Unit 1: Cosmology and Earth's Place in Space

Objectives:

E5.1A - Describe the position and motion of our solar system in our galaxy and the overall scale, structure, and age of the universe.

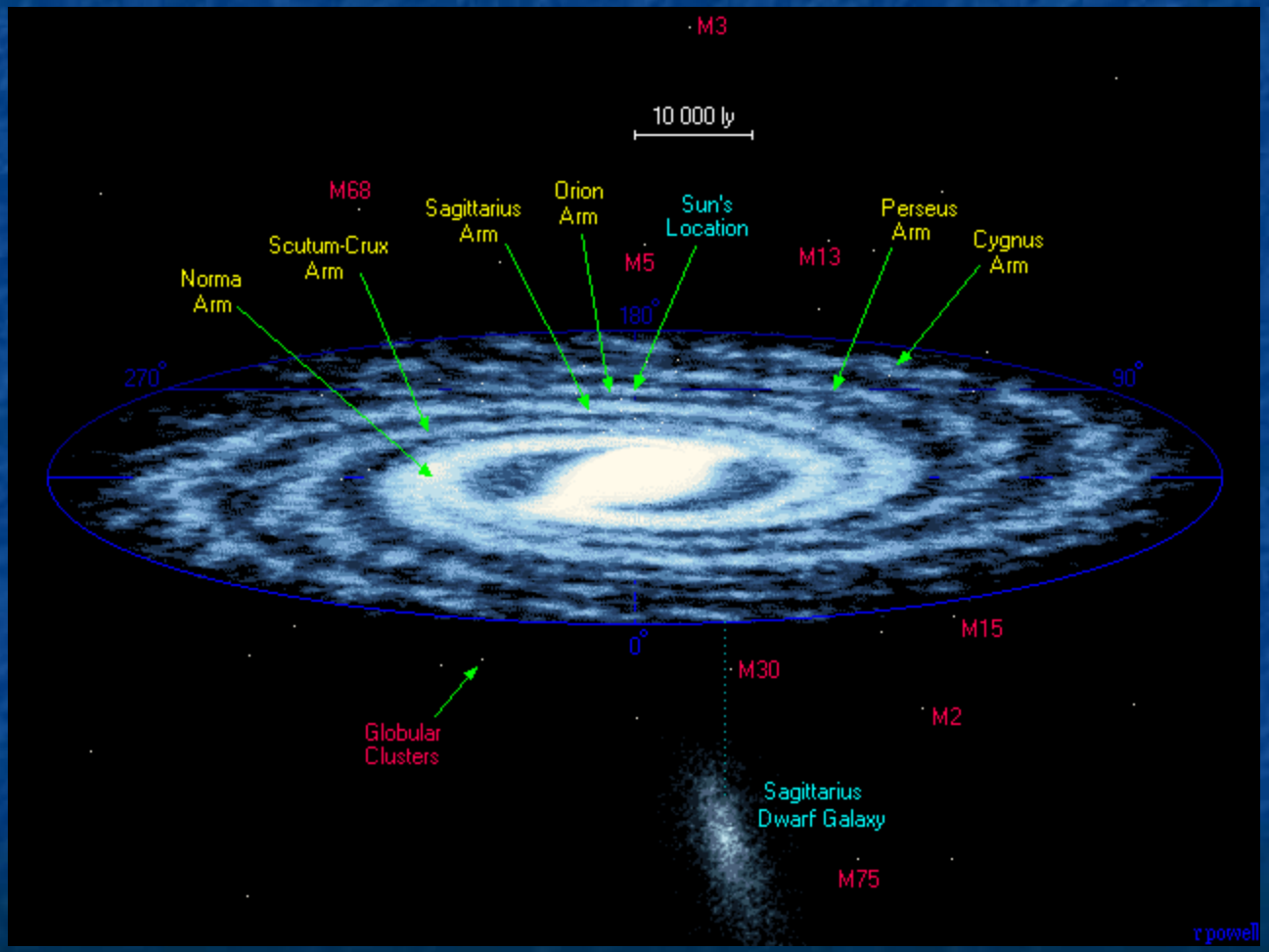
E5.1d - Differentiate between the cosmological and Doppler red shift.

