Unit 5
Stars & Celestial Objects

GALAXIES

Fact: Our knowledge of our universe is based on observational evidence of light.

- If we can see it (visible and other forms of light)
- If we can measure it (types of light, intensity of light)

Galaxies, stars, and other celestial objects are spaced very far apart and lie very far away from Earth.
The preferred unit of distance is the light year. A **light year** is a unit of distance that equals the distance that light moves through space at the speed of light.

- Light year in a vacuum = **9.46×10^{12} km** or **9,460,000,000,000 km**
- Speed of light in a vacuum = **300,000 km/s**
- By comparison, speed of sound in air = **0.340 km/s**

Light is a form of energy. Light will move a distance and requires time to move from one place to another. Light has to be created & released by the object, or reflected by the object, travel through space to the Earth.

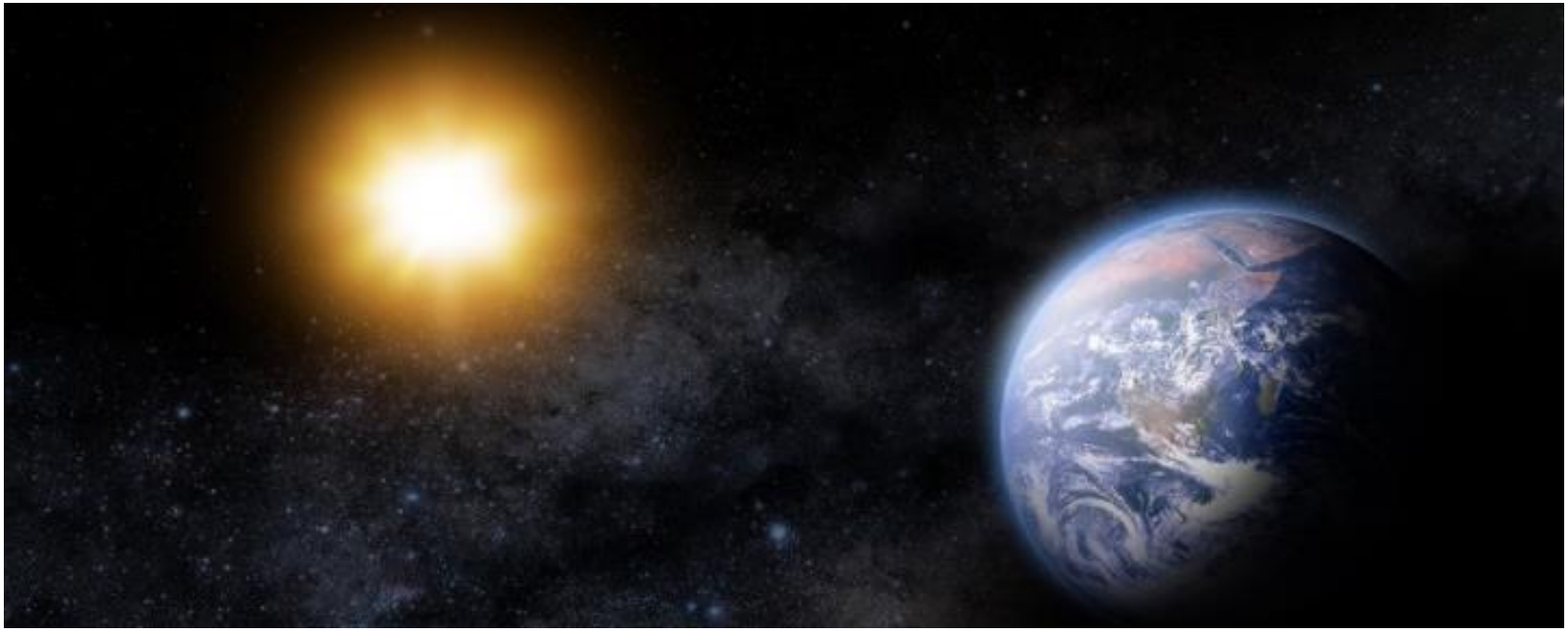
We see space objects based on the light that arrives to Earth.

AND

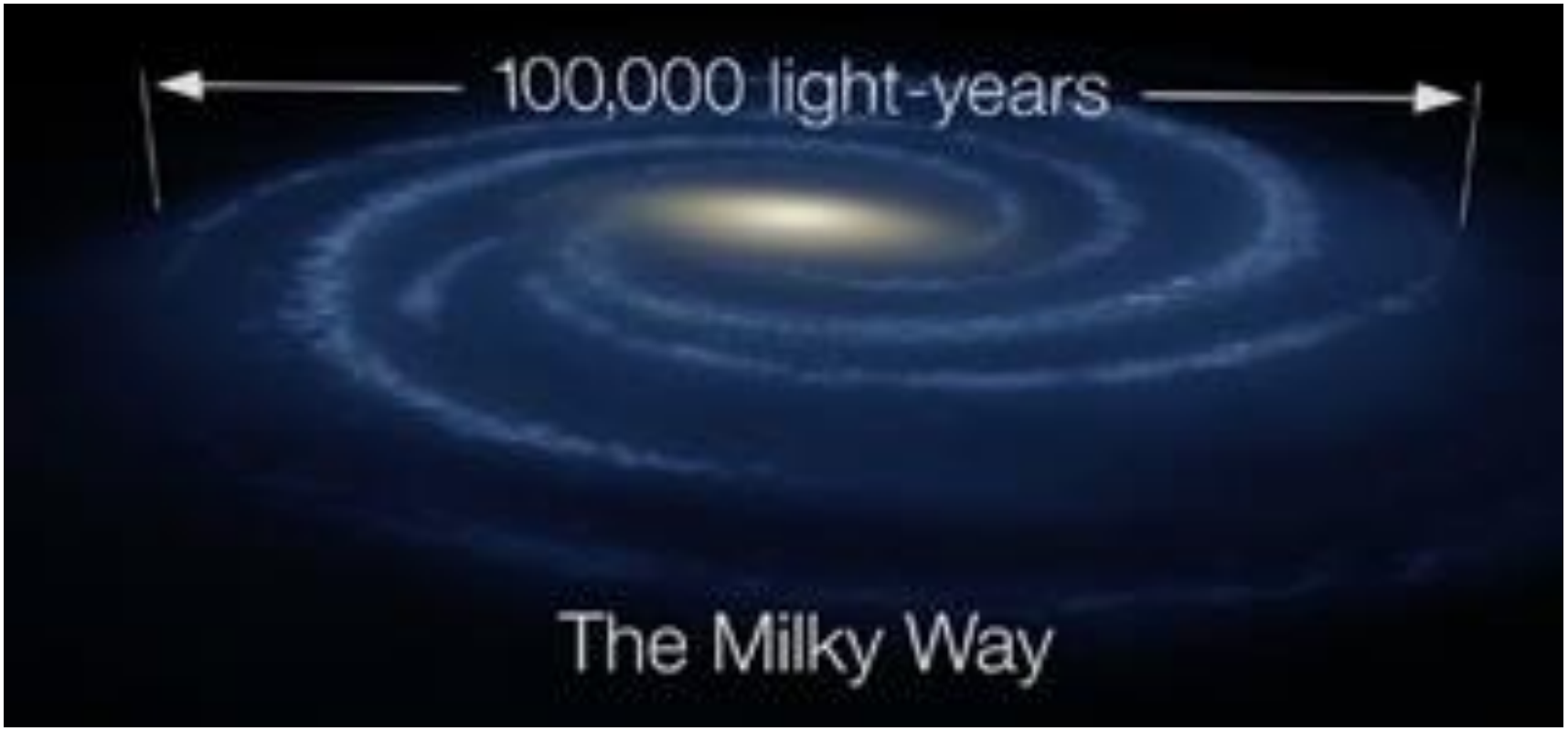
We see space objects as they were in the past when the light was released NOT as the space objects are at this moment in time.

The Sun is one astronomical unit (150,000,000 km) away from Earth. Light released by the Sun takes 8.33 minutes to move from the Sun to Earth.

When we see the Sun in the sky, we see the light that was released by the Sun 8.33 minutes earlier NOT as the Sun is at that moment in time.

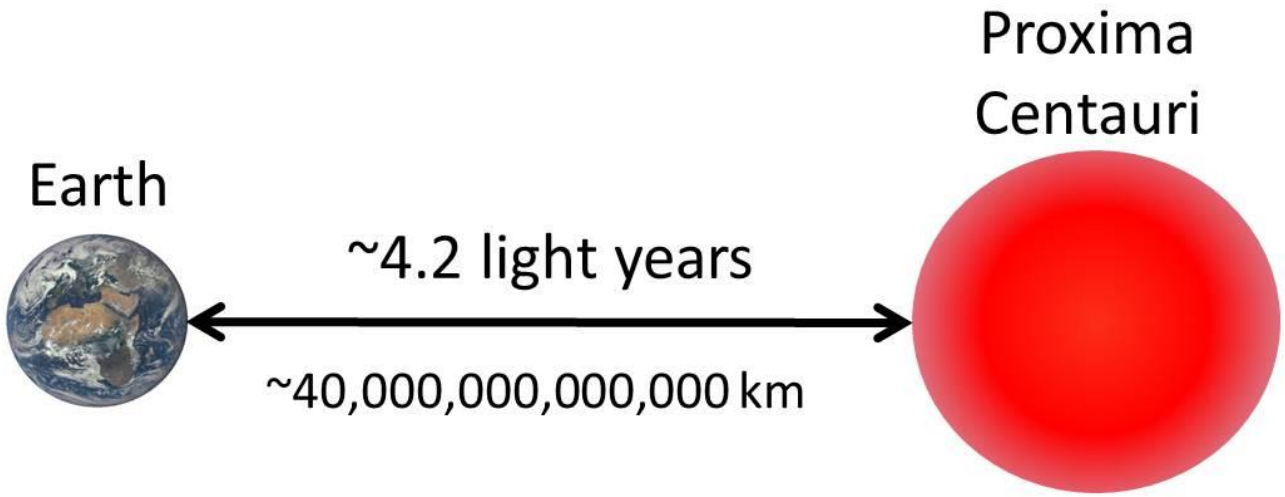


The diameter of the Milky Way Galaxy is approximately 100,000 light years. It takes light 100,000 years to move from a star at one edge through the galaxy to the other edge.

