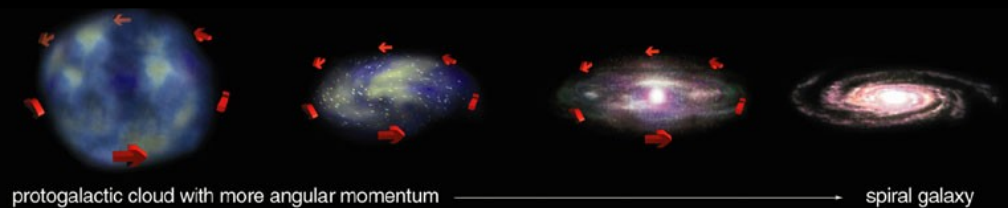
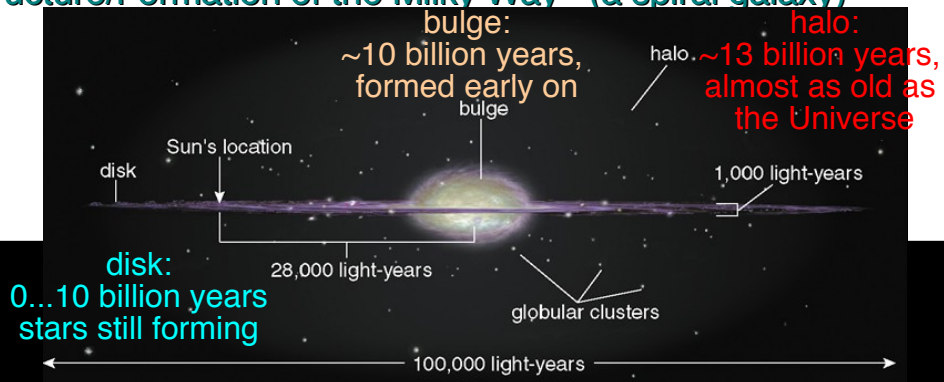
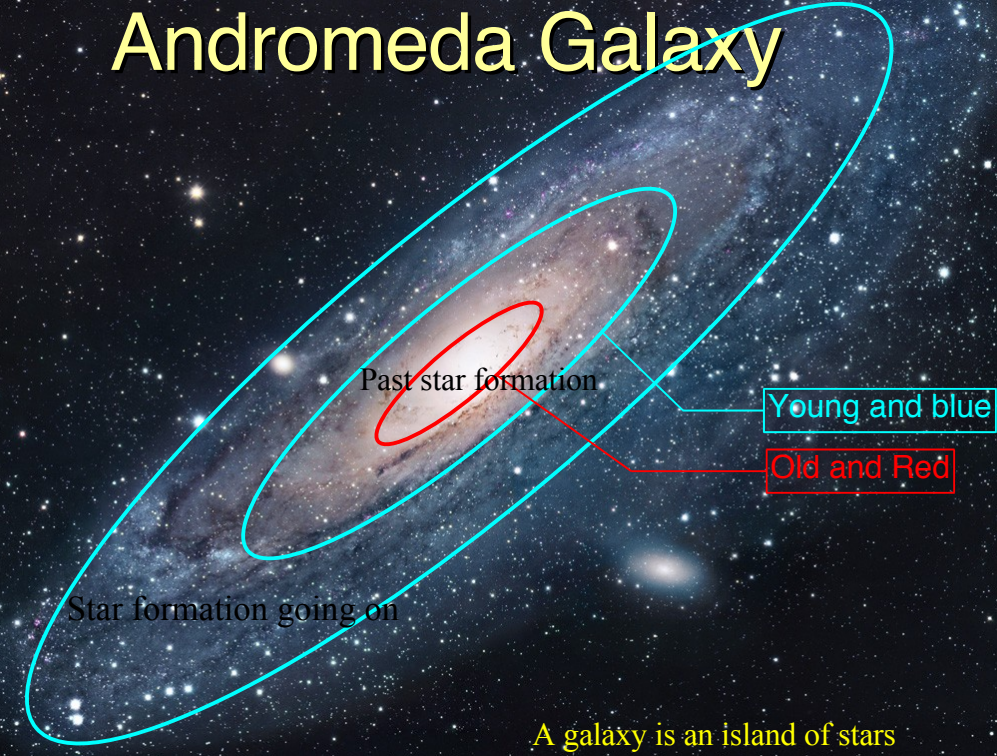


Structure/Formation of the Milky Way (a spiral galaxy)



Andromeda Galaxy



GALAXY ZOO.org

Welcome | Home | The Science | How to Take Part | Galaxy Analysis | Forum | Press | Blog | FAQ | Links | Contact Us | Login | Register

How to Take Part - Tutorial

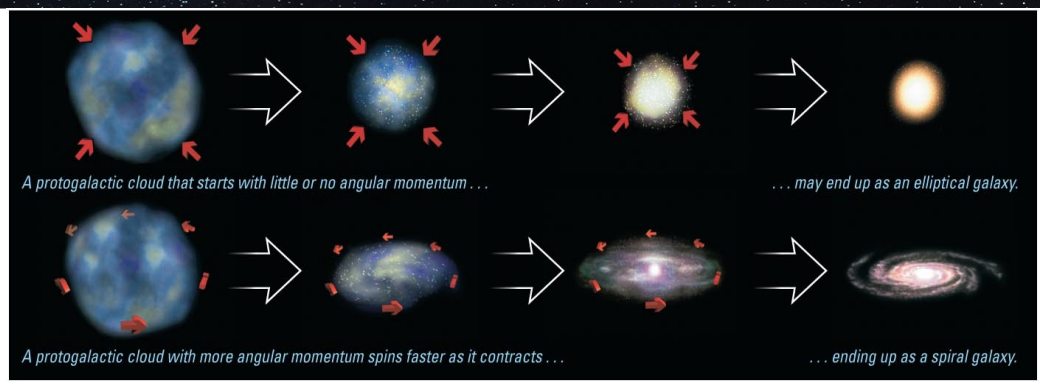
Your job is very simple! All you need to do is look out for the features that mark out spiral and elliptical galaxies. In fact, as you're a human and not a computer, most galaxies should be easy to classify since they're obviously spirals or obviously elliptical. On this page, you will practice classifying galaxies. On the next page, you will take a short trial to test your skills. If you don't pass the trial, you can try again. Once you pass the trial, you can start contributing to Galaxy Zoo science!

Part 1A ... Spiral or Elliptical Galaxies?

Try your hands at some! Click the image to see if you're right.