Milky Way Galaxy*

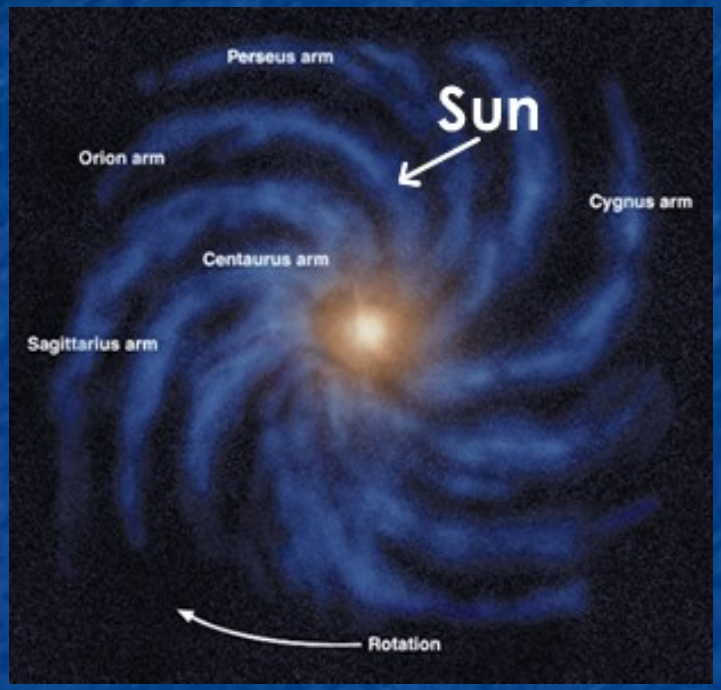
Here is the known universe within 50000 light years of Earth.

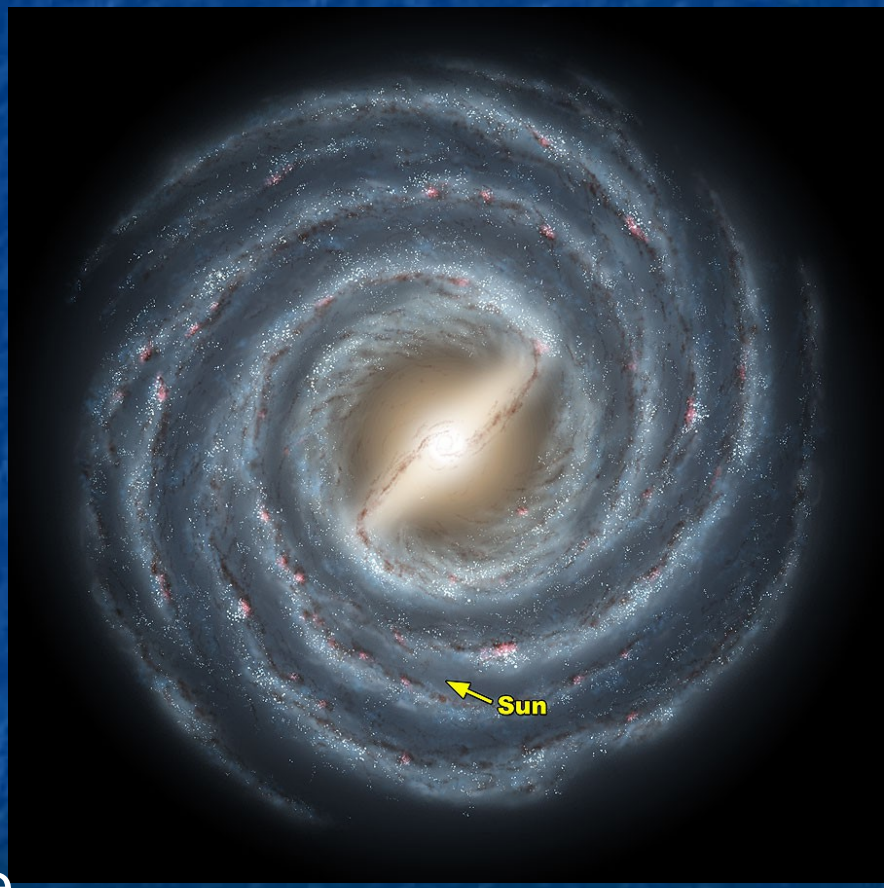
The number of stars estimated to exist within this distance is 200 billion.

