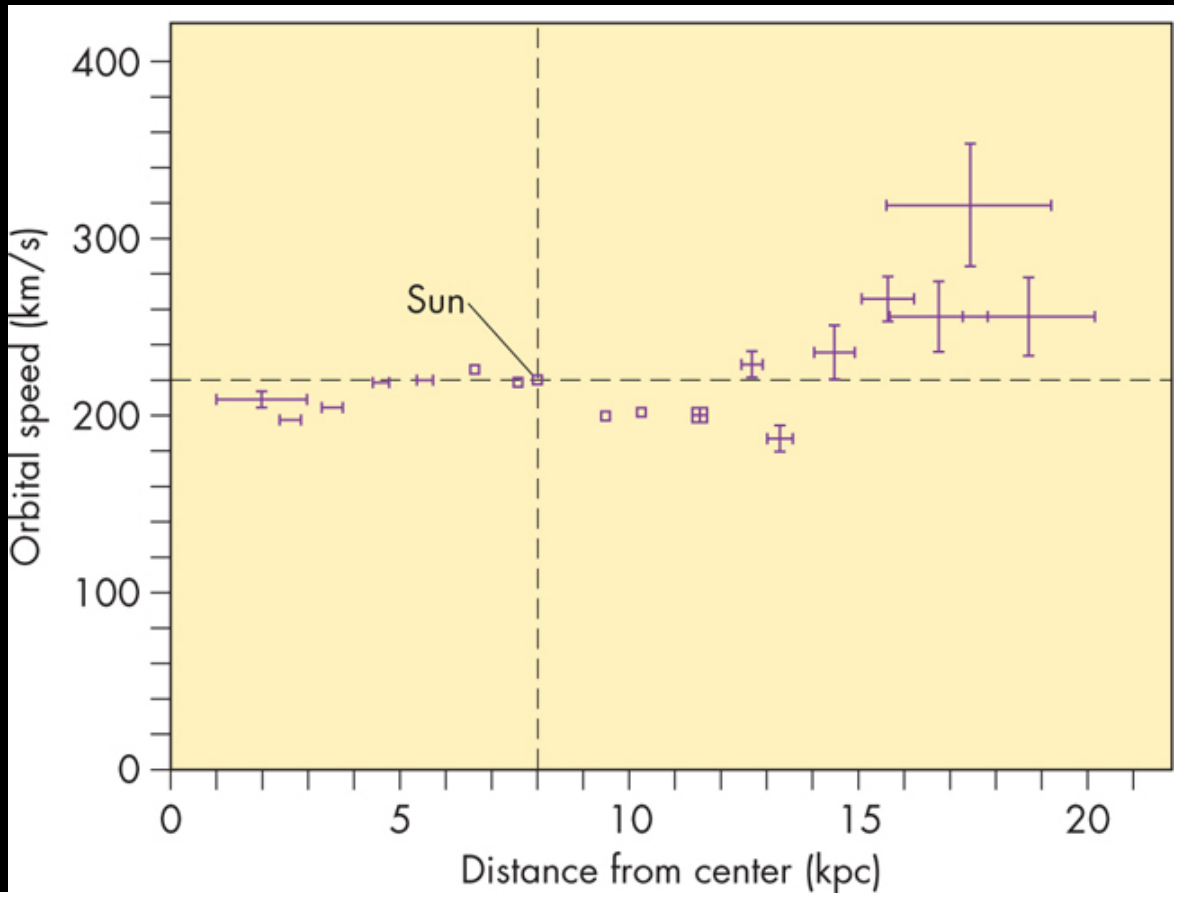
The rotation curve for the Milky Way shows neither!

The flat rotation curve of the Milky Way says that the amount of mass increases with distance from the center.

But since we don't see that matter, it's called

Dark Matter

Nobody knows what it is

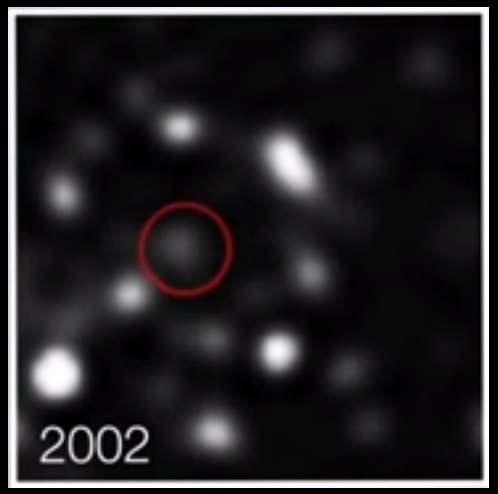


Black Hole

There is indirect evidence that there is a black hole at the center of the Milky Way galaxy,

with a mass of about $4 \times 10^6 M_\odot$

Video 1: Zooming in to Sagitarius A*



Astronomers have tracked stars in this region for the past 16 years. One star even completed a full orbit in that time.

Video 2: Paths of stars in center of galaxy

Video 3: Stellar Orbits Around Milky Way's Central Black Hole (1995 - 2195)