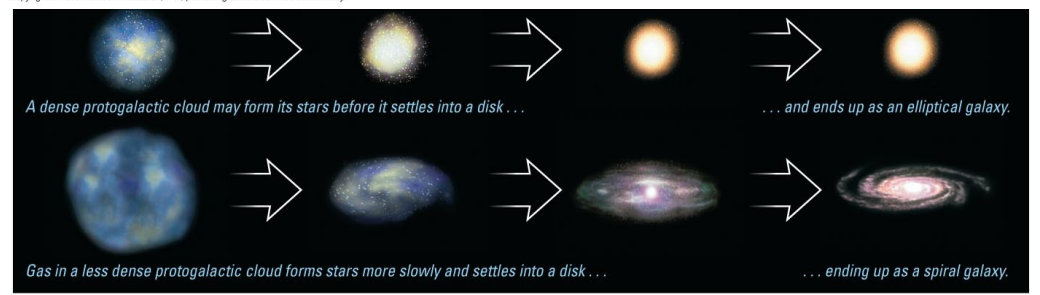
This is a face-on Sp... see the spiral!

Elliptical galaxies are no longer forming stars, so they look red.



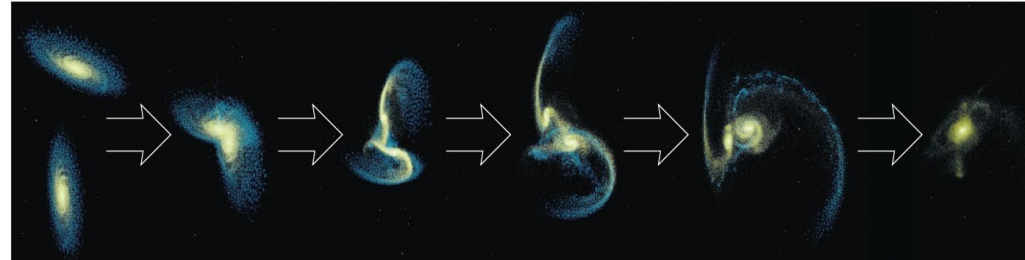
a The angular momentum of a protogalactic cloud may determine whether it ends up spiral or elliptical.

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b The density of a protogalactic cloud may determine whether it ends up spiral or elliptical.

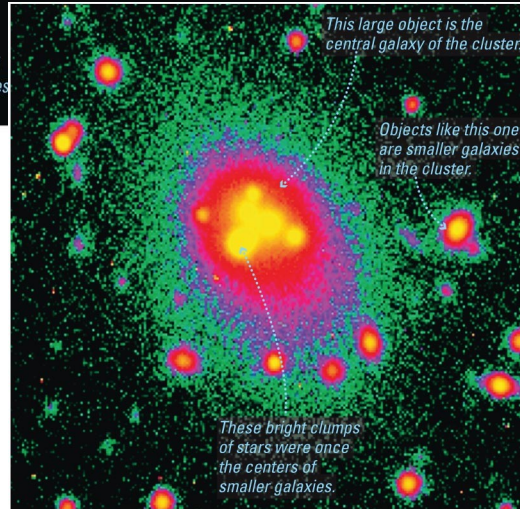
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Two simulated spiral galaxies approach each other on a collision course.

The first encounter begins to disrupt the two galaxies and sends them into orbit around each other.

As the collision continues, much of the gas in the disk of each galaxy collapses toward the center.



This large object is the central galaxy of the cluster.

Objects like this one are smaller galaxies in the cluster.

These bright clumps of stars were once the centers of smaller galaxies.

Elliptical galaxies grow by swallowing other galaxies.

Abell 3827: clumps of stars were centers of consumed galaxies.

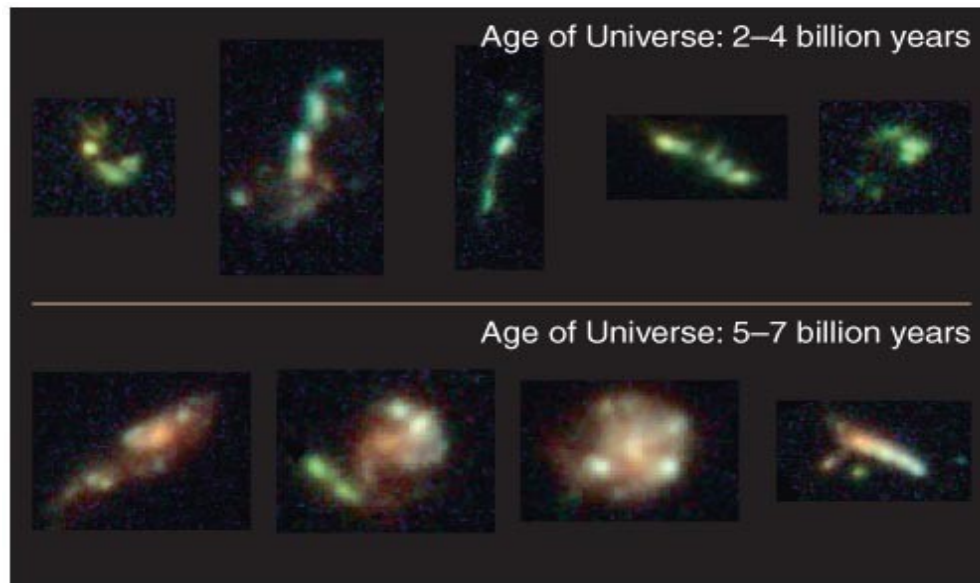
Galaxy Evolution

Nature or Nurture?



It helps to be able to see galaxies when they are just born.

Look out into space = look back in time



Age of Universe: 2–4 billion years

Age of Universe: 5–7 billion years

More spiral galaxies

Sombrero galaxy (infrared + optical)