Notice our Sun is located within the Orion Arm of the Milky Way galaxy.



Milky Way Galaxy





Scientists use to think the Milky Way galaxy was a spiral galaxy, however, new studies now believe that we might be barred spiral galaxy.

Milky Way Galaxy*

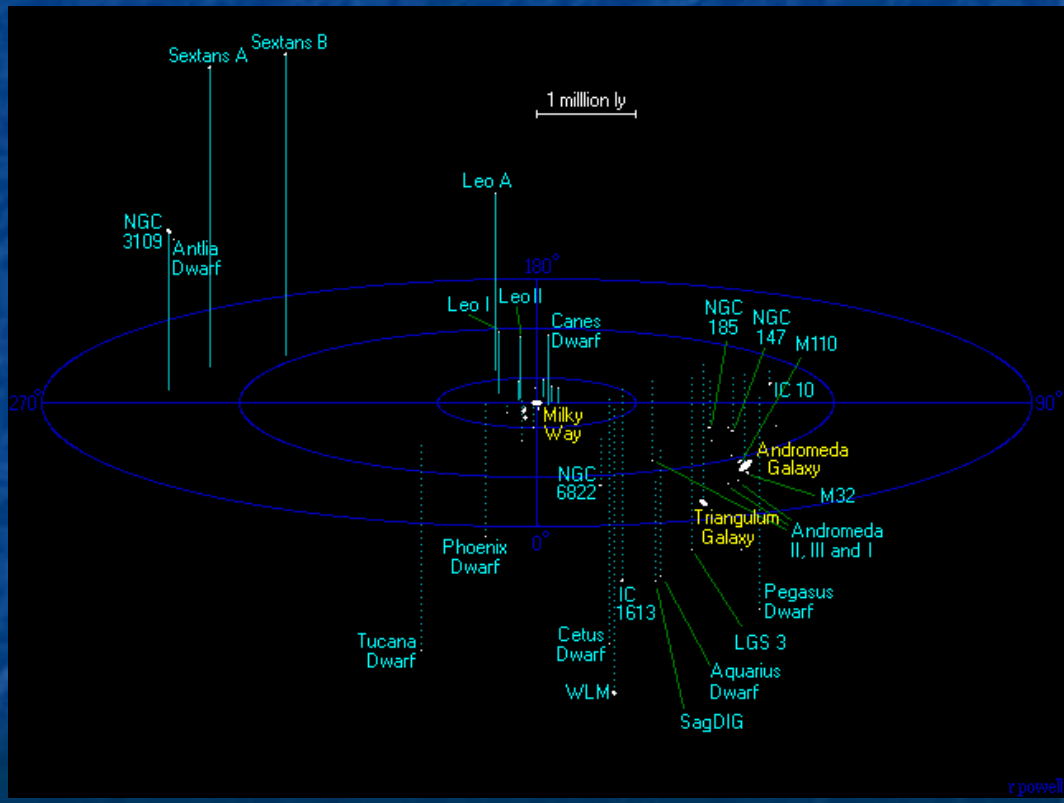
Where is our Sun and solar system located within the Milky Way galaxy?

Scientists believe that our Sun is located about 26000 light years from the center of the Milky Way galaxy. Our Sun is moving at a velocity of about 220 km/s (136 mi/s) around the galaxy, with an orbital period of 225 million years.

The Local Group

The Milky Way galaxy is part of a group of galaxies that is known as the ***Local Group***.

