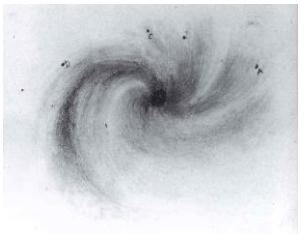
Galaxies

Galaxies vs Non-galaxies
Fuzzy objects
Spirals are common
Fuzzy things = nebulae
(sing. nebula)



Must find **distances** to the nebulae.

_____

Cepheids in the Andromeda Nebula
What does that tell you?
Distance!
More than 2 million light years away!

_____ introduced the method of determining distances to galaxies using _____

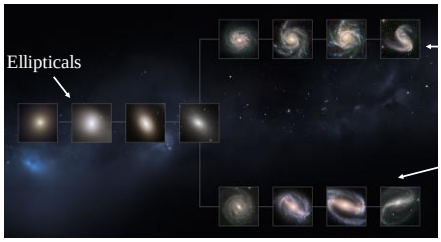
_____- Bright, well defined properties
Used to determine distances
Examples -

_____
_____
_____
_____
_____
_____
_____
_____
_____

and many more
End result – distances

Galaxy Classification

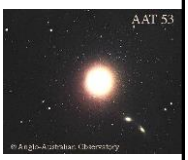
_____ Tuning Fork



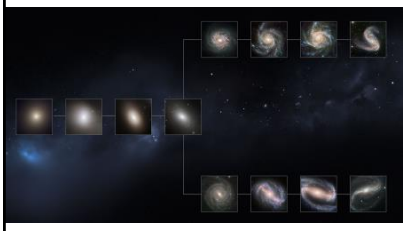
Irregulars

Ellipticals

No structure, or star formation
"E" + number based on ellipticity
0 = circle (E0)
7 = most elliptical (E7)
Very massive - _____
Very small - _____



Spirals



Two Main types

Those with bars

Those without bars

Spiral = S

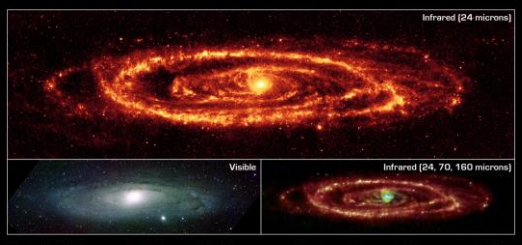
Barred Spiral = SB

Tightness of arms/size of bulge = _____

Possible Types:

No bars - _____

With bars - _____

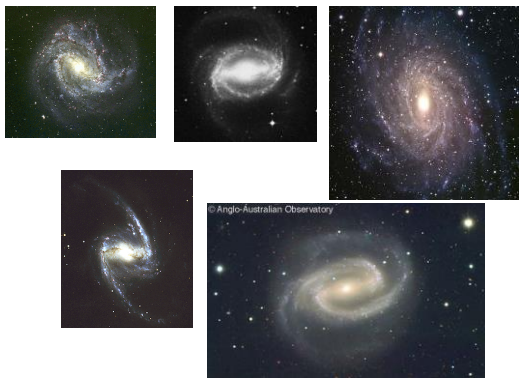


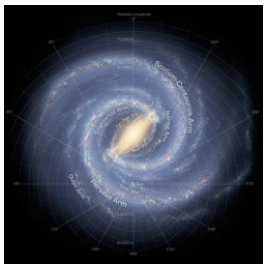
Dust in Andromeda Galaxy (M31) — **Spitzer Space Telescope • MIPS**

NASA / JPL-Caltech / K. Gordon (University of Arizona) — Visible: NOAO — ssc2005-20a

Spiral Galaxy M101 — Spitzer Space Telescope • Hubble Space Telescope • Chandra X-Ray Observatory

NASA / JPL-Caltech / ESA / CXC / STScI — ssc2009-03b






Irregular Galaxy

A once normal galaxy, where something has gone horribly, horribly, wrong….

Lots of star formation often





Galaxy Velocity

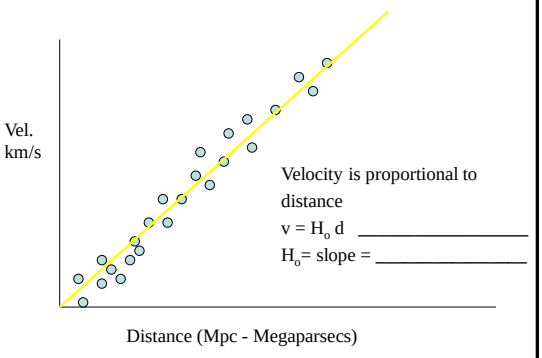
Galaxys move in space

Edwin Hubble

Distances to galaxies

Combined with galaxy velocities through space

Get the _____



Importance of Hubble's Law

1. Determines distances (d)

What is H_o?