Face-on

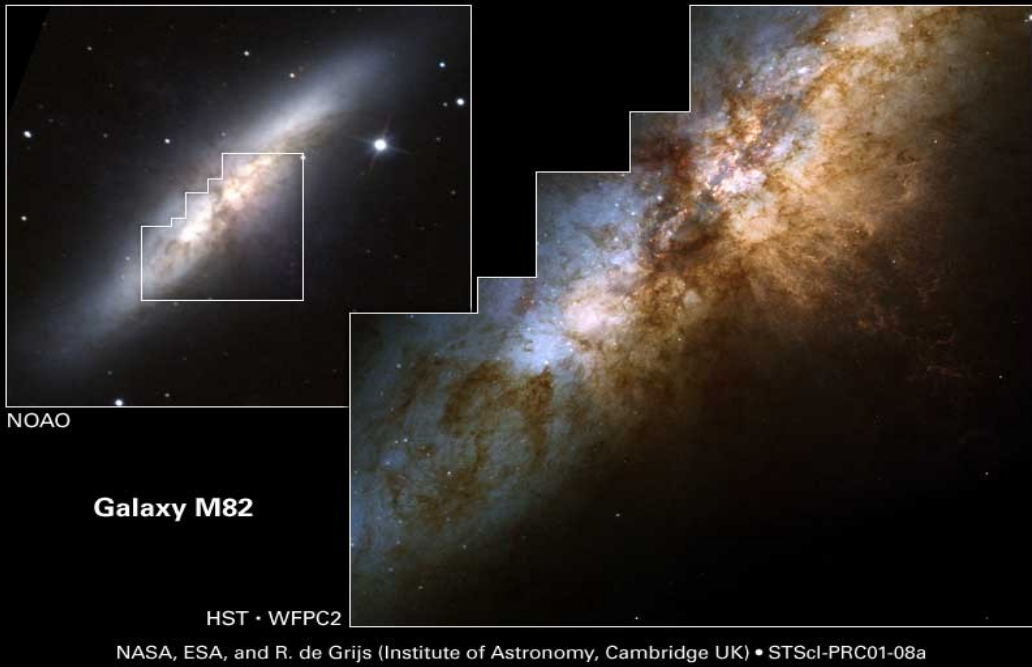


edge-on

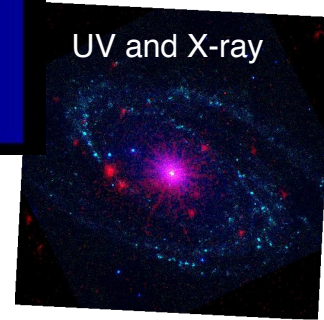
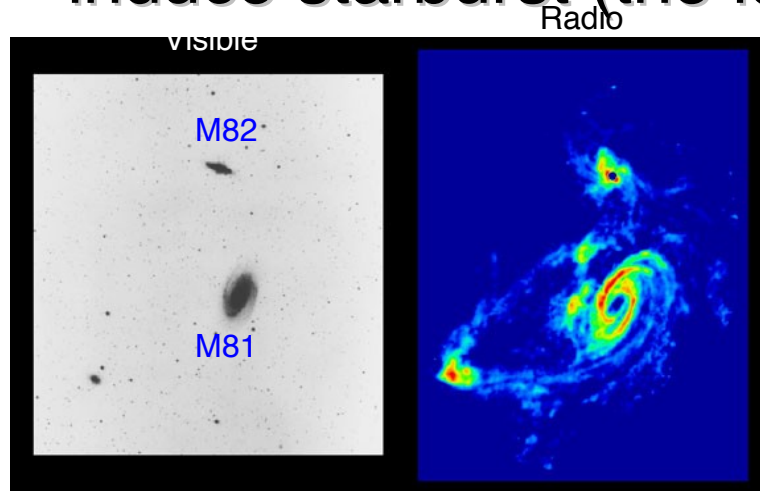
Dusty lane where stars are being born

Milky Way: currently forming stars in the disk at a rate of $\sim 1 M_{\text{sun}}/\text{year}$ mostly at spiral arms (the slow mode)

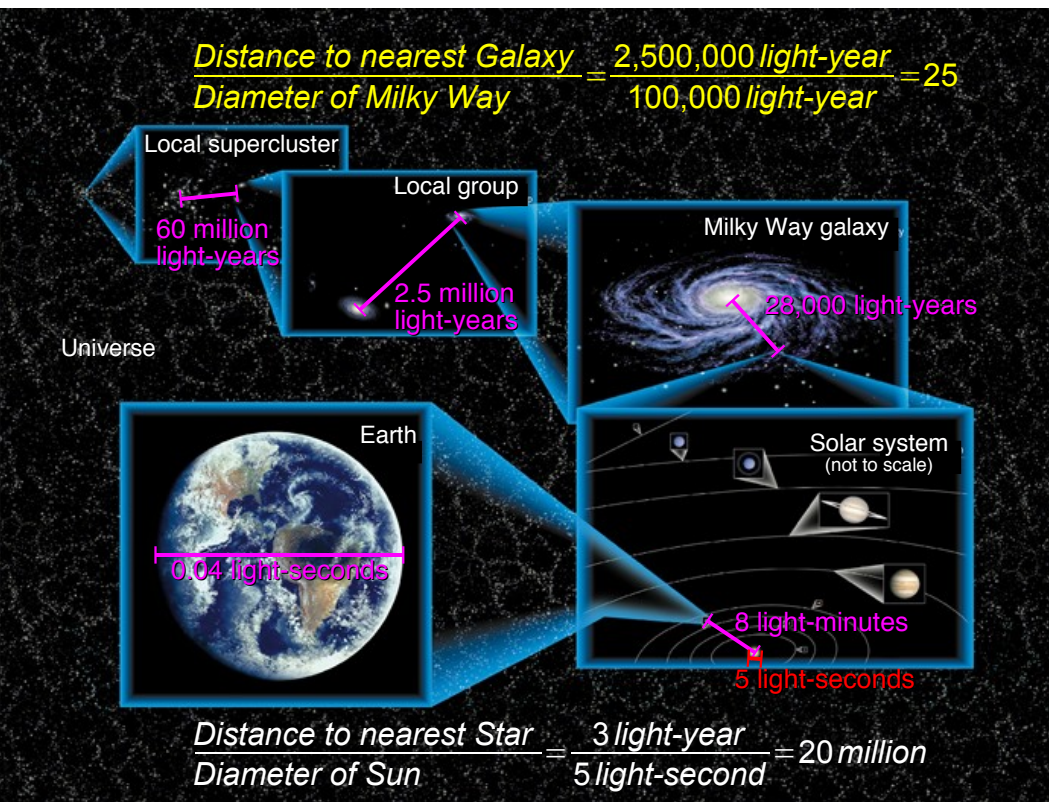
star formation in the past much more intense (starbursts, the fast mode)
new stars formed out of recycled materials;



Galaxy-galaxy collisions induce starburst (the fast mode)



Our neighbor M82 has a star formation rate ~ 10 times higher (starburst).
Lots of supernova and galactic superwind...