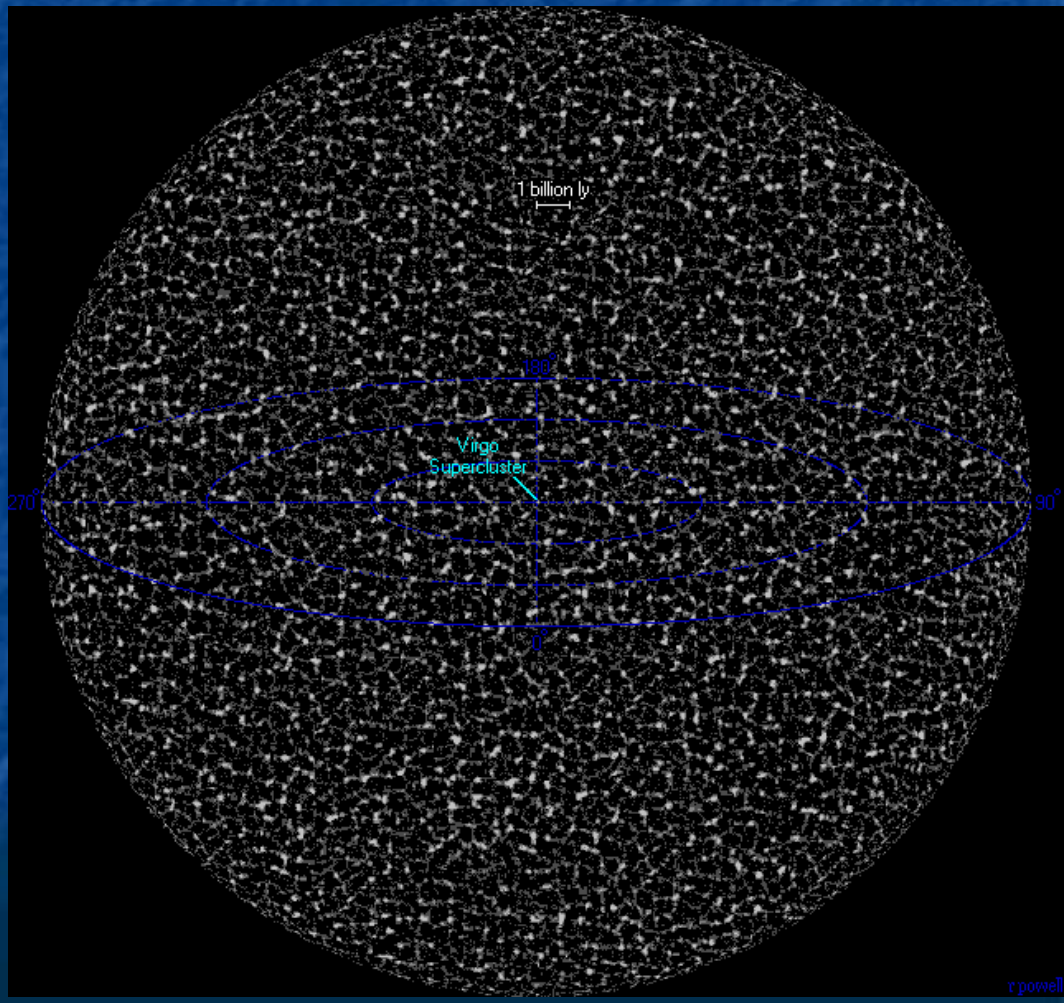
The Local Group contains approximately 27 galaxies, including some dwarf galaxies. However, dwarf galaxies are so faint, that there are probably several more waiting to be discovered.