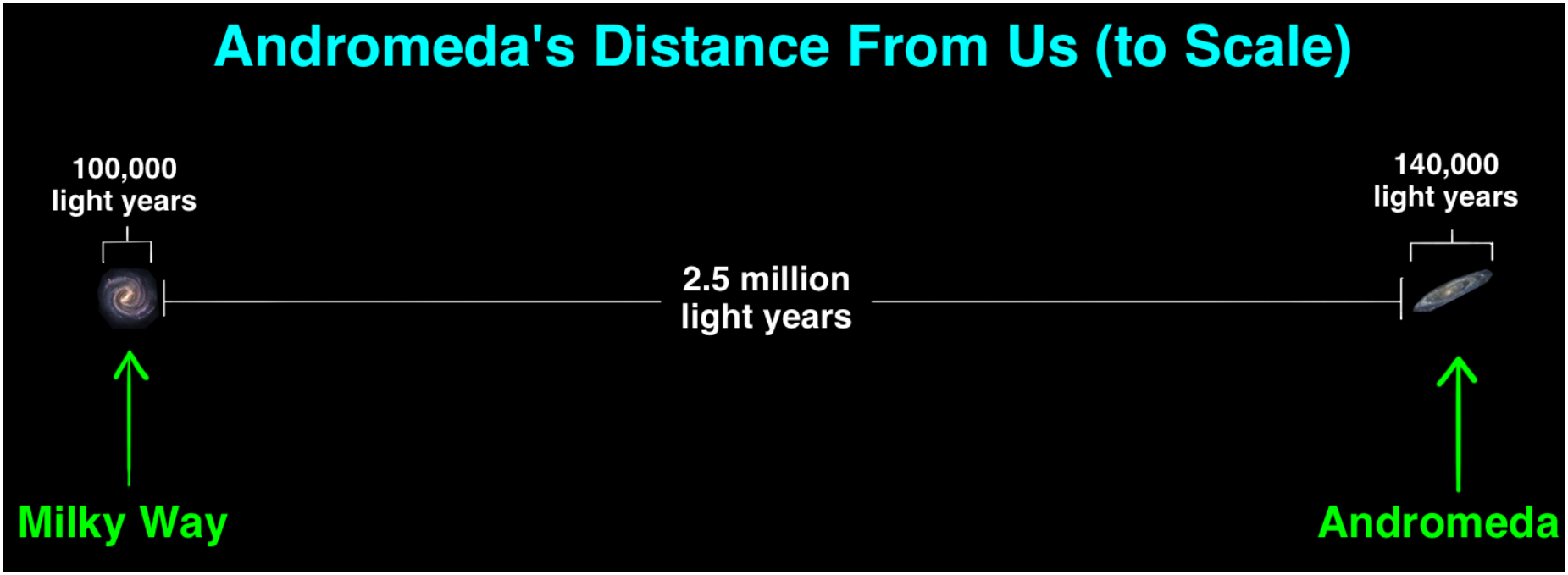


Proxima Centauri is a star in the **Centaur** constellation. It is a red dwarf star and is the next closest star to Earth after the Sun. It lies at a distance of 4.2-4.4 light years away.

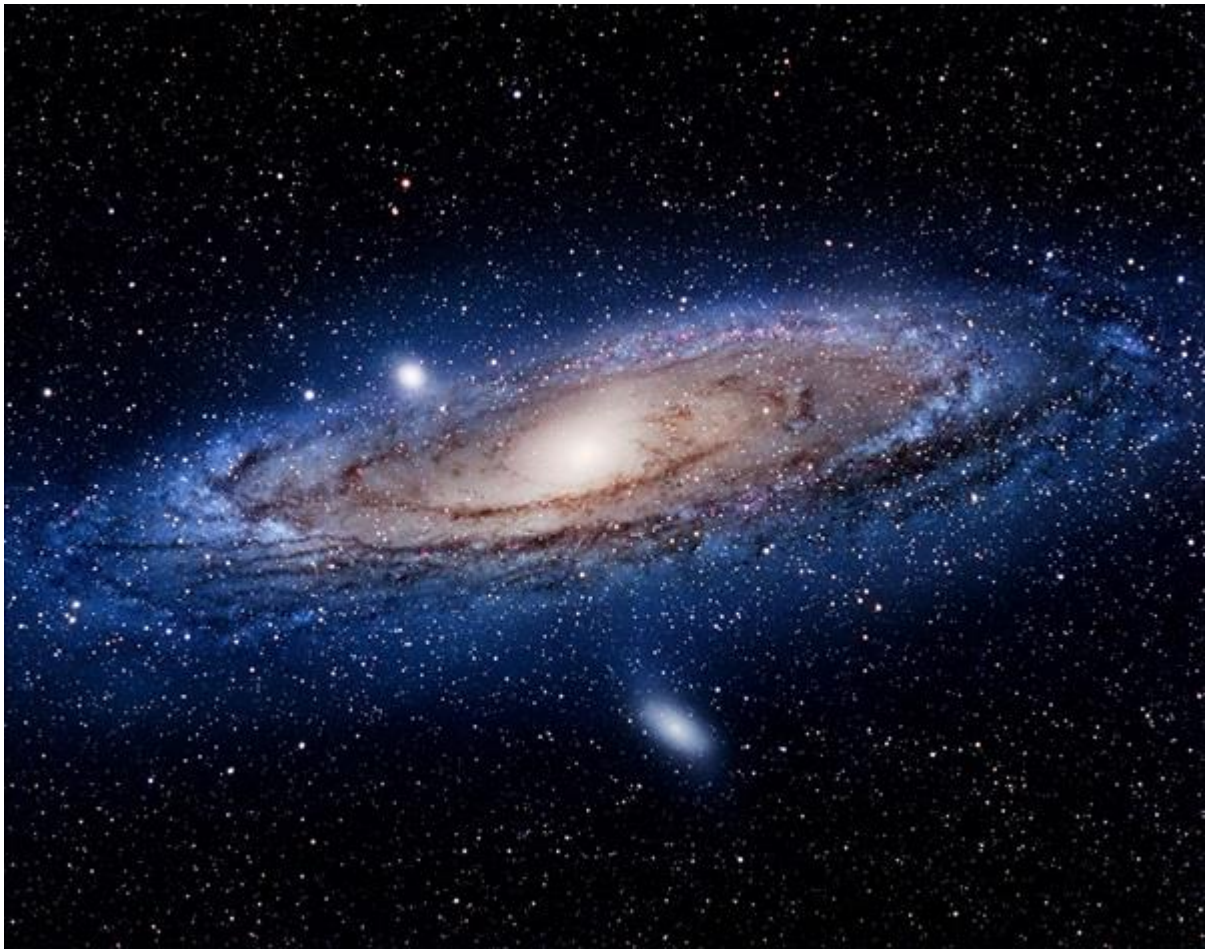
It takes light 4.2-4.4 years to move from Proxima Centauri to Earth. *When we see Proxima Centauri in the night sky, we see it as it was 4.2-4.4 years earlier (2017) not as it is now 2021.*



The **Andromeda Galaxy** is 2.5 million light years distance from Earth (more or less). It takes light from Andromeda 2.5 million years to move through space to the Earth. *When we see Andromeda in the night sky, we see it as it was 2.5 million years ago NOT as it is now.*