Collisions

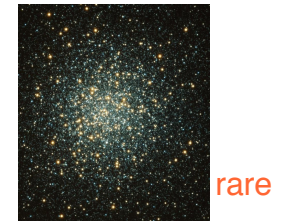
Stars inside a galaxy



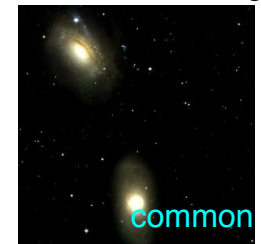
Stars in open cluster



Stars in globular cluster



Galaxies inside a group



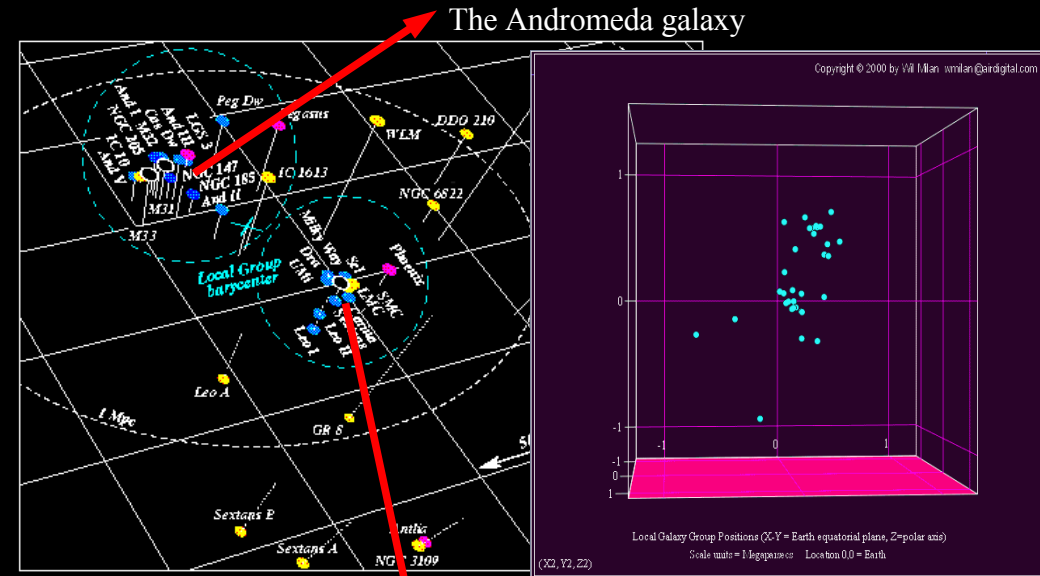
Galaxies inside a cluster



Galaxy Clusters

Some galaxy-galaxy collision leads to merger and great starbursts. Central galaxies in galaxy clusters have undergone a lot of collisions and mergers. They are more massive and redder (oligarchs).

Local Group

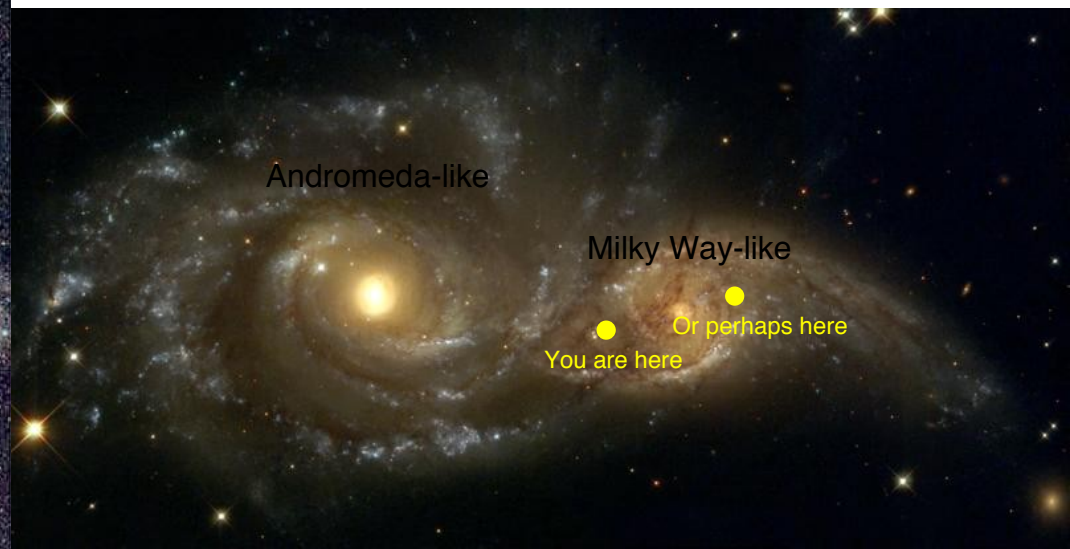


The Milky way has cannibalized a number of smaller galaxies, and is eating more...

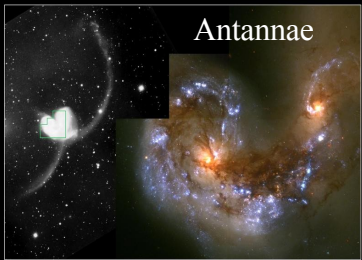
Remains of our cannibalism



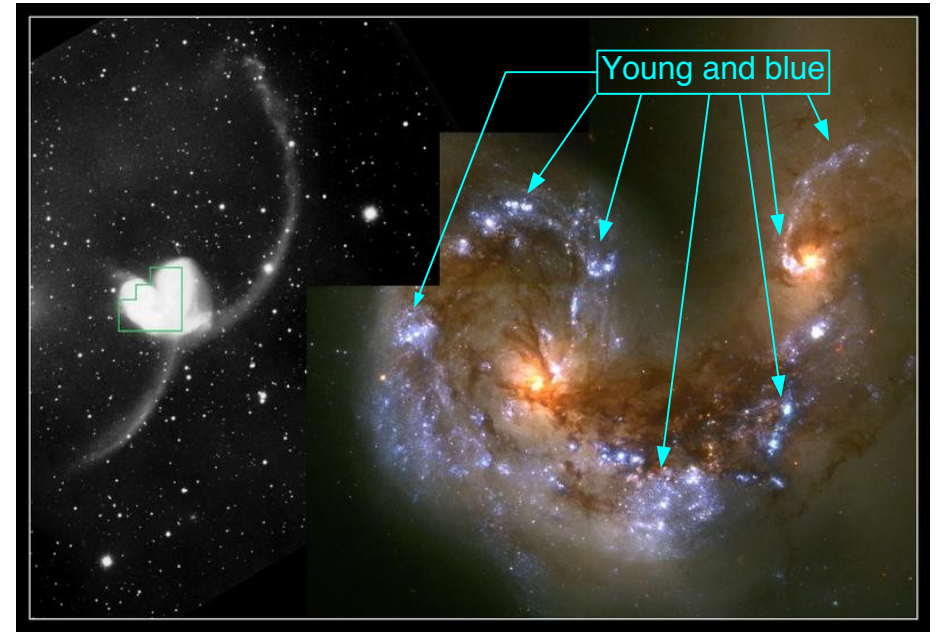
Also for us, in 2-3 billion years?



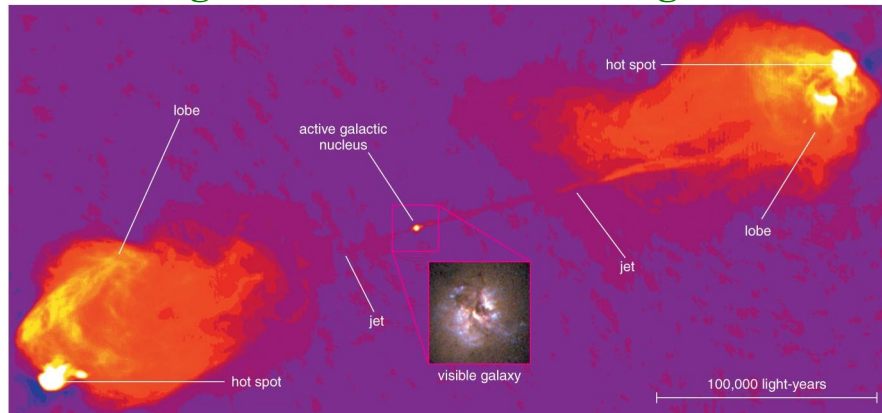
The sky will light up very brightly; the Sun may leave the galaxy, be incorporated into the mega-galaxy, or...