Our Universe*

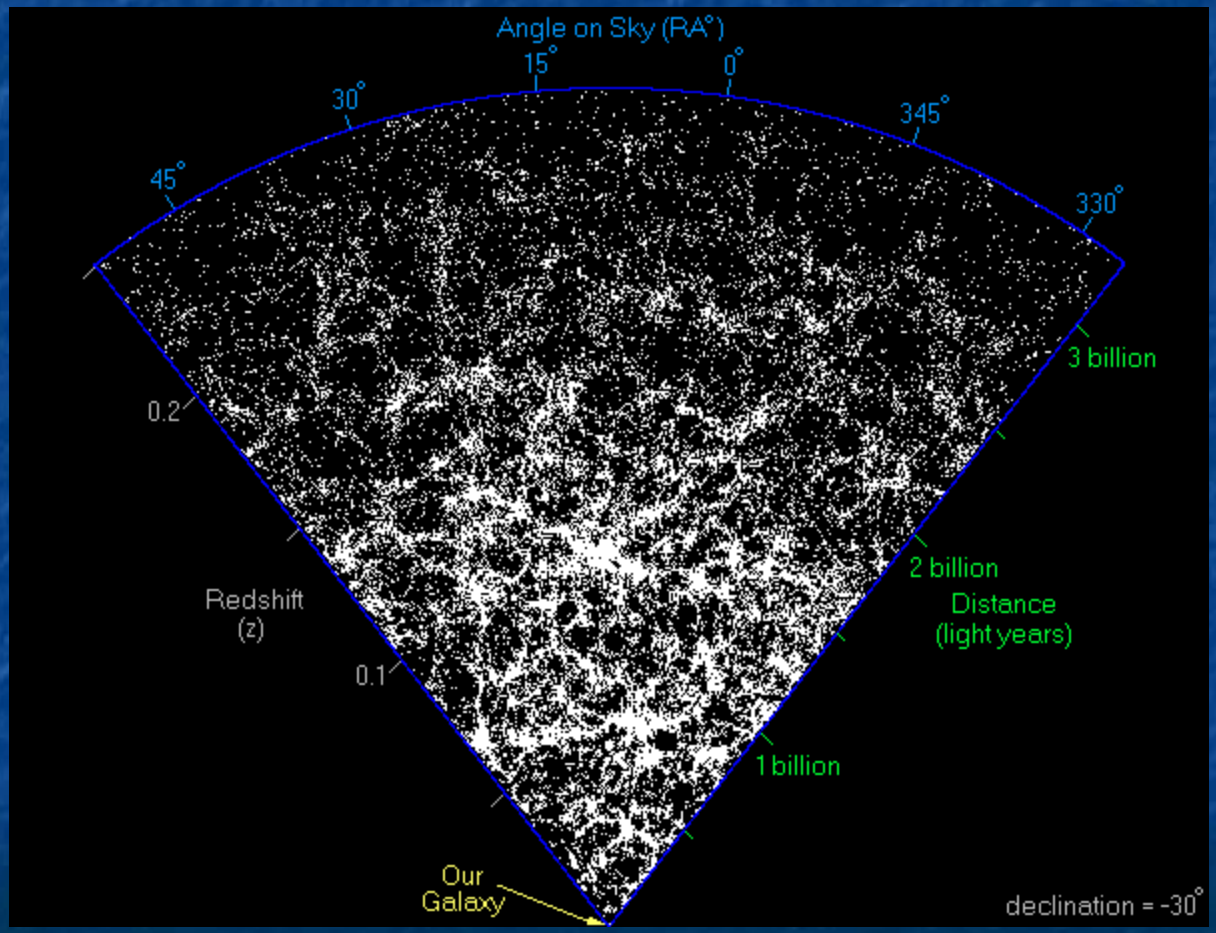
We now believe our universe to be somewhere around 13.7 to 14 billion years old.

Scientists estimate that there are 350 billion galaxies in the observable universe. Galaxies tend to collect into superclusters surrounded by large voids. 10 million of these superclusters may exist.



Our Universe

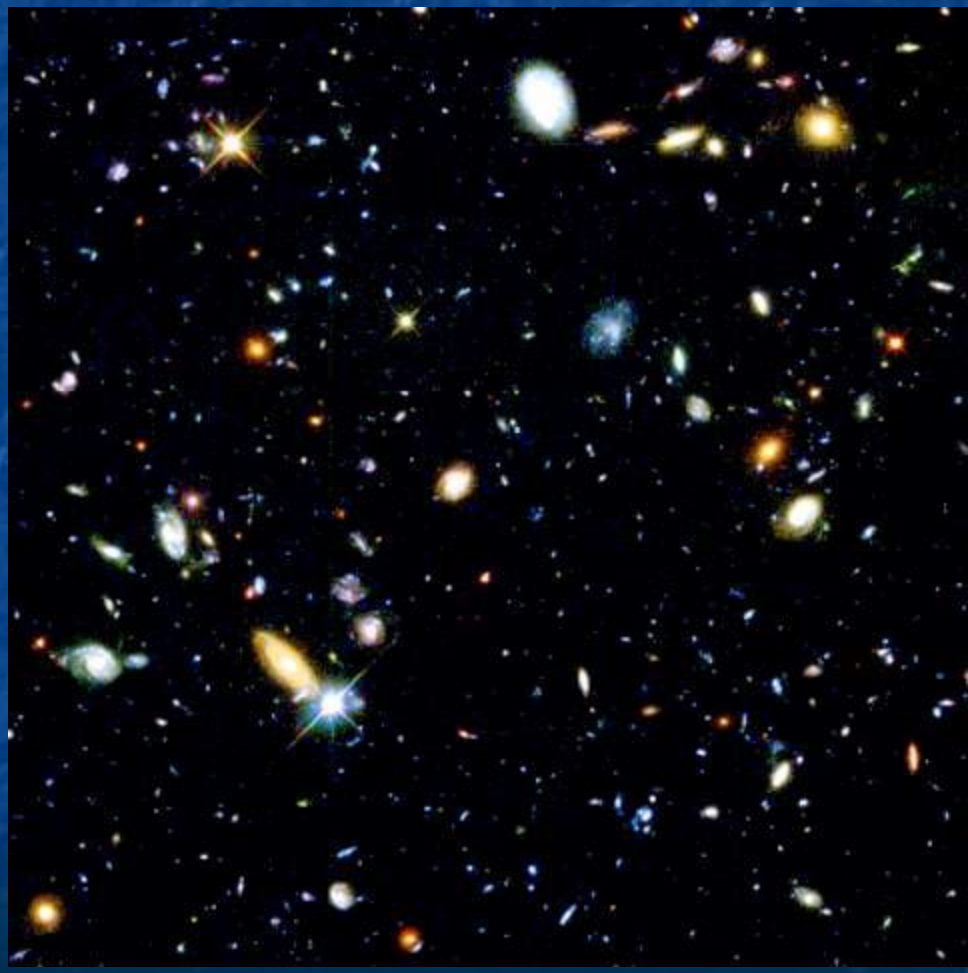
Here is a slice of the universe, where we are looking out from our galaxy 3.5 billion years. What you are seeing are about 52000 galaxies. Notice how clustered even this small number of galaxies are.