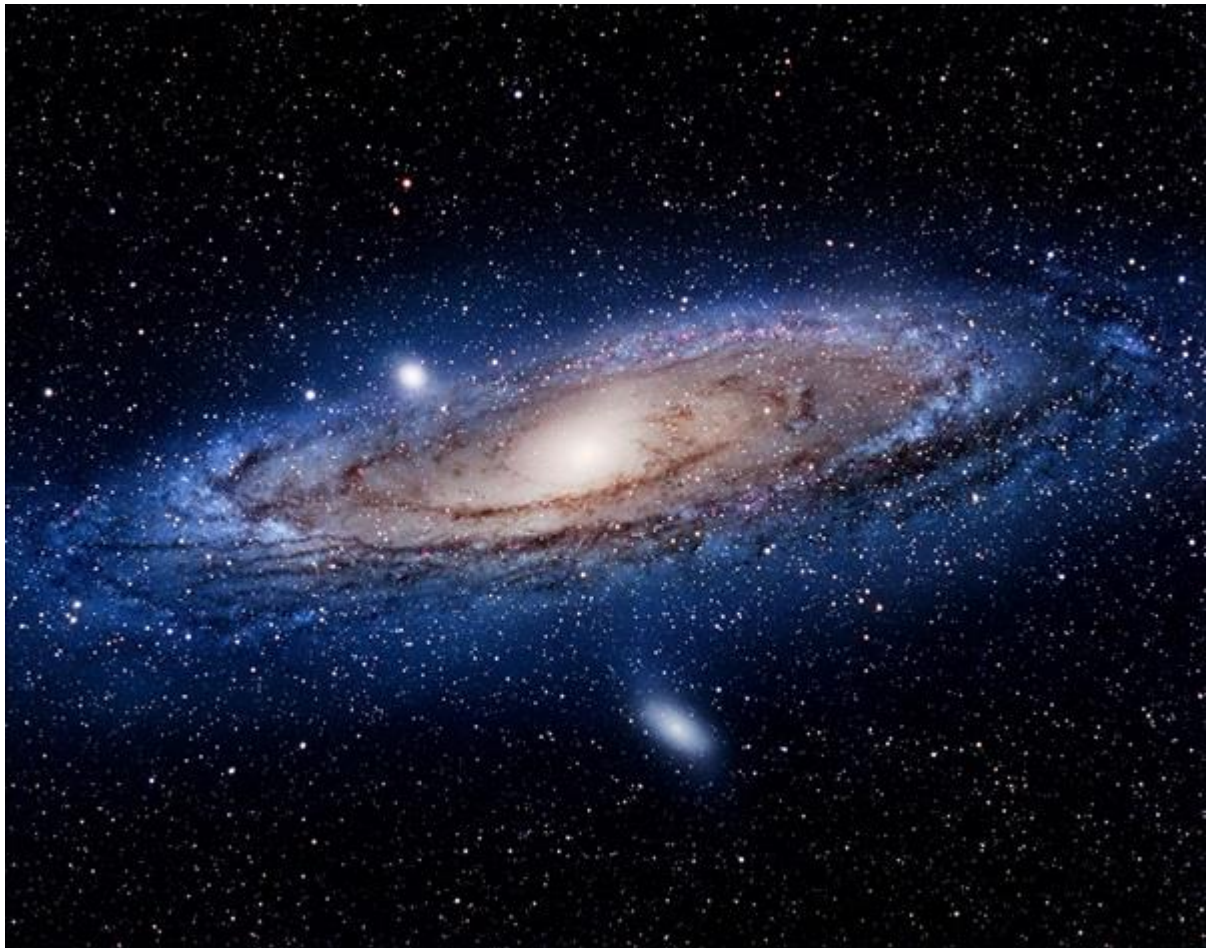


A **galaxy** is a large collection of stars, dust, and gas that is associated and held together as a unit by gravity. Galaxies have a diversity of objects: stars, nebulae, black holes, neutron stars to name a few.



The word galaxy is derived from Greek as **“milk”** because of their white, fuzzy color due to the stars. They looked like spilled milk in the night sky.

Small galaxies may contain 10-100 million stars. Most galaxies have 100-500 billion stars. The largest galaxies may have over a trillion stars.

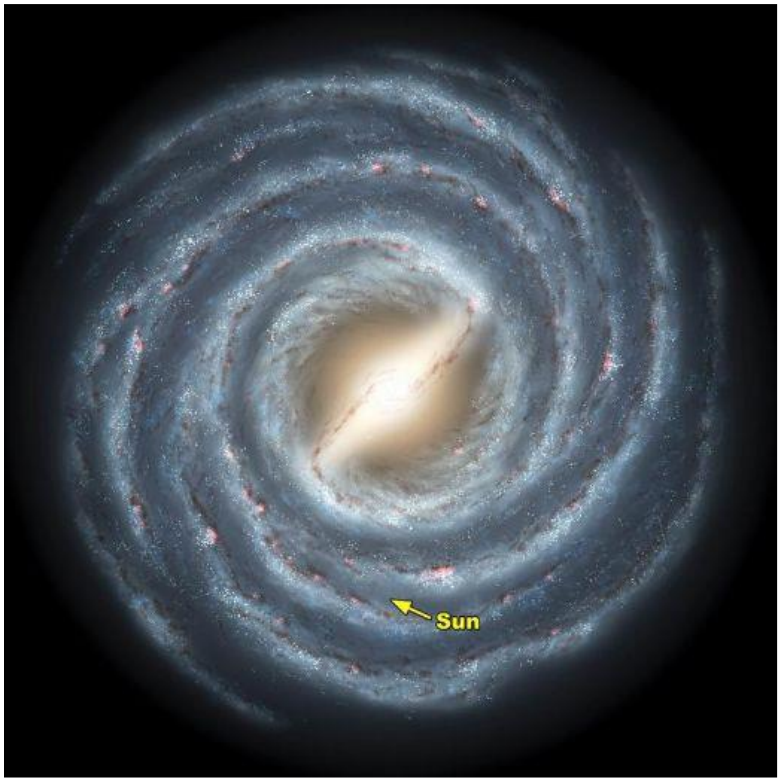


The spacing between stars and nebulae within galaxies are many to hundreds of light years apart. The chances of stars colliding is almost zero.

The Milky Way Galaxy

As seen from Earth, **Milky Way** looks like a whitish cloudy smudge in an elongated swath across the night sky. The Milky Way galaxy is a small galaxy with ~ 100 to 300 billion stars.

From Earth



Earth's position

From Earth's perspective, we are looking from the edge of the galaxy inward toward the Milky Way's center.

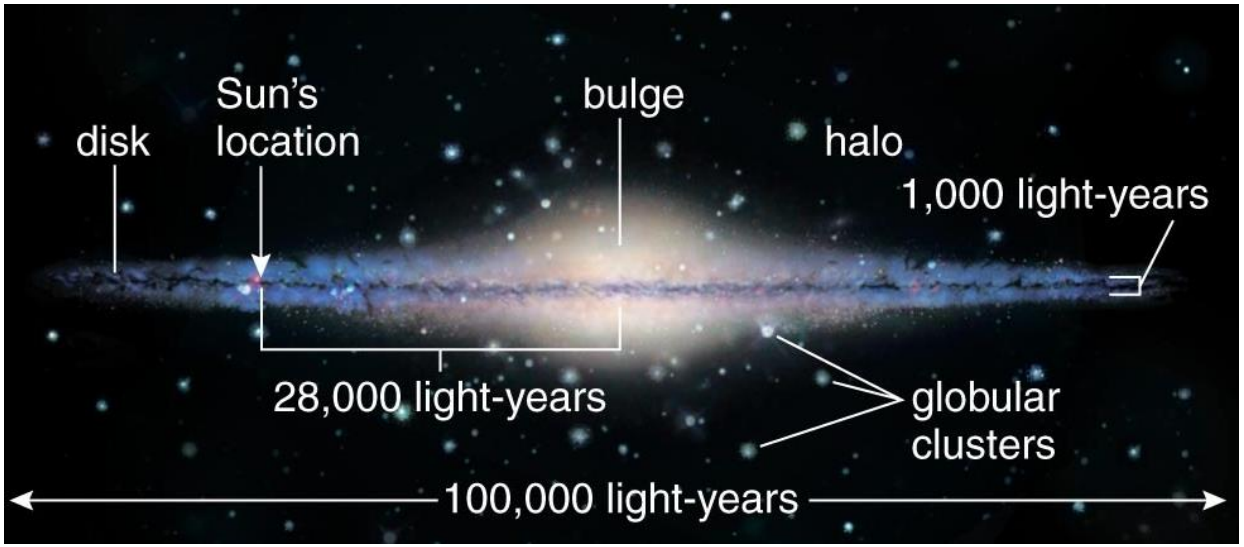
We cannot observe the true center of the Milky Way because of the 100's of millions of stars and large clouds of interstellar dust and gas blocking the view.

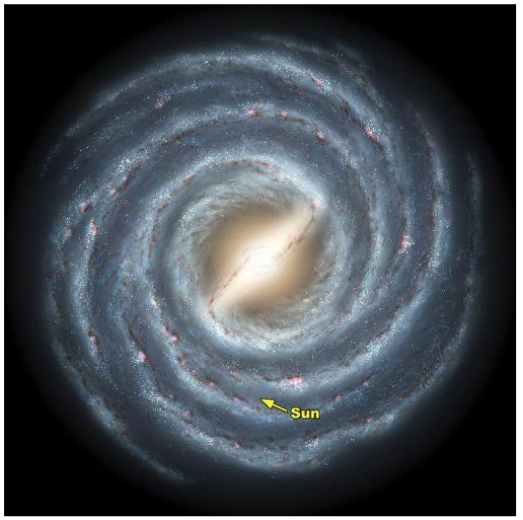
Looking inward toward the center of the Milky Way from Earth's perspective

If viewed by visible light methods, the center of the Milky Way Galaxy is hidden by cooler clouds of dust and gas. We cannot see the structure of the galaxy.

Same perspective as the previous picture, but viewed by infrared light instead of visible light.

Infrared is invisible to human eyes, so a special camera is needed. Infrared imaging is heat imaging. It shows the hot galactic bulge and the hot stars that make up the disk.





The Milky Way is a **barred spiral galaxy**—the density of stars across the galactic bulge forms an elongated swath (bar).