Uncertain Fate Starbursts induced by mergers



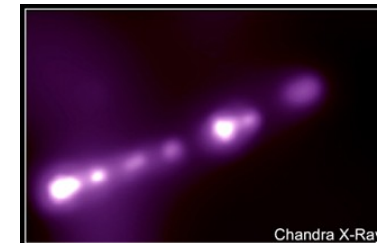
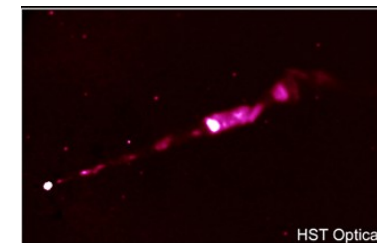
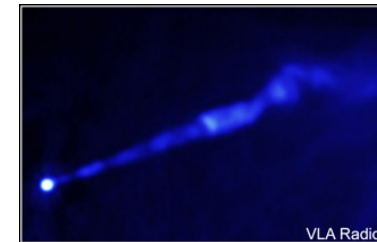
Something is astir in the centers of galaxies



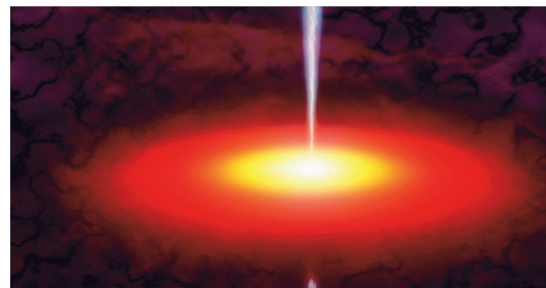
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M87

Central black hole mass ~
a few billion solar masses



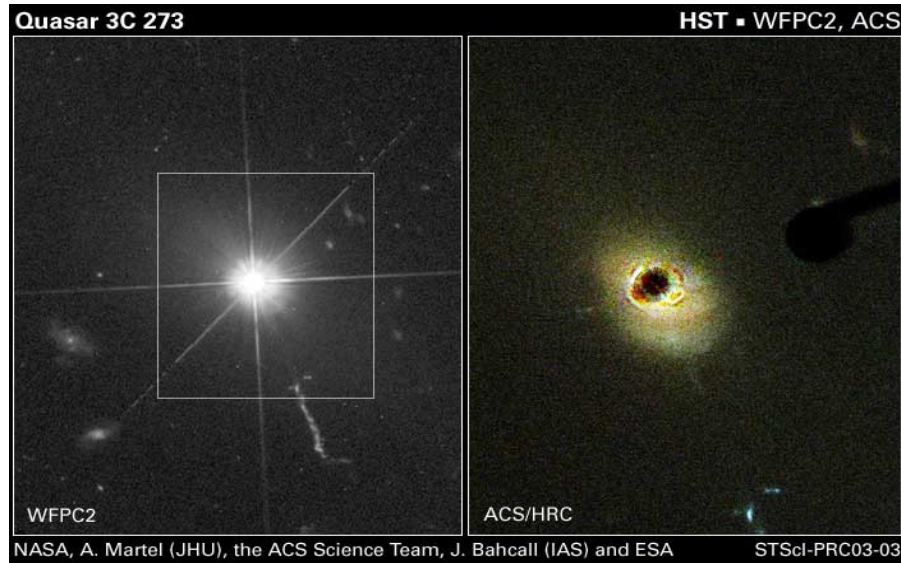
Supermassive blackholes
lurking in the center



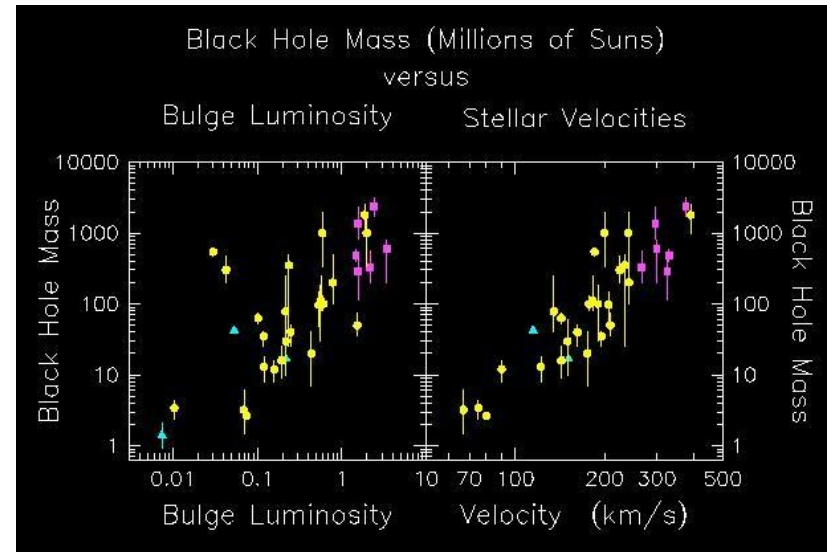
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Quasi Stellar Objects

a blackhole outshining 100 billion stars?
Or are you joking?

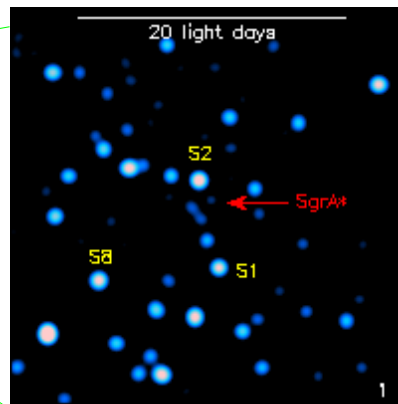
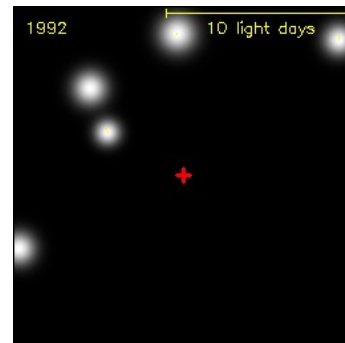
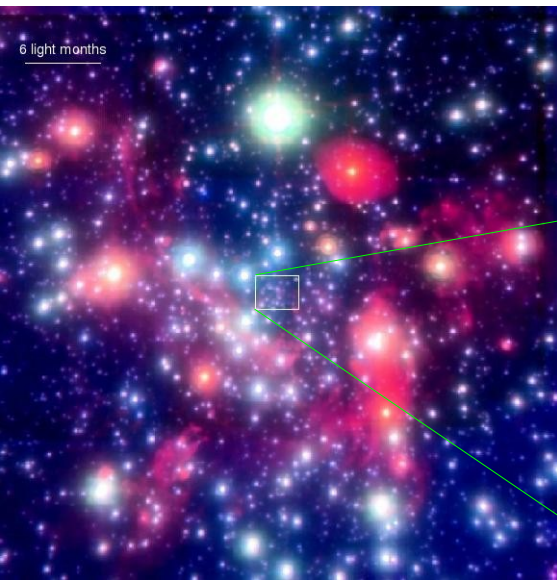


