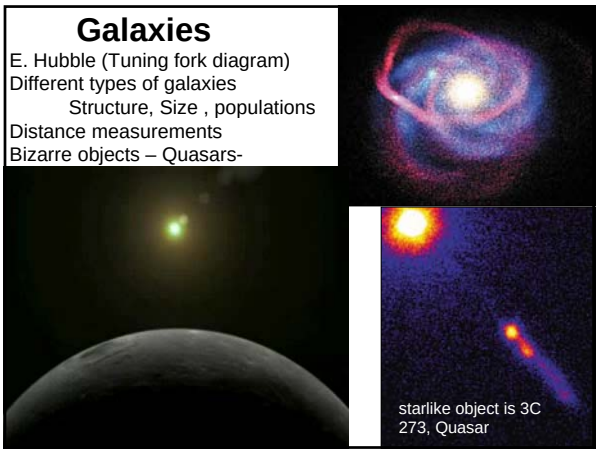
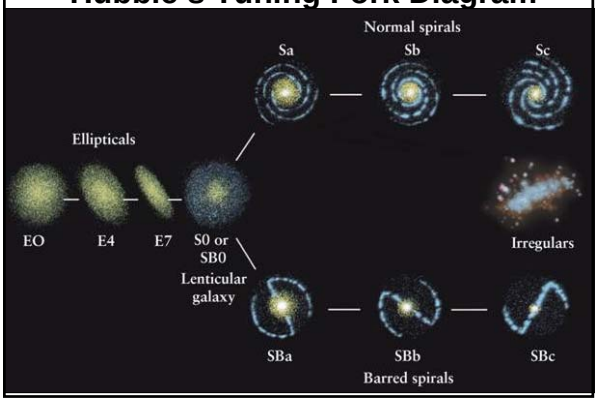
Galaxies

E. Hubble (Tuning fork diagram)
Different types of galaxies
Structure, Size , populations
Distance measurements
Bizarre objects – Quasars-

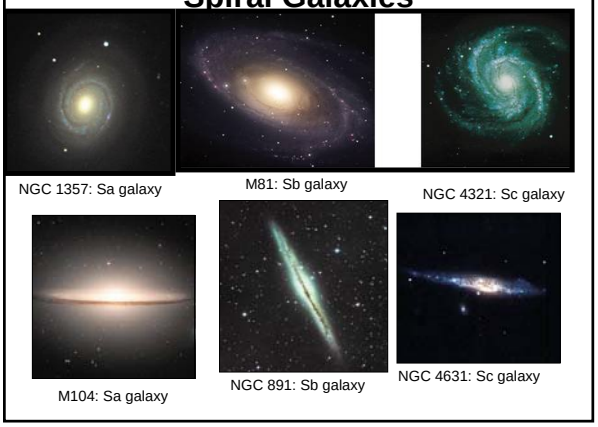


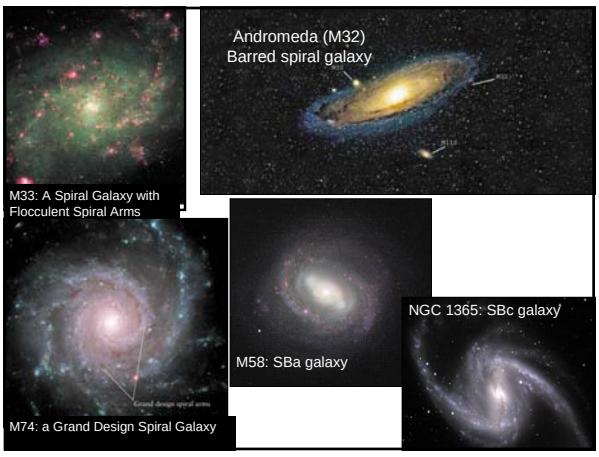
Hubble's Tuning Fork Diagram



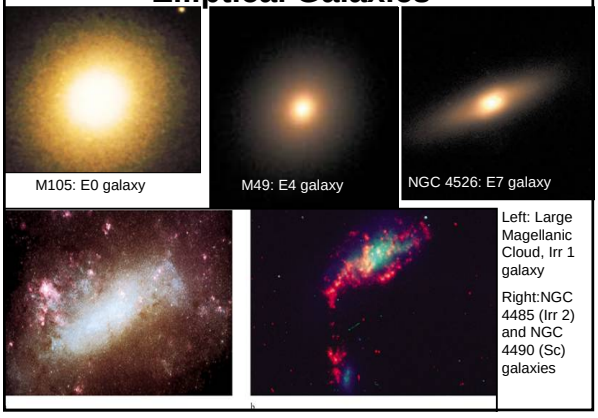
	Spiral	Elliptical	Irregular
Mass (M sun)	$10^9 – 10^{11}$	$10^5 – 10^{13}$	$10^8 – 10^{10}$
Luminosity (L sun)	$10^8 – 10^{10}$	$10^5 – 10^{11}$	$10^7 – 10^9$
Stellar populations I – metal rich II -metal poor	I in disk II in halo and bulge	Mostly II some I	Mostly I
Percentage of observed galaxies	77%	20%	3%