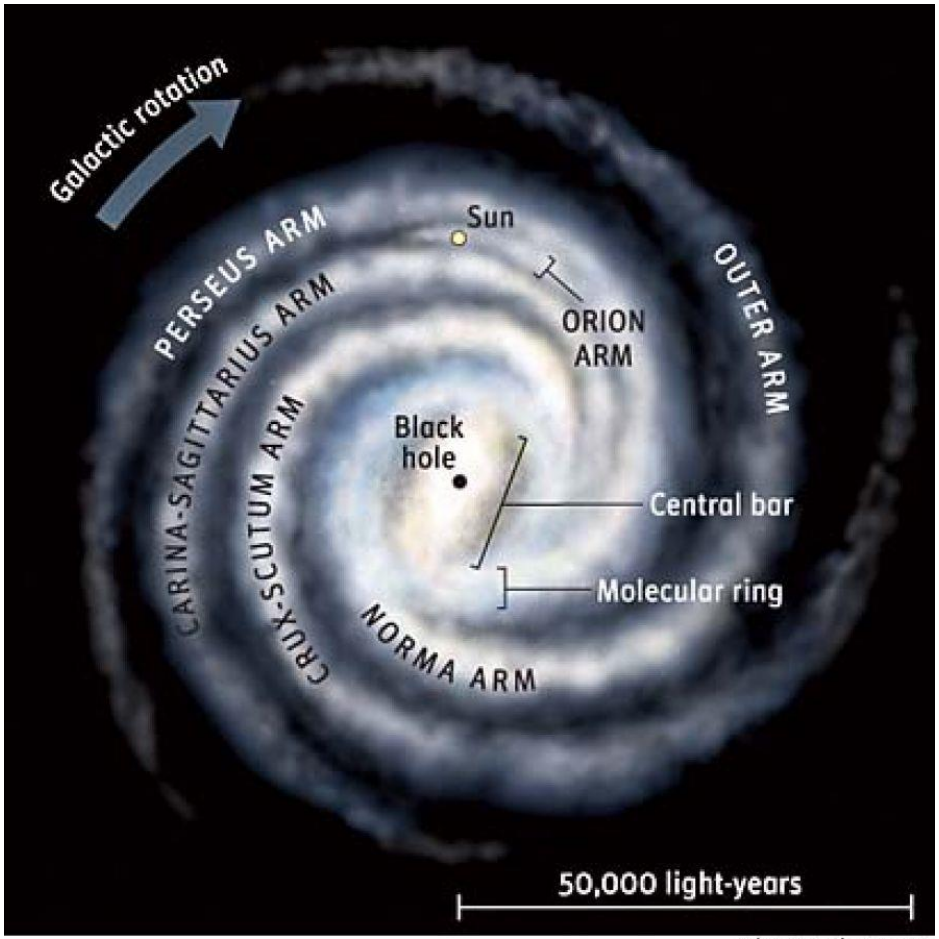
200-300 Billion stars.

Flattened rotating disk of orbiting stars with a galactic bulge in the center and elongated spiral arms of stars (like a pinwheel) twirling outward

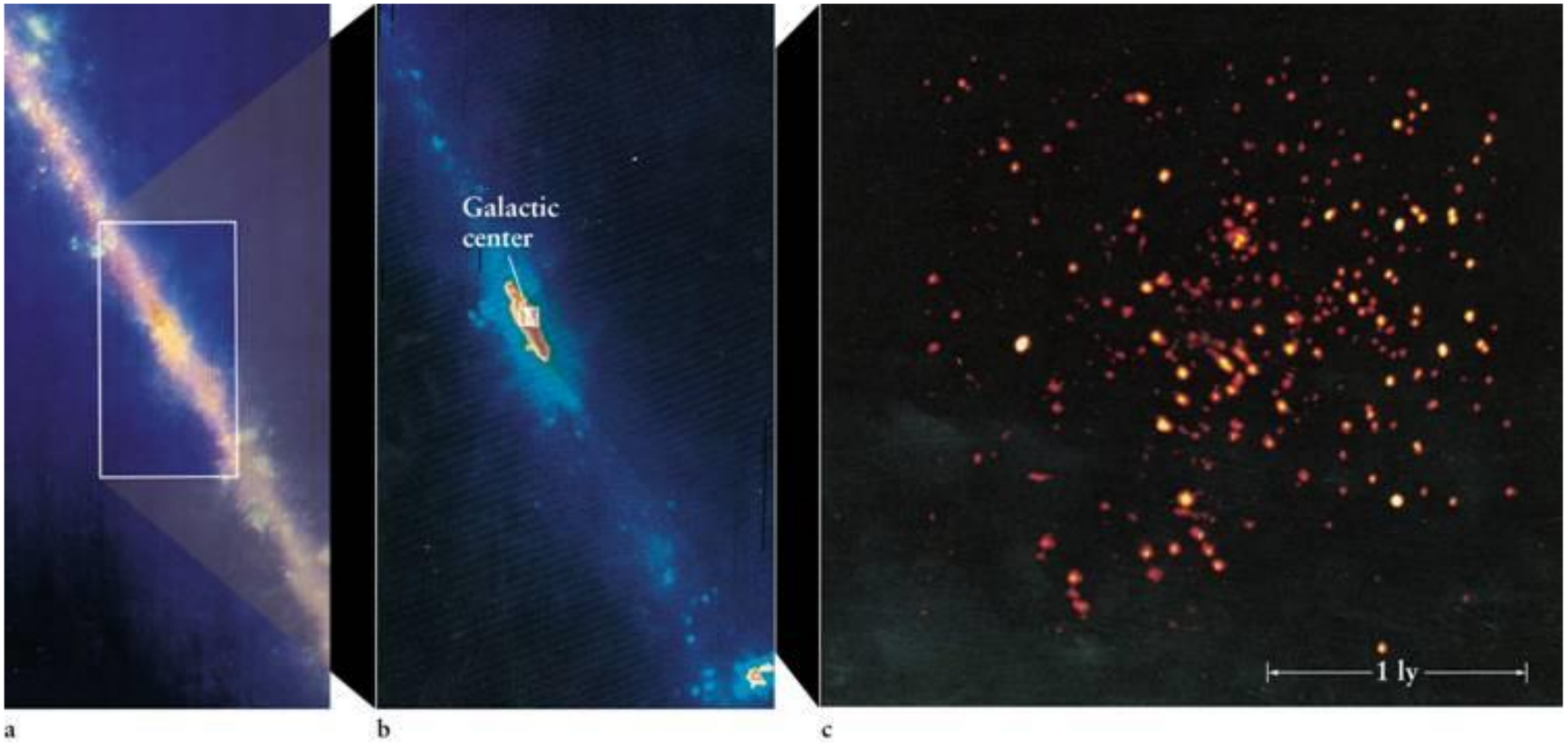
Our solar system lies in the **Orion Arm** about 2/3 distance from the galactic bulge.

Sun orbits the Milky Way Galaxy in ~220 Million years.

The galactic bulge contains a **supermassive black hole** with immense gravity.

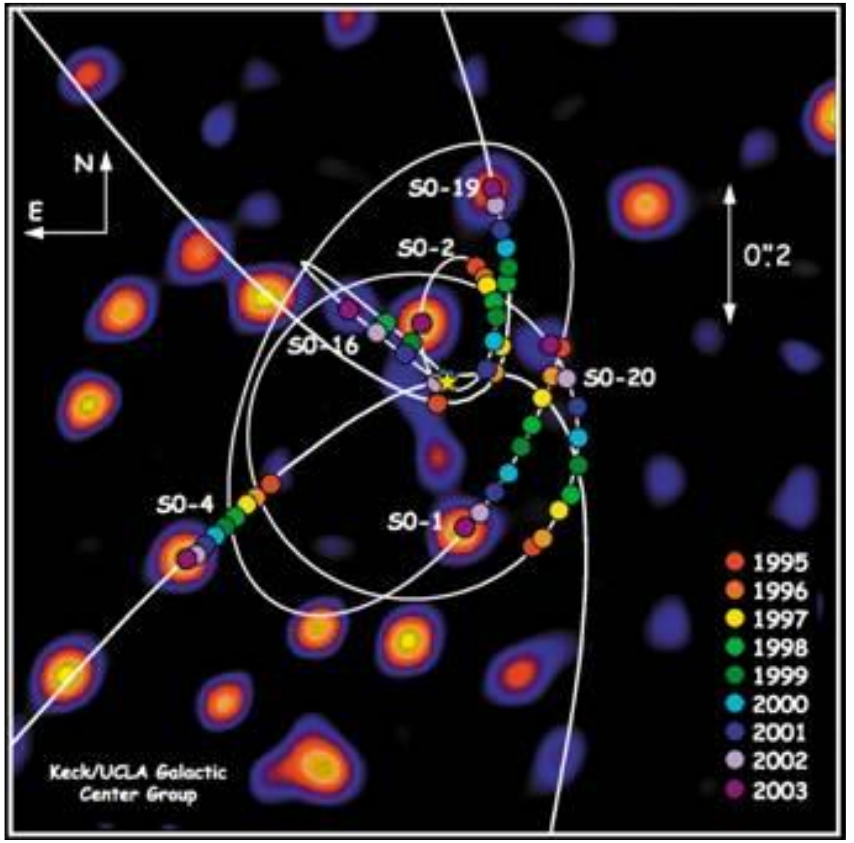


The Milky Way's galactic bulge (nucleus) is ~ 20,000 light years in thickness with a much greater density of stars



Increasing magnification

The picture to the right is a star map of stars in the galactic bulge of the Milky Way Galaxy. They were imaged using infrared and x-ray methods.