Our Universe

In 1995, the Hubble Space Telescope pointed at a blank area of the sky near Ursa Major for 10 days. It produced this picture. Almost all the objects in this photograph are galaxies that are located between 5 and 10 billion light years away from Earth.

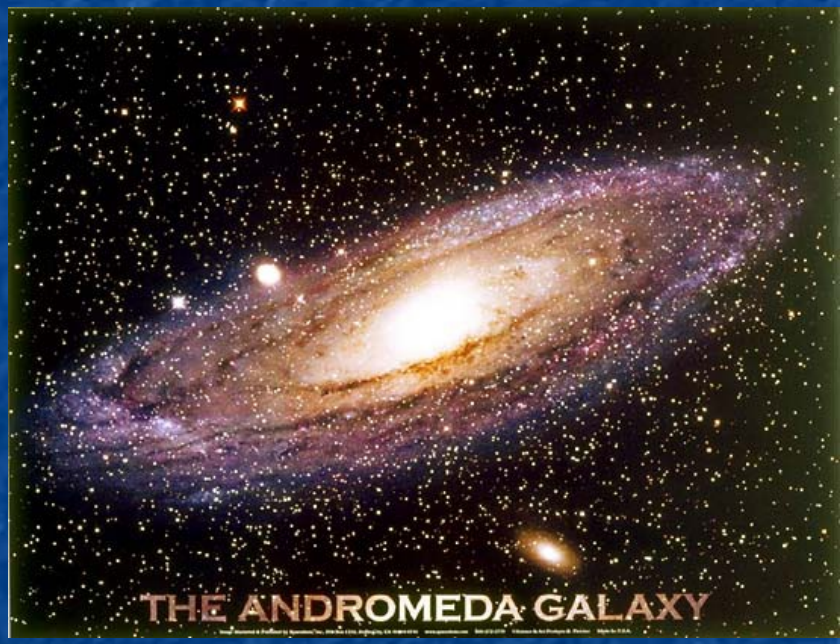
Younger galaxies are blue while older galaxies are red in color.



Types of Galaxies

No two galaxies are exactly alike. Most galaxies can be classified by shape.

Spiral galaxies (like the Milky Way) come in a range of types – from ones with large, bright nuclei of stars and tightly wound spiral arms, to ones with very small, dim nuclei and open sprawling arms.