Spiral Galaxies

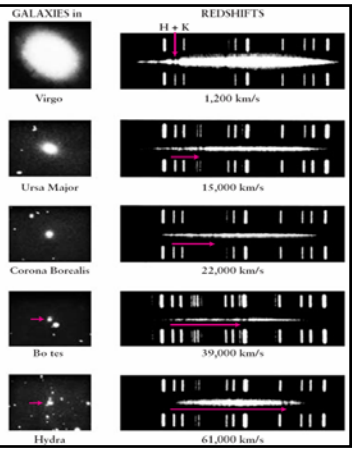


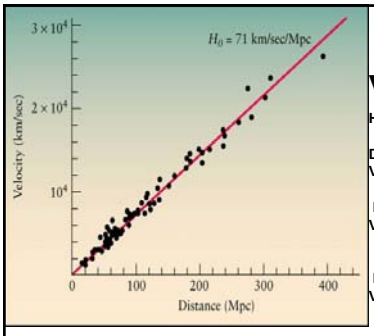


Elliptical Galaxies



Five Galaxies and Their Spectra





The Hubble Law

V = H * D

H=71km/s/Mpc= 20km/s/Mly

Distance = 10 million lys
V=20km/s/Mly* 10mly=200km/s

Distance = 100 million lys
V=20km/s/Mly* 100mly
=2000km/s

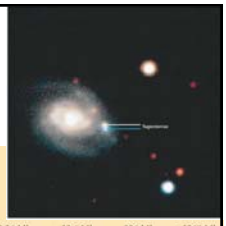
Distance = 1 billion lys
V=20km/s/Mly* 1000mly
=20, 000km/s

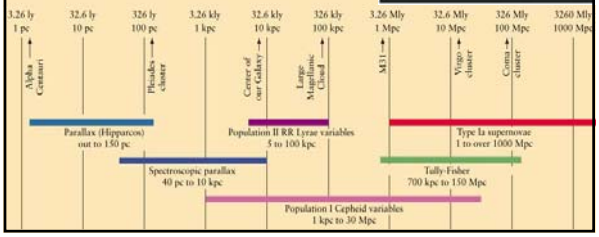
the age of the universe:

H_o = 3.09x10^{19}km/Mpc = 13.6 x 10^9 years
71km/s/Mpc

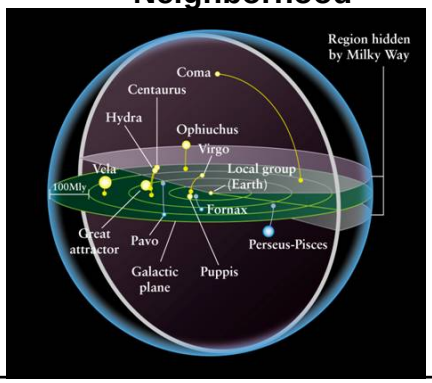
13.6 billion yrs old

Techniques for Measuring Cosmological Distances

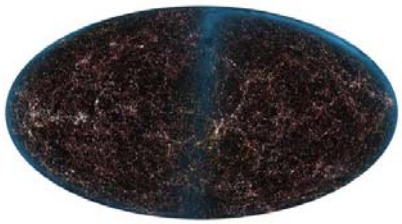




Clusters of Galaxies in Our Neighborhood



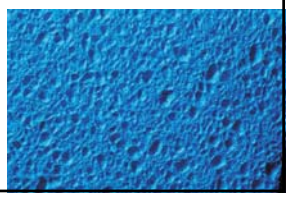
Structure in the Universe



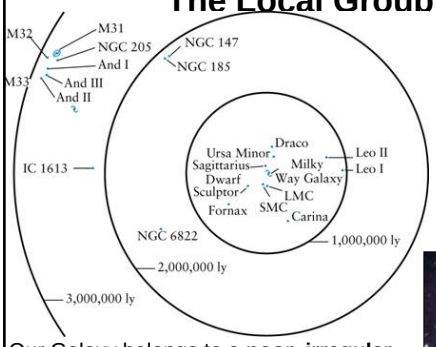
2-Micron All Sky Survey

Foamy Structure of the Universe

The empty spaces in the foam are analogous to the voids found throughout the universe. The spongy regions are analogous to the locations of most of the galaxies.