_____

2. Why does the law exist?

The law exists because _____

3. What does H_o measure?

_____

A law to describe the Universe!!!!

Galaxy Masses

Galaxy _____→ Galaxy Masses

Galaxies masses 100's of billions - trillions $M_\odot$

Problem?

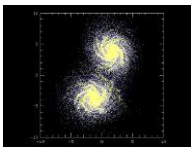
Galaxies are too faint for the mass observed

M/L ratio - Mass to light ratio

M/L - Always large

A large amount of *unseen* material

_____



Galaxy Clusters

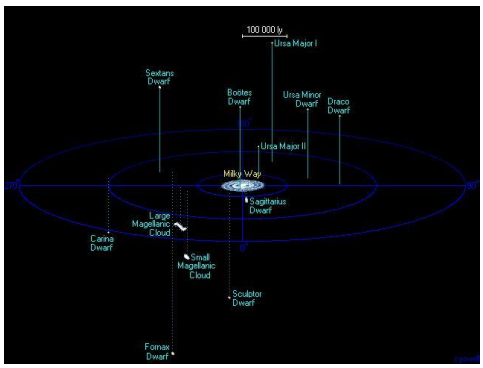
_____- our galaxy cluster

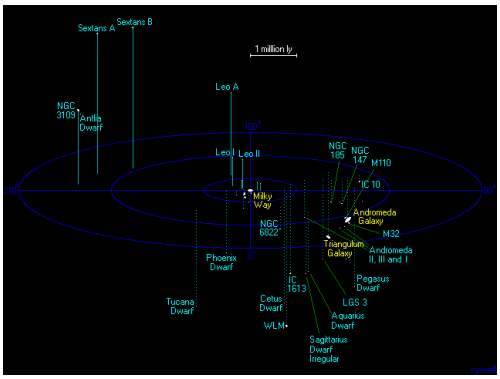
Contains ~60 galaxies, 3 big ones, many little ones

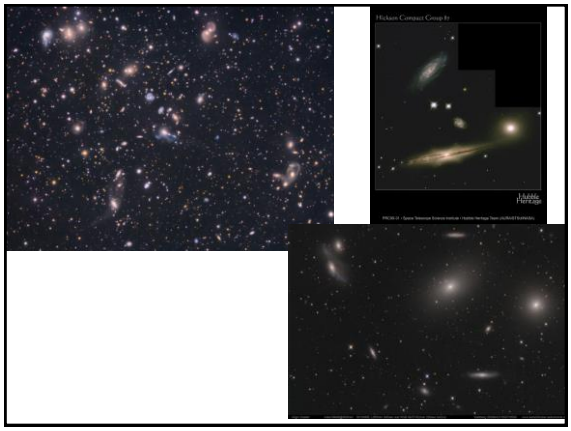
1 Mpc (million pc) in size

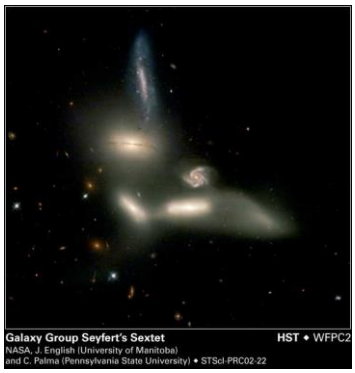
A relatively _____**cluster** - few galaxies

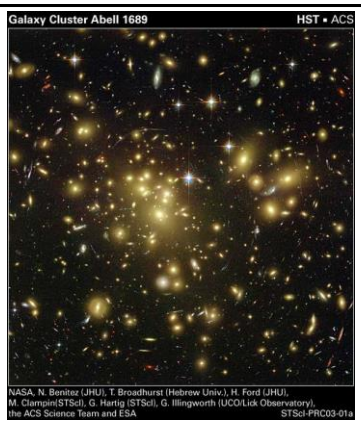
_____**clusters** - have hundreds, thousands of galaxies







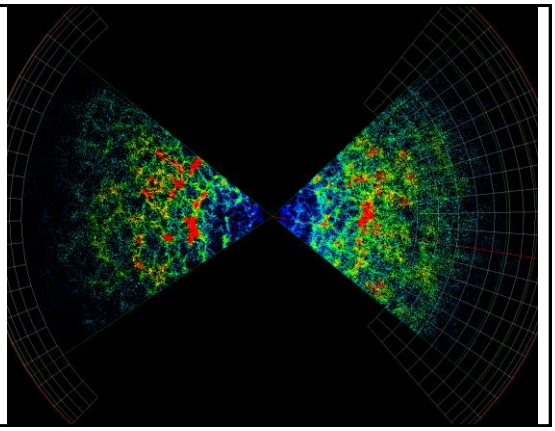

Galaxy Group Seyfert's Sextet
HST • WFPC2
NASA, J. English (University of Manitoba)
and C. Palma (Pennsylvania State University) • STScI-PRC02-22