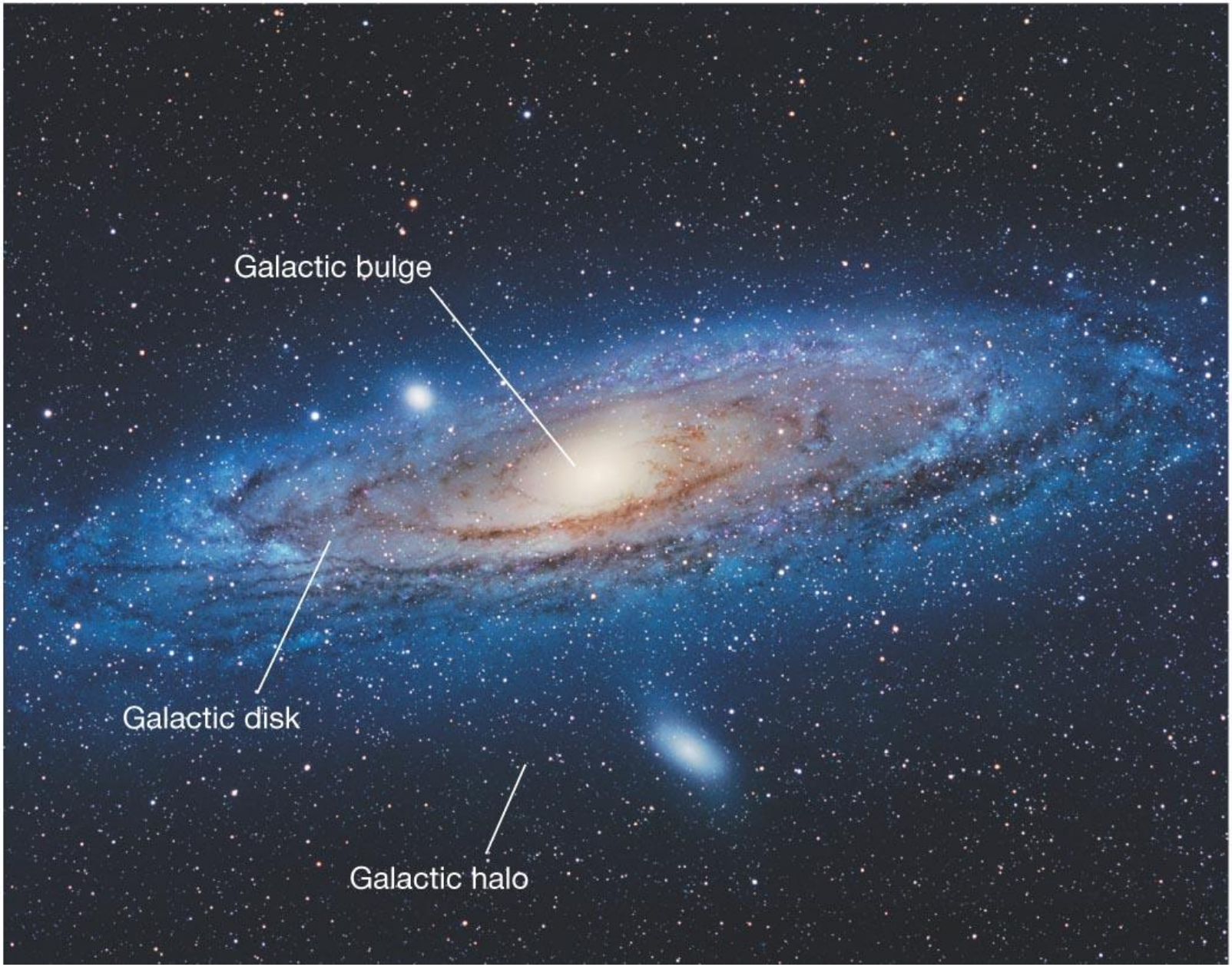


Stars in the center of the galactic bulge are moving very, very fast because they are orbiting around the supermassive black hole in the center of the Milky Way. The gravity of the supermassive black hole is so strong, stars must move very fast around it.

Review of Concepts

- The Milky Way is a _____ galaxy.
- The Milky Way has about _____ stars.
- ____ is at the center of the Milky Way
- Where is our Solar System located in the Milky Way Galaxy?
- The Solar System is in the _____, part of the spiral about 26,000 light years from the center of the Galaxy.
- It takes the Sun ____ years to orbit one time around the center of the Milky Way.

The structure of a typical galaxy.



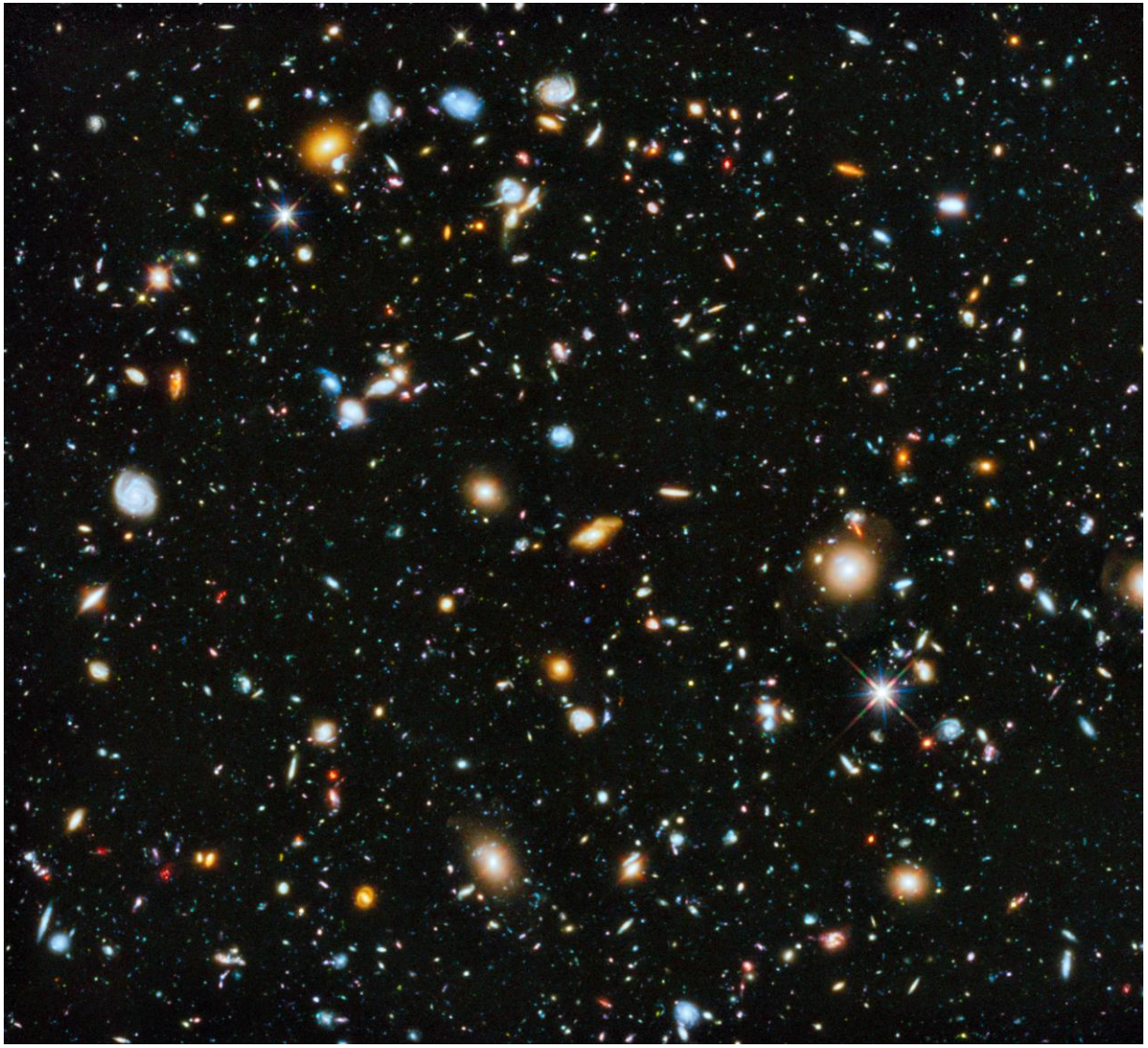
Galactic bulge (nucleus): The center of most galaxies with the greatest density of stars and most mass.

Galactic disk: (stellar disk) The flattened rotating part of the galaxy, the plane in which the spiral arms lie. The stars in the galactic disk revolve around the galactic bulge.

Galactic halo: (stellar halo) The diffuse spherical region containing hot gas clouds and stars that surround the main galaxy.