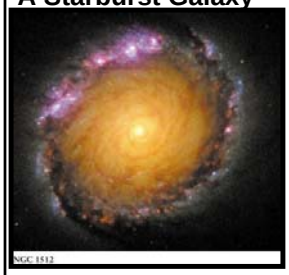
The Local Group



Our Galaxy belongs to a **poor, irregular cluster** consisting of about 40 galaxies called the Local Group.

Antlia: Recently Discovered Member of the Local Group

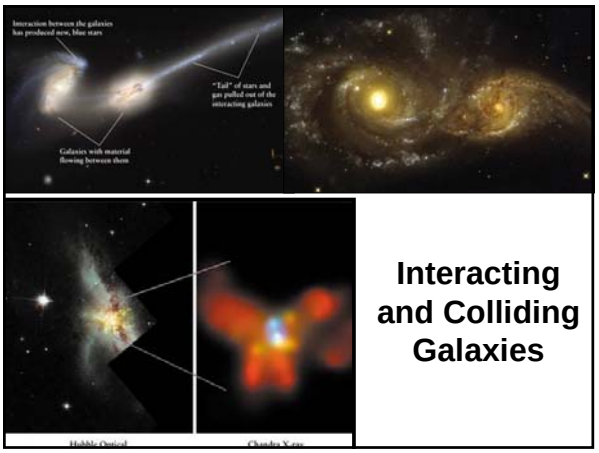
A Starburst Galaxy



Bright colors =Young stars
Young stars at the outer part of the galaxy may be as result of galactic collision.

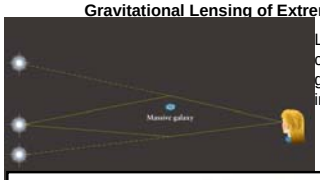
The Cartwheel Galaxy

This ring-shaped assemblage is the likely result of one galaxy (right) having passed through the middle of the larger one (left).
In constellation Sculptor in southern hemisphere.

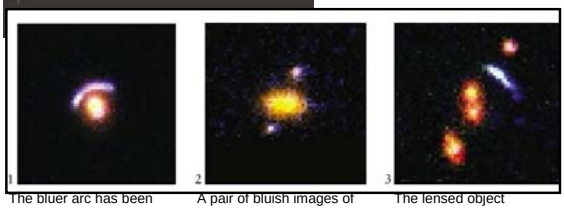


Interacting and Colliding Galaxies

Gravitational Lensing of Extremely Distant Galaxies



Light from the distant object changes direction due to the gravitational attraction of the intervening galaxy.



1 The bluer arc has been lensed by the redder elliptical galaxy.

2 A pair of bluish images of the same object lensed by the brighter galaxy between them.

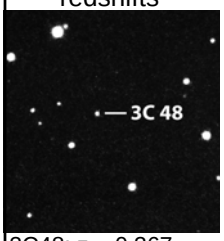
3 The lensed object appears as a blue arc under the gravitational influence of the group of four galaxies.

Video 14: Active Galaxies

The discussion of galaxies continues in this lesson by focusing on a special group of galaxies with very energetic cores called active galaxies. Different types of active galaxies are introduced, from Seyfert galaxies and blazars to quasars.

- How are active galaxies different form standard galaxies that we previously talked about?
- What are Seyfert galaxies?
- What are blazars
- What are quasars?

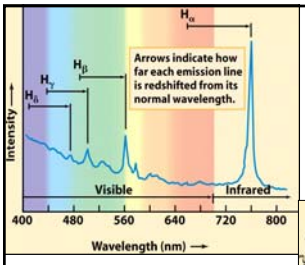
Quasars look like stars but have huge redshifts

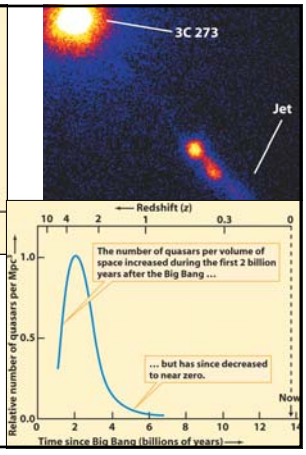


3C48: z = 0.367
How far is this star like object?

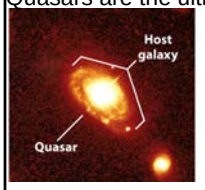
Redshift z	Recessional velocity v/c	Distance (Mpc)	Distance (10^9 ly)
0	0	0	0
0.1	0.095	394	1.29
0.2	0.180	739	2.41
0.3	0.257	1040	3.39
0.4	0.324	1310	4.26
0.5	0.385	1540	5.02
0.75	0.508	2010	6.57
1	0.600	2370	7.73
1.5	0.724	2860	9.32
2	0.800	3170	10.3
3	0.882	3520	11.5
4	0.923	3710	12.1
5	0.946	3830	12.5
10	0.984	4040	13.2
Infinite	1	4190	13.7

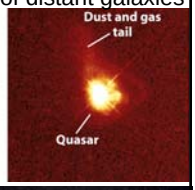
This table assumes a Hubble constant $H_0 = 71$ km/s/Mpc, a matter density parameter $\Omega_m = 0.27$, and a dark energy density parameter $\Omega_\Lambda = 0.73$ (see Chapter 28). The distance in light-years is equal to the light travel time in years.