The larger the galaxy,
the bigger the black hole



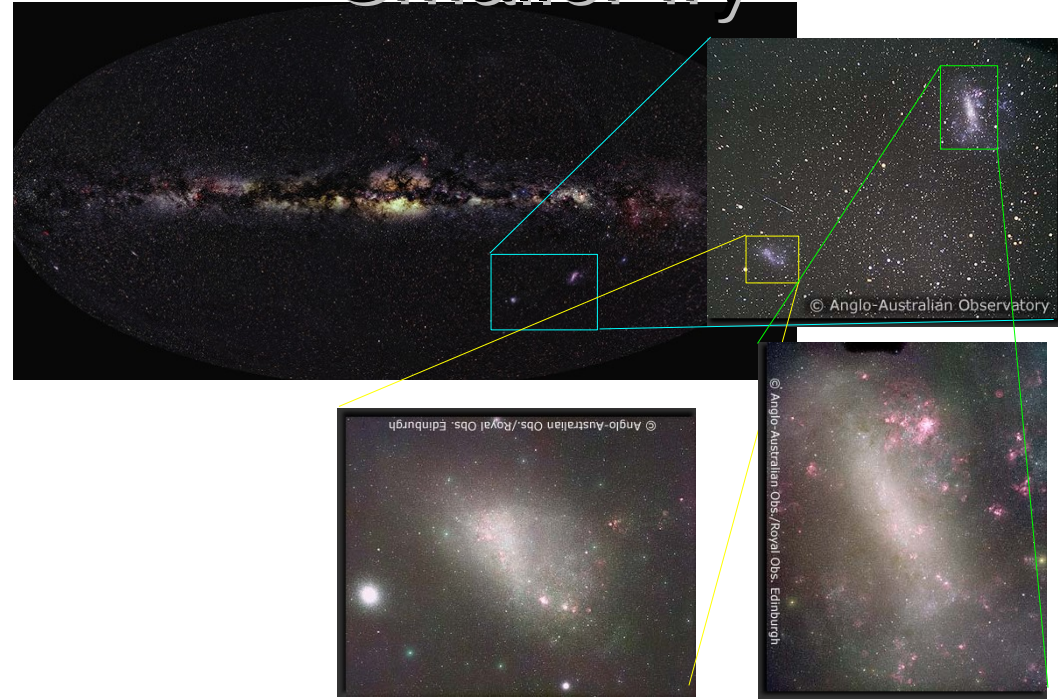
Black Hole in the Galactic Centre

$$M_{BH} = 3.6 \times 10^6 M_{sun}$$



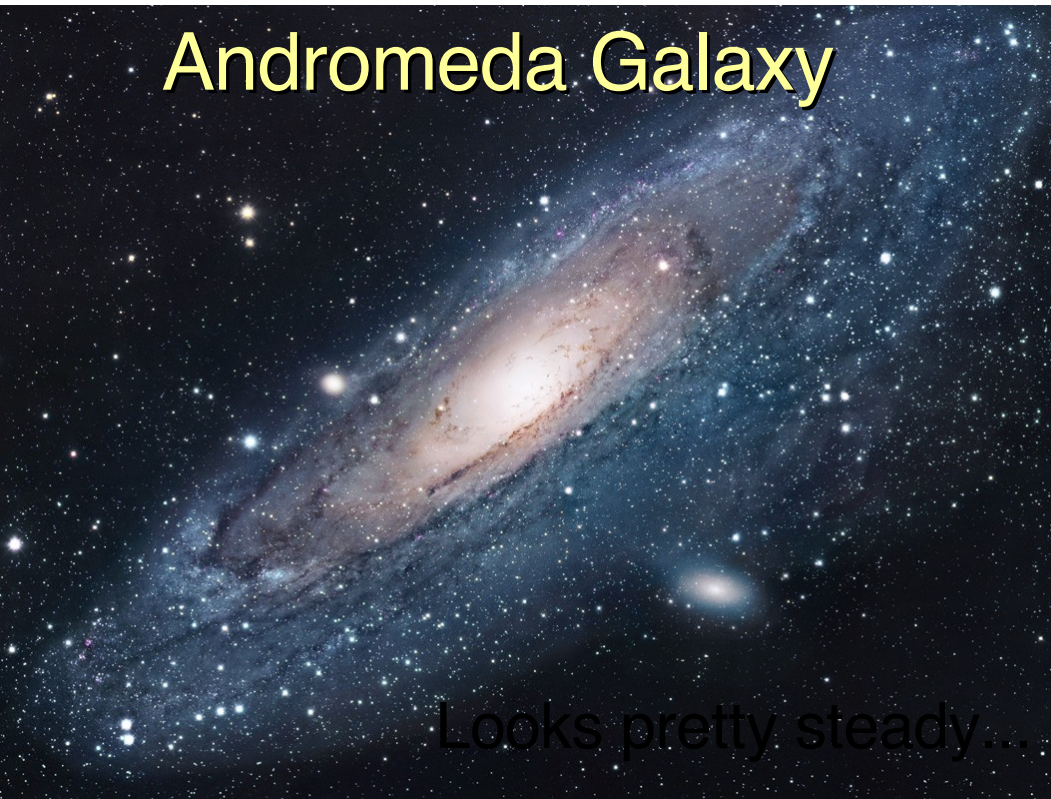
Did someone just drop a blackhole in our galactic center?