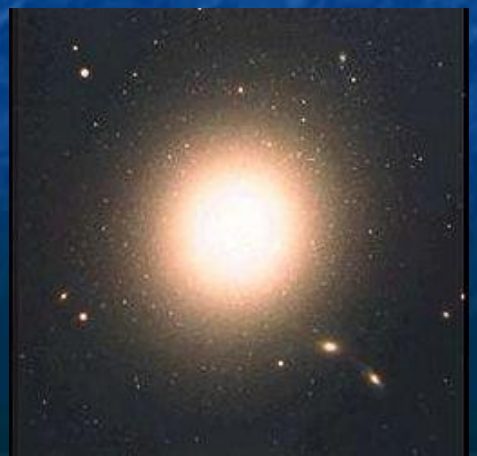


The Andromeda Galaxy is also a spiral galaxy.

Types of Galaxies

Elliptical galaxies range from nearly spherical to lens-shaped. Their stars are concentrated in their centers, and they have no arms. Elliptical galaxies contain far less interstellar gas and dust (than spiral galaxies), and contain few, if any, young stars.

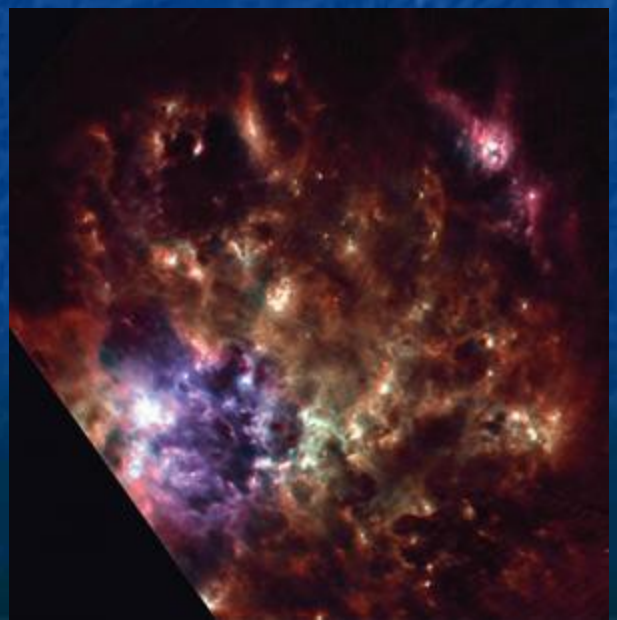
The galaxy called M87 is an elliptical galaxy.



Types of Galaxies

Irregular galaxies have irregular shapes and are much smaller and fainter than both spiral and elliptical galaxies. Stars in irregular galaxies are spread out unevenly.

The two Magellanic Clouds are irregular galaxies.