Quasars are the ultraluminous centers of distant galaxies

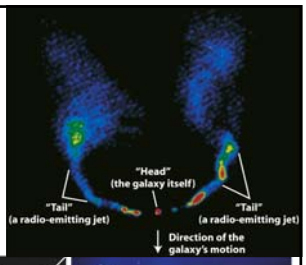


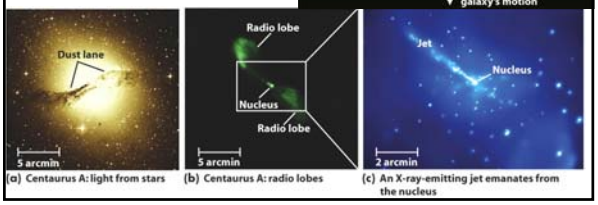


- Seyfert galaxies seem to be nearby, low-luminosity, radio-quiet quasars
- Seyfert galaxies are spiral galaxies with bright nuclei that are strong sources of radiation

Radio galaxies

- Radio galaxies are elliptical galaxies located midway between the lobes of a double radio source
- Seyferts and radio galaxies bridge the gap between normal galaxies and quasars



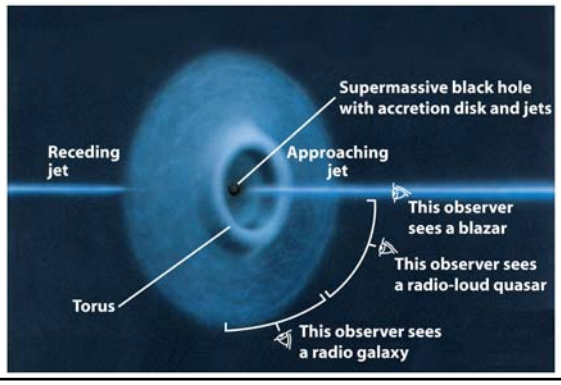


Quasars, blazars, Seyferts, and radio galaxies are active galaxies

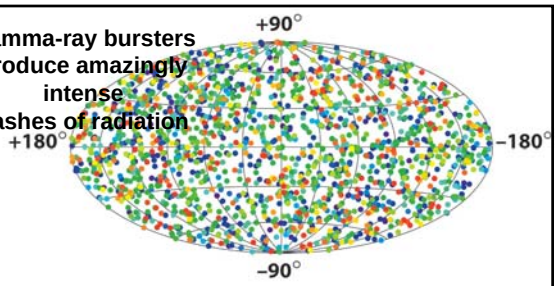
Object	Found in which type of galaxy	Strength of radio emission	Type of emission lines in spectrum	Luminosity (watts)	Luminosity (Milky Way Galaxy = 1)
Blazar	Elliptical	Strong	Weak (compared to synchrotron emission)	10^{38} to 10^{42}	10 to 10^5
Radio-loud quasar	Elliptical	Strong	Broad	10^{38} to 10^{42}	10 to 10^5
Radio galaxy	Elliptical	Strong	Narrow	10^{36} to 10^{38}	0.1 to 10
Radio-quiet quasar	Spiral or elliptical	Weak	Broad	10^{38} to 10^{42}	10 to 10^5
Seyfert 1	Spiral	Weak	Broad	10^{36} to 10^{38}	0.1 to 10
Seyfert 2	Spiral	Weak	Narrow	10^{36} to 10^{38}	0.1 to 10

- Quasars, blazars, and Seyfert and radio galaxies are examples of active galaxies
- The energy source at the center of an active galaxy is called an active galactic nucleus (AGN)
- Rapid fluctuations in the brightness of active galaxies indicate that the region that emits radiation is quite small

Quasars, blazars, and radio galaxies may be the same kind of object seen from different angles



Gamma-ray bursters produce amazingly intense flashes of radiation



- Short, intense bursts of gamma rays are observed at random times coming from random parts of the sky**Are they in Halo of our galaxy?**
- Long duration gamma ray bursters – 2 to 1000 seconds-
- First after glow measured: z=0.835. Nor observed up to Z=4.5
- The origin of short-duration gamma-ray bursters is unknown

What could bursters be?

- Bursters does not seem to be the galactic core of active galaxy
- The bursts are correlated with supernovae, and may be due to an exotic type of supernova called a collapsar, or hyper nova
- Collapsar is a giant supernova –greater than 30M sun at the end at rotating very fast. Forms black hole before the star collapse. 5 seconds later: Long duration gamma ray burst!