Smaller fry



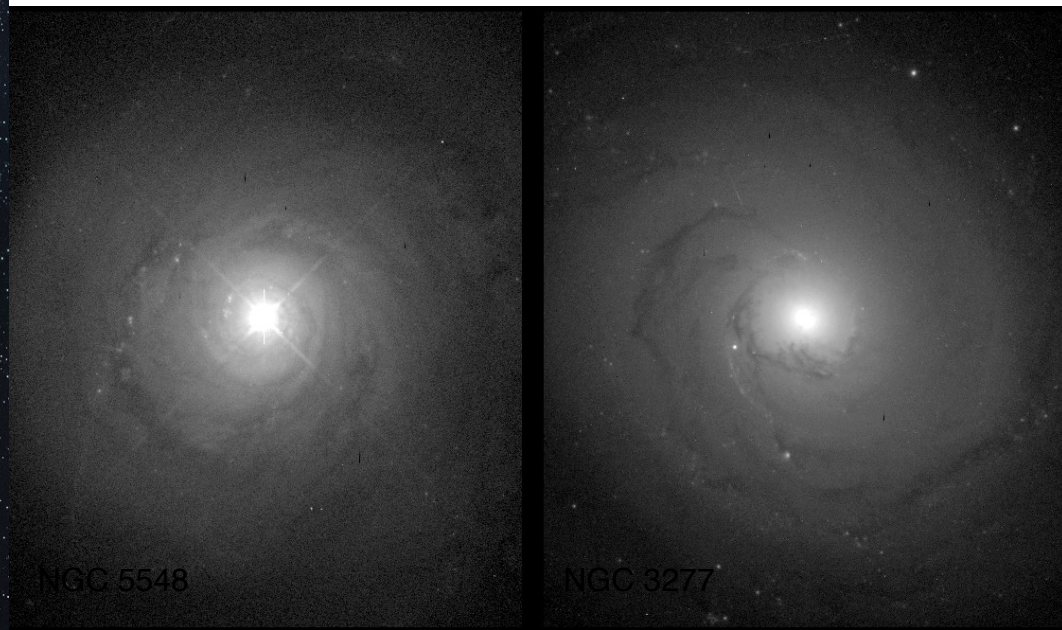
Assignment 8 due next monday.

Andromeda Galaxy



Looks pretty steady...

Active Galactic Nuclei

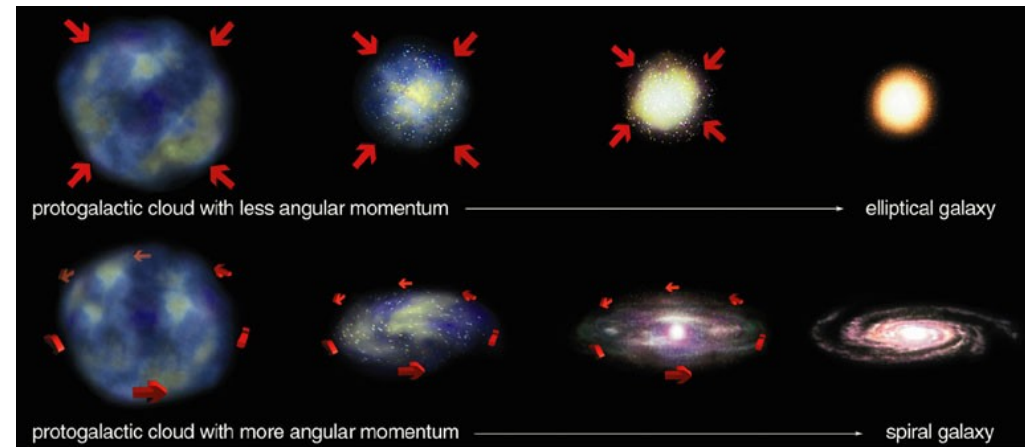
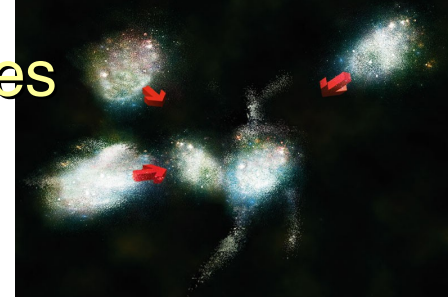