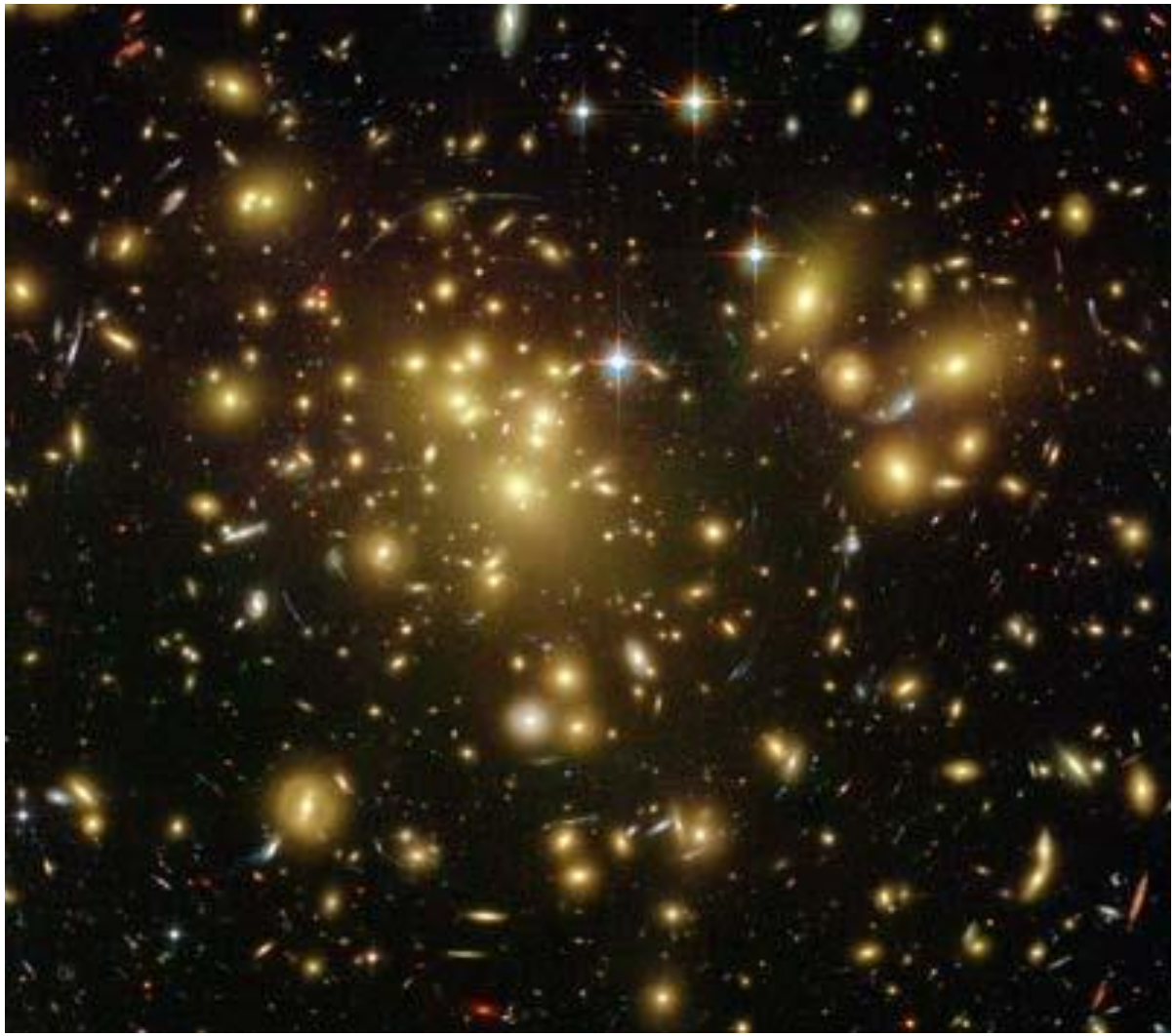
Globular clusters: Clusters of thousands of stars that lie outside of the galactic disk and halo, but are gravitationally held close to the galaxy.

Deep field view of the one region of the night sky showing hundreds of galaxies.

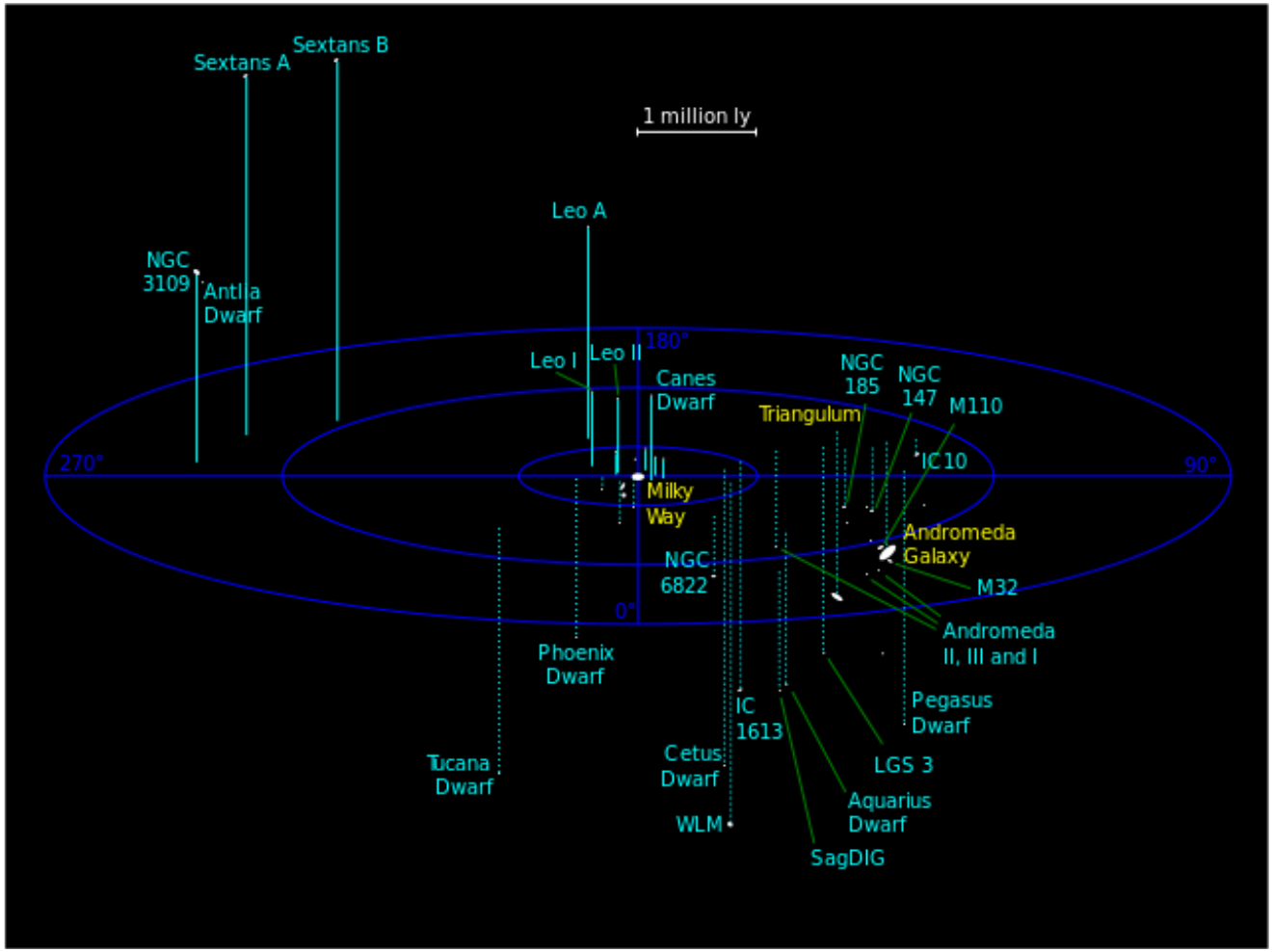


The Milky Way Galaxy is one of billions of galaxies in the observable universe. (taken by Hubble Space Observatory).

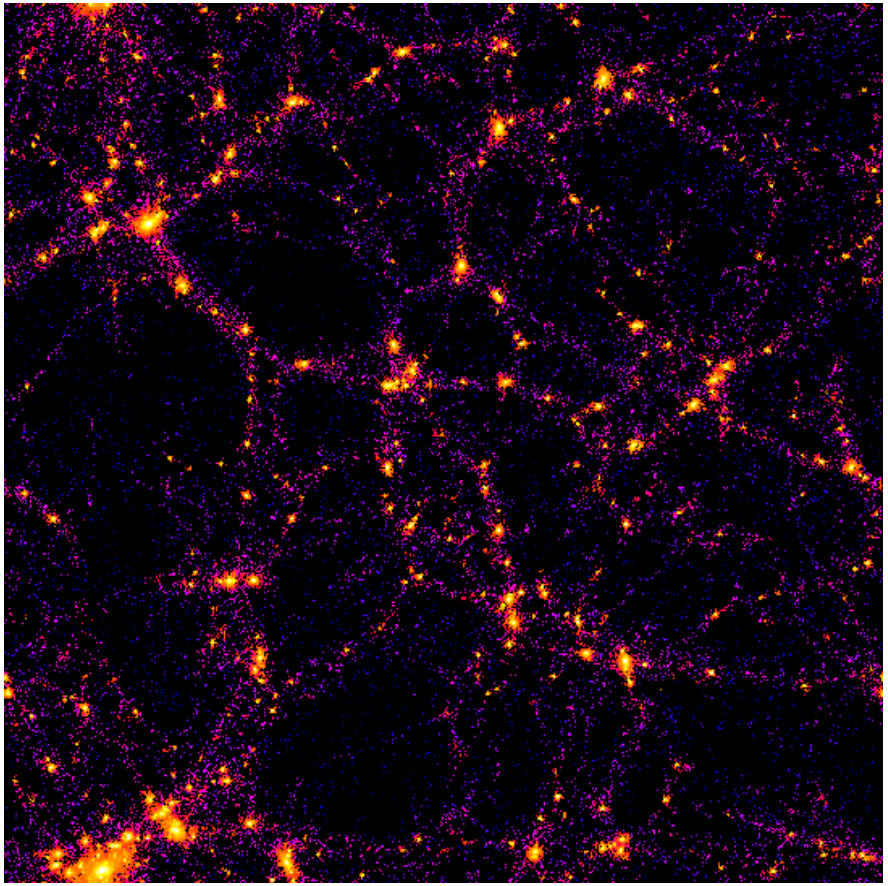
Galaxy clusters (sometimes called groups or superclusters depending on size) are groups of galaxies, hundreds to thousands, associated by gravity.