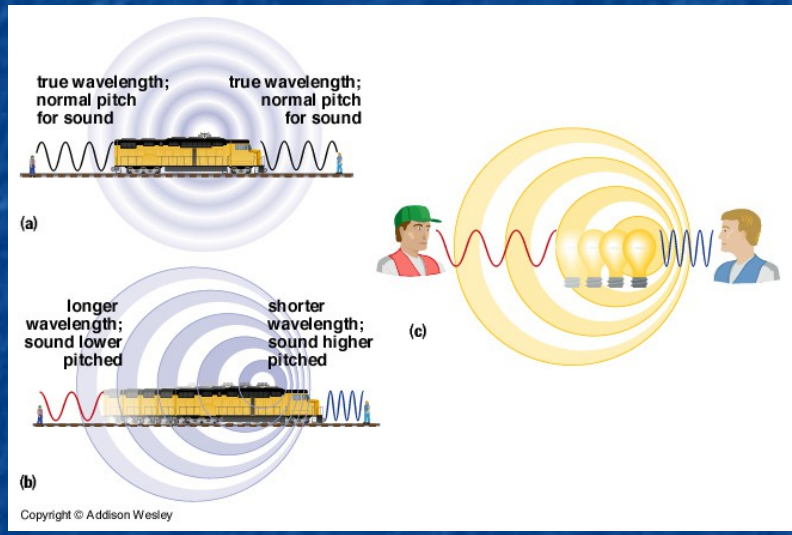


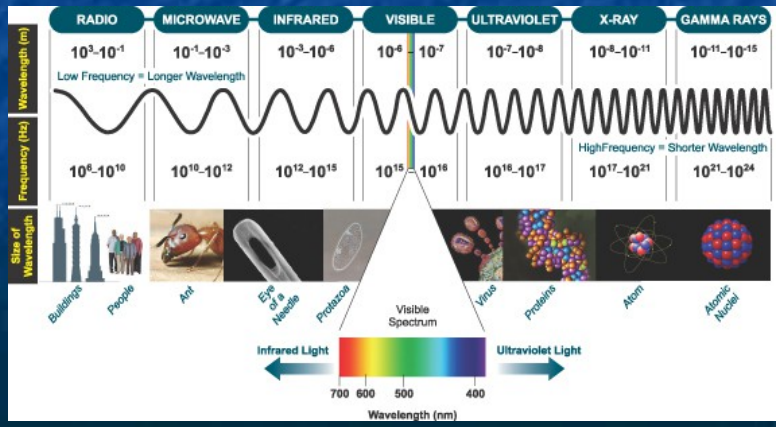
Large Magellanic Cloud galaxy (left), Small Magellanic Cloud galaxy (right)

Doppler Red Shift

You've experienced the ***Doppler effect*** if you've ever had a train go past you and heard the whistle go to a lower pitch (corresponding to a longer wavelength for the sound wave) as the train moves away.

It turns out that just like for sound waves, the wavelength of light emitted by an object that is moving away from you is longer when you measure it than it is when measured in the rest frame of the emitting object.



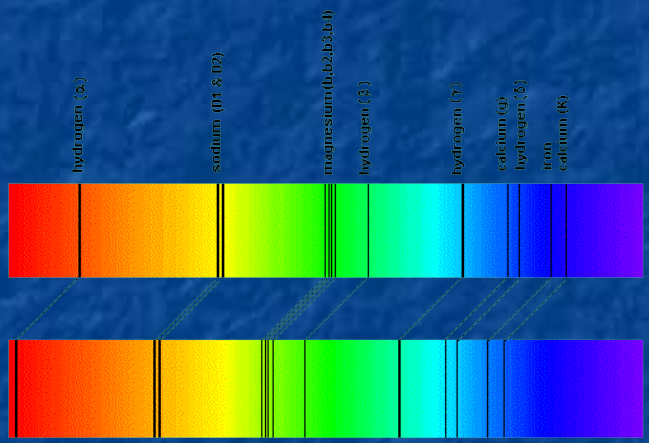


Doppler Red Shift*

In our example, the top band is our Sun, while the bottom band represents the spectrum of a star that is moving away from the Earth. Notice how the entire pattern of black lines has been shifted toward the red end of the spectrum.

If the bottom band had been a star that is moving toward the Earth, then the pattern of black lines would have been shifted toward the blue end of the spectrum.

A lack of shifting means that the star is not moving relative to our Earth.

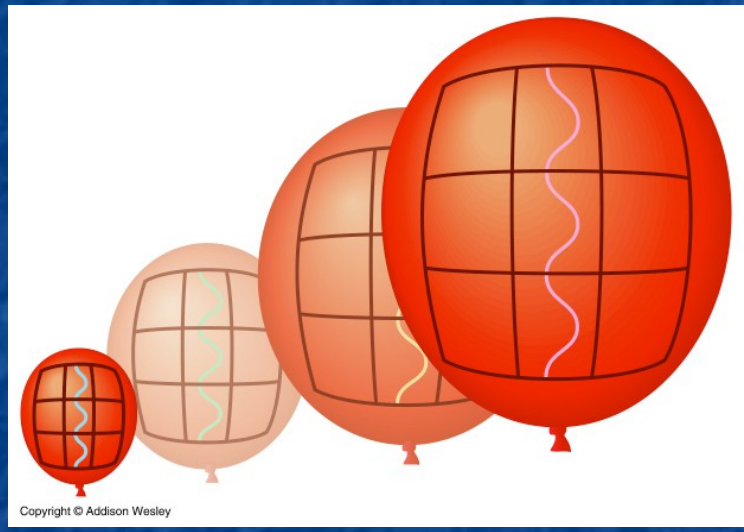


Red shifting causes all the bands to be shifted the same amount so each band can still be identified and the amount of red shift measured.

Cosmological Red Shift*

In the case of ***cosmological red shift***, the object that is emitting light is expanding along with the rest of the universe. If the rate of expansion changes between the time the light is emitted and the time it is received, that will effect the received wavelength.

The cosmological red shift is a measure of the total "stretching" that the universe has undergone between the time the light was emitted and the time it was received.



This red shift is due to the expansion of space itself!