NGC 5548

NGC 3277



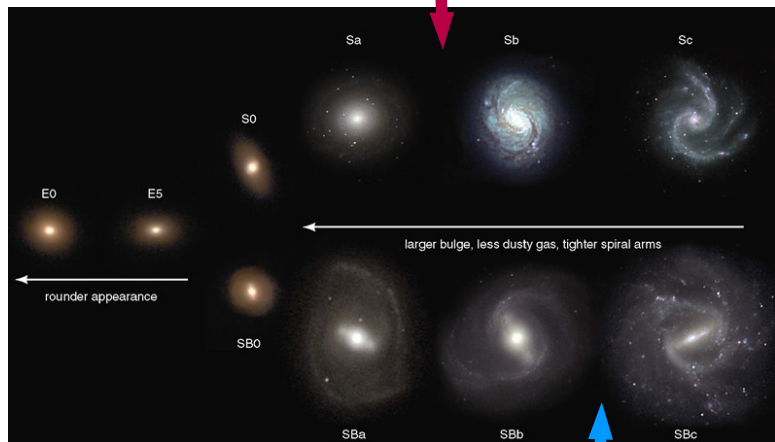
Formation of Galaxies



Hubble's tuning fork

Andromeda

SMC

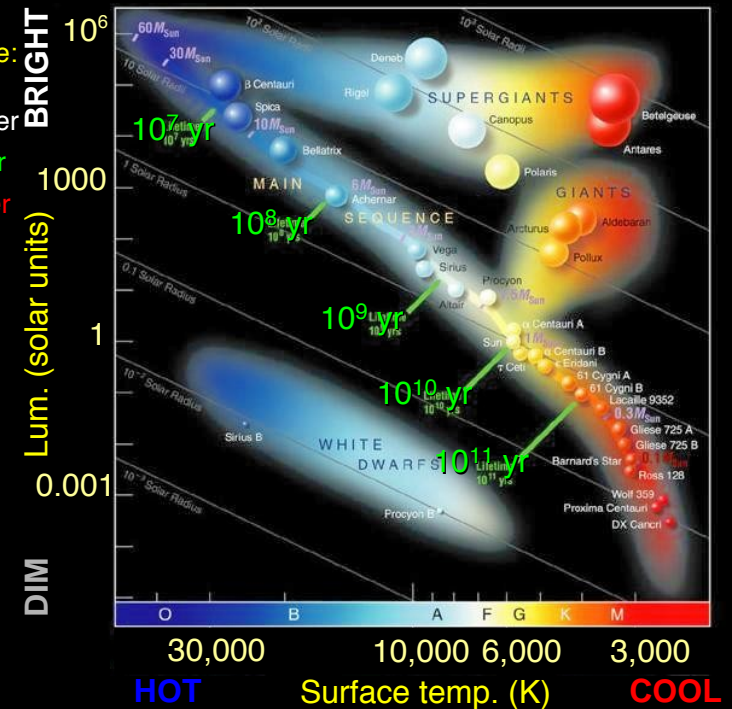


LMC

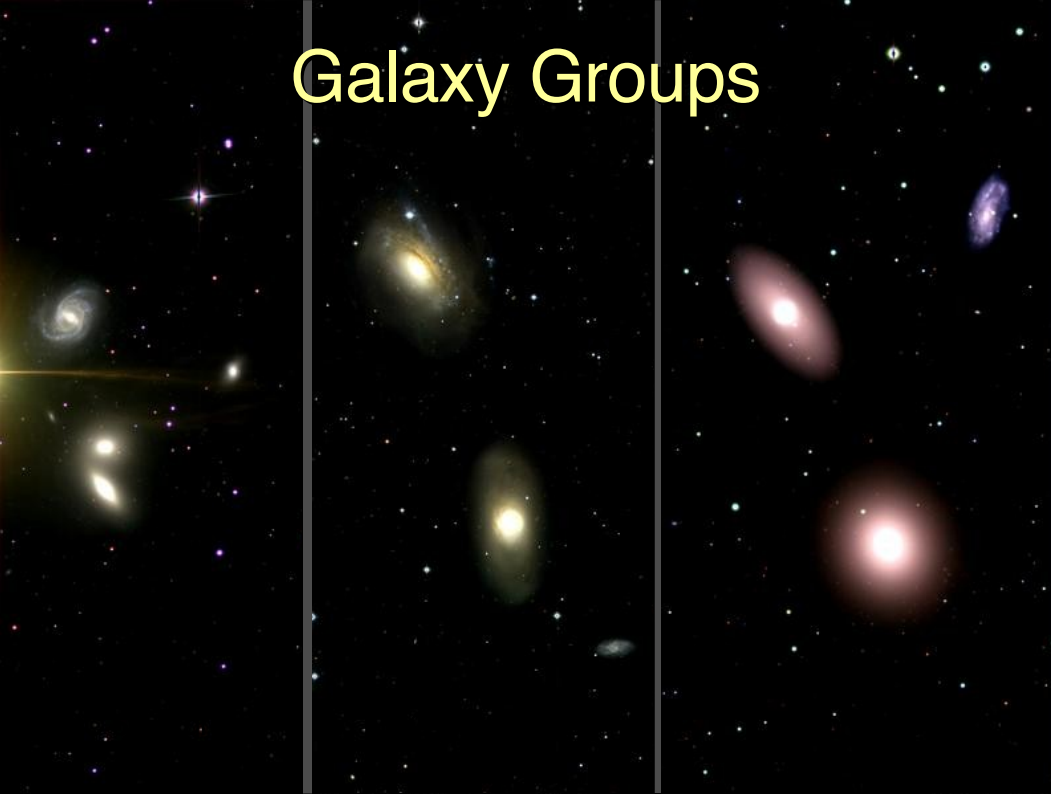
Milky Way

Hertzsprung-Russell Diagram

Along the Main Sequence:
 More Massive
 ⇒ Much Brighter
 ⇒ Burns Faster
 ⇒ Lives Shorter



Galaxy Groups

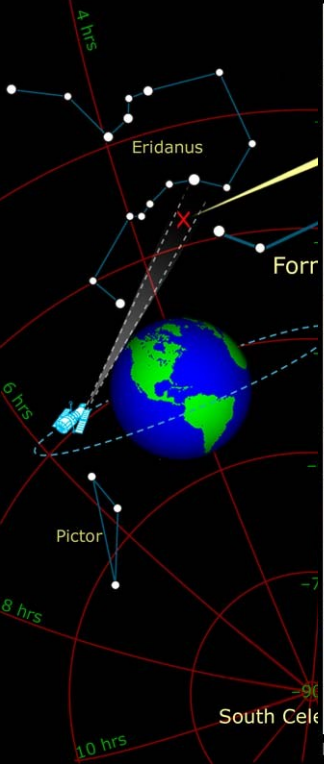


More interactions in clusters



Hubble Ultra Deep Field

HST - ACS



NASA, ESA, S. Beckwith (STScI) and The HUDF Team

STScI-PRC04-07a

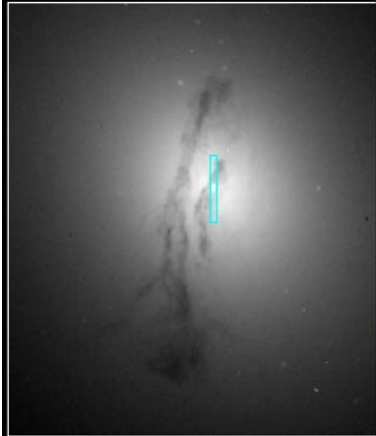
Hubble Ultradeep Field



M84

$$M_{BH} > 3 \times 10^8 M_{sun}$$

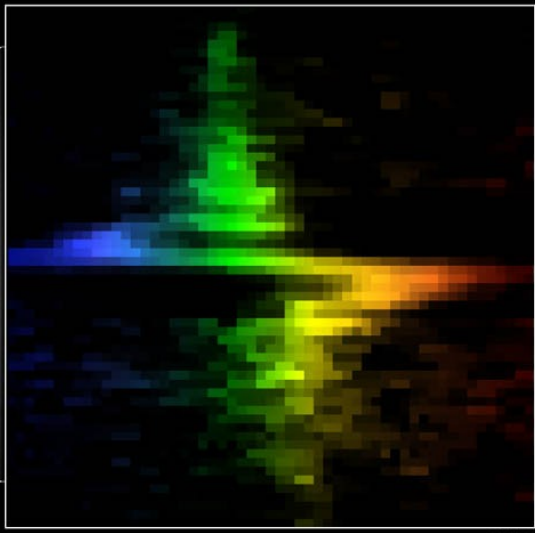
Galaxy M84 Nucleus



WFPC2

Hubble Space Telescope

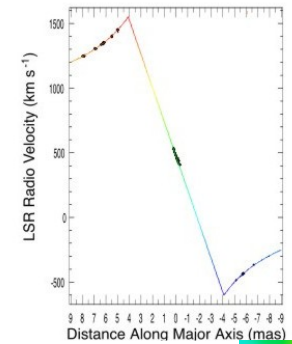
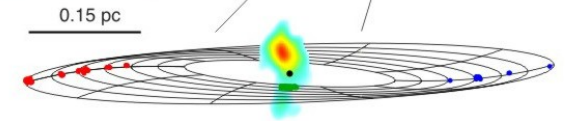
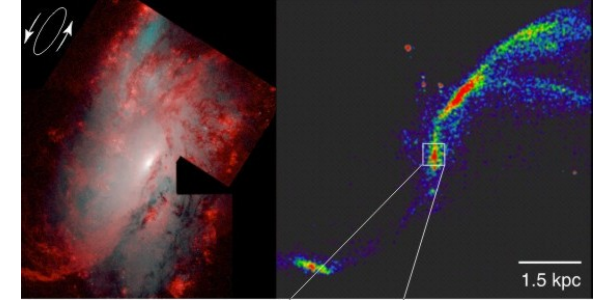
PRC97-12 • ST Scl OPO • May 12, 1997 • B. Woodgate (GSFC), G. Bower (NOAO) and NASA