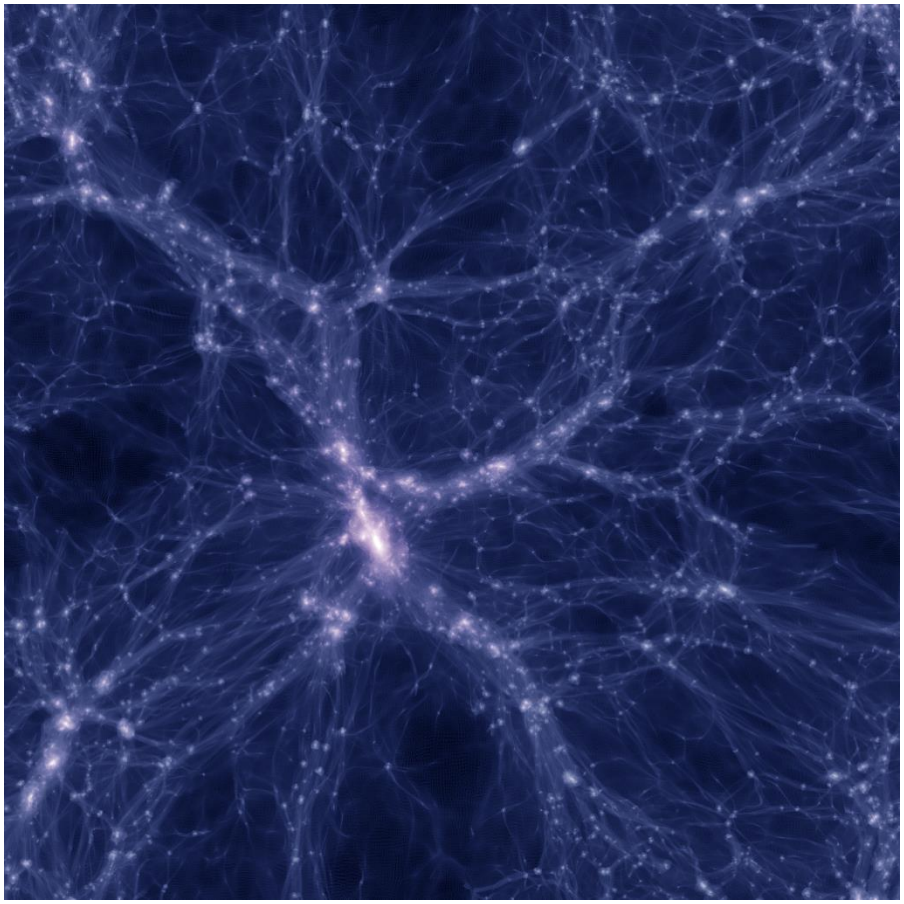


The Milky Way galaxy lies in the **Local Group**, a smaller cluster of 54 of our closest galaxies. Our local group is a very small part of the **Virgo Supercluster** of galaxies.



Galactic superclusters are grouped together and lie within the web-like arrangement in the observable deep field view. The web-like arrangement is through to be defined by gravity waves of ***dark matter***.



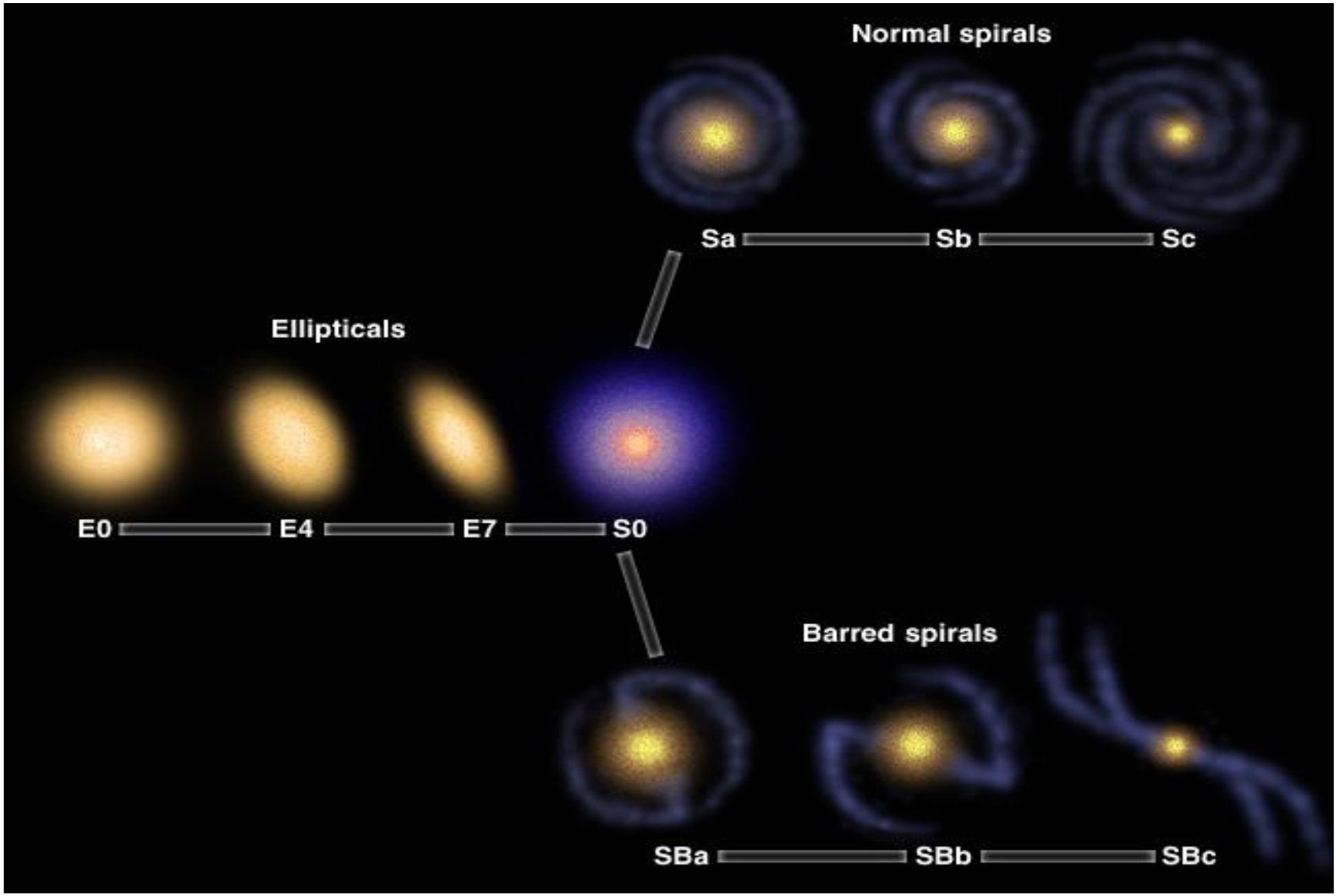


Galaxies are classified according to their shape (structure).

- Elliptical galaxies (E)
- Regular spiral or barred spiral galaxies (S or Sb)
- Irregular galaxies (I)
- and sometimes Lenticular galaxies are included (S0).

The **Hubble classification** system defines galaxies based on their structure and how spherical or how arranged the spiral arms are.

Hubble's Galactic "Tuning Fork"



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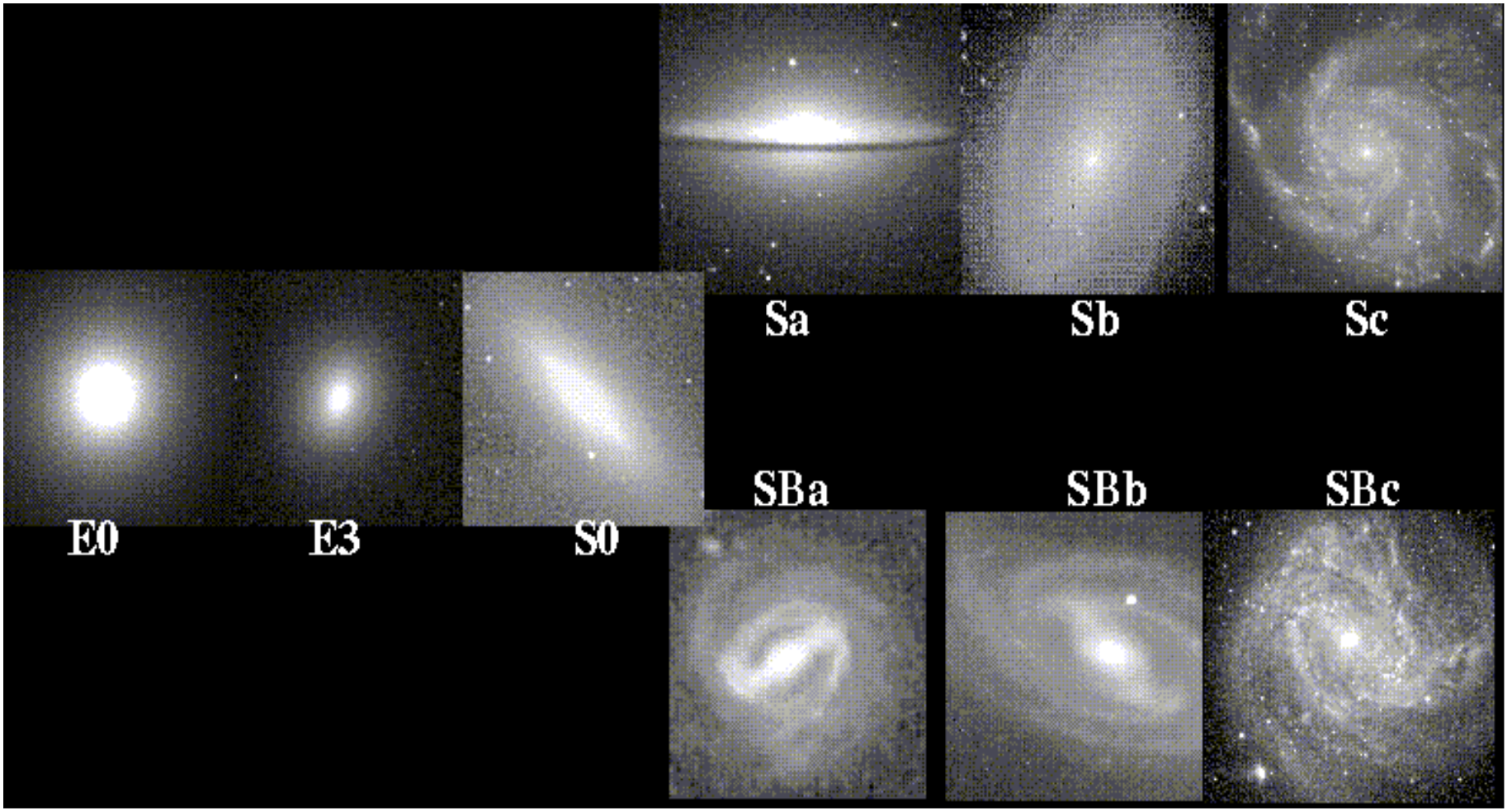