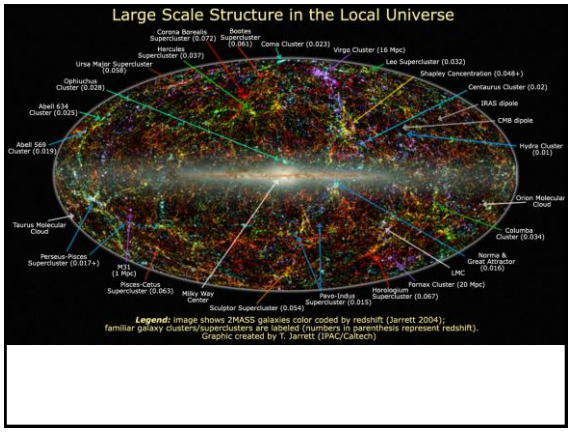

Galaxy Cluster Abell 1689
HST • ACS
NASA, N. Benitez (JHU), T. Broadhurst (Hebrew Univ.), H. Ford (JHU),
M. Clampin(STScI), G. Hartig (STScI), G. Illingworth (UCO/Lick Observatory),
the ACS Science Team and ESA
STScI-PRC03-01a

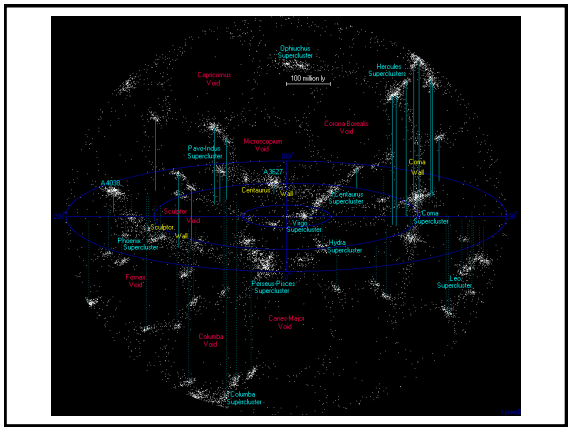
What keeps galaxies in clusters?
Gravity! Lots of gravity (mass)!
A lot of **Dark Matter**!
What is it?
WIMPs or MACHOs
WIMPs - _____
MACHOs - _____
Which is it?
_____.
How much dark matter is there in the Universe?
_____of the matter in the Universe

Superclusters

Clusters are clustered into Superclusters
_____- our supercluster
Are the superclusters clustered?
What would you call it?
Who cares, we'll just stop at superclusters…..
Superclusters and clusters of superclusters tell us about the "structure" of the Universe - things aren't randomly spread out




Large Scale Structure in the Local Universe
Corona Borealis Supercluster (0.072)
Bootes Supercluster (0.061)
Coma Cluster (0.023)
Virgo Cluster (16 Mpc)
Hercules Supercluster (0.037)
Ursa Major Supercluster (0.058)
Leo Supercluster (0.032)
Shapley Concentration (0.048+)
Ophiuchus Cluster (0.028)
Centaurus Cluster (0.02)
Abell 634 Cluster (0.025)
IRAS dipole
CMB dipole
Abell 569 Cluster (0.019)
Hydra Cluster (0.01)
Orion Molecular Cloud
Taurus Molecular Cloud
Columba Cluster (0.034)
Perseus-Pisces Supercluster (0.017+)
M31 (1 Mpc)
Norma & Great Attractor (0.016)
LMC
Pisces-Cetus Supercluster (0.063)
Fornax Cluster (20 Mpc)
Milky Way Center
Pavo-Indus Supercluster (0.015)
Horologium Supercluster (0.067)
Sculptor Supercluster (0.054)
Legend: image shows 2MASS galaxies color coded by redshift (Jarrett 2004);
familiar galaxy clusters/superclusters are labeled (numbers in parenthesis represent redshift).
Graphic created by T. Jarrett (IPAC/Caltech)


Ophiuchus Supercluster
100 million ly
Capricornus Void
Hercules Superclusters
Corona Borealis Void
Microscopium Void
Pavo-Indus Supercluster
A3627
Coma Void
Centaurus Void
Centaurus Supercluster
Coma Supercluster
Sculptor Void
Sculptor Void
Hydra Supercluster
Phoenix Supercluster
Fornax Void
Perseus-Pisces Supercluster
Leo Supercluster
Canes Major Void
Columba Void
Columba Supercluster