Spiral galaxies are galaxies that have a central galactic bulge with “spiral arms” radiating outward like blades of a pinwheel. Typically, spiral galaxies are flattened rotating “disks”

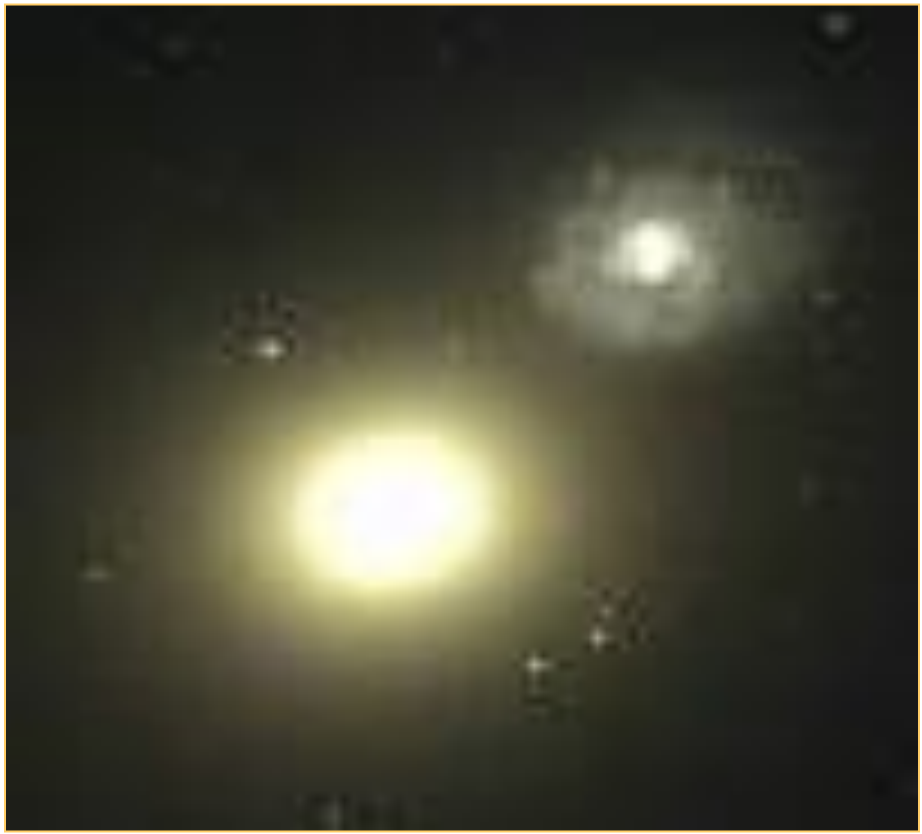
Regular Spiral galaxies have a spherical galactic bulge and the spiral arms tend to radiate away evenly from the galactic bulge.

Barred Spiral galaxies are galaxies that have an elongated central galactic bulge with “spiral arms” radiating outward from the “bar”.

Regular Spiral Galaxy

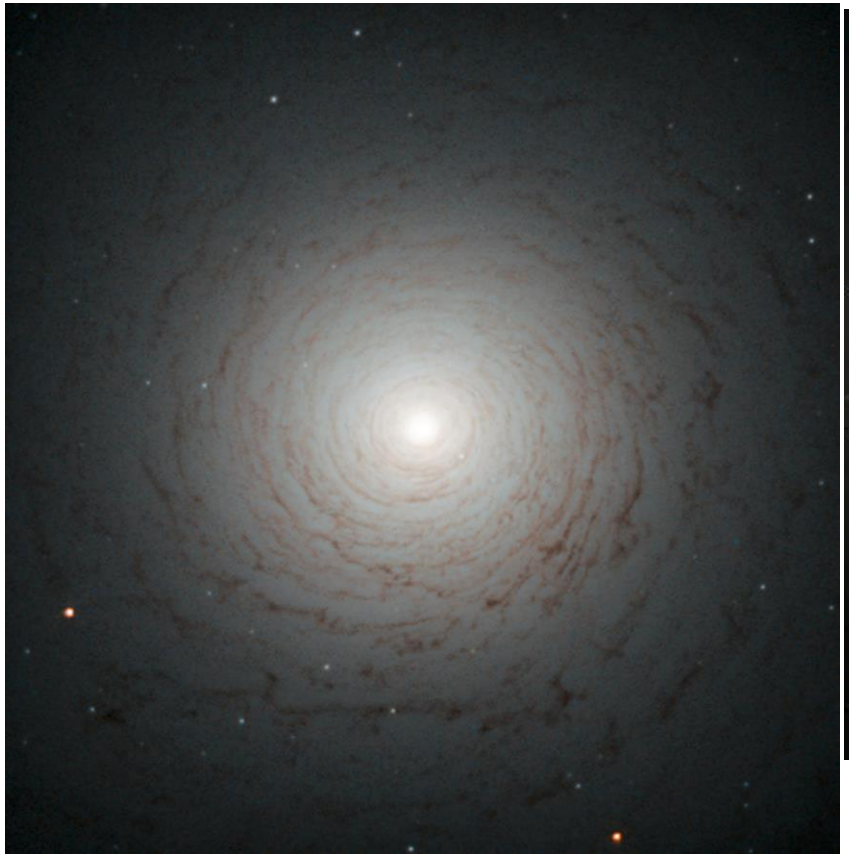
Regular Spiral Galaxy

Elliptical galaxies are galaxies that are oval or spherical shaped. They tend to be made of older stars with limited to no new star formation. They have very little dust and nebulae.



Irregular galaxies are large masses of stars without a defined shape. They do not fit into any other category. Irregular galaxies are like chaotic mix of stars, gas and dust. They may form by collisions between galaxies that disrupt the spiral or elliptical structure.

Lenticular galaxies are intermediate in shape between elliptical galaxies and spiral galaxies. Lenticulars are disk shaped with a galactic bulg. They have rotation like spiral galaxies, but lack spiral arms.



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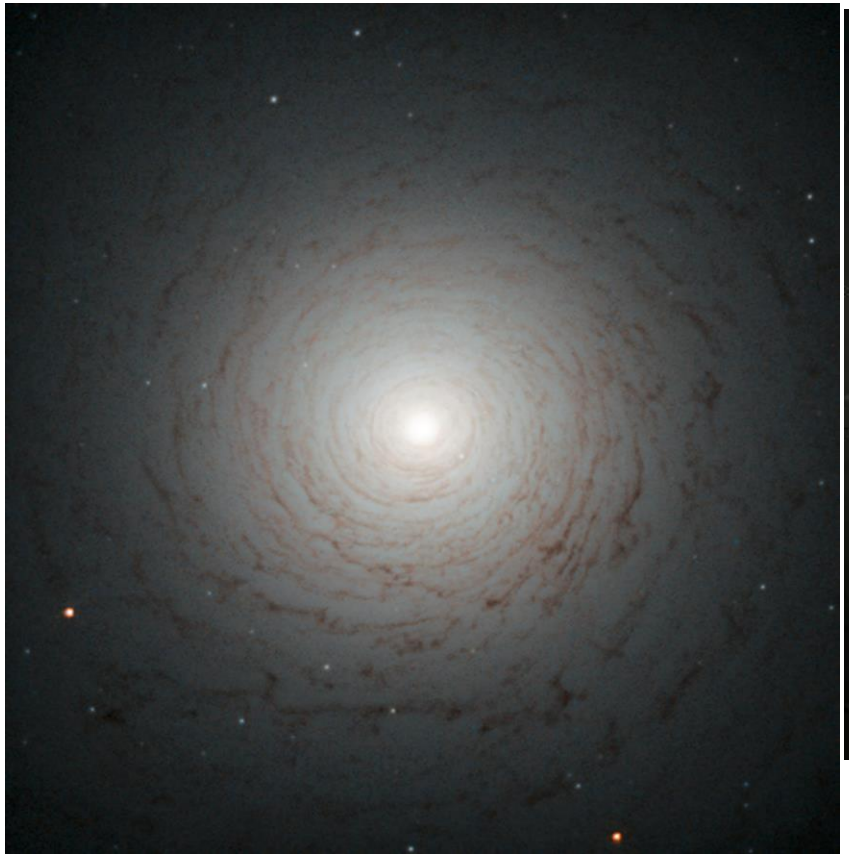

Galaxies are in motion. Galaxies have gravity that can attract other galaxies. Galaxies can collide and tear apart their structures.

Colliding galaxies most likely will produce one or more irregular galaxies as star clusters are flung multi-directionally by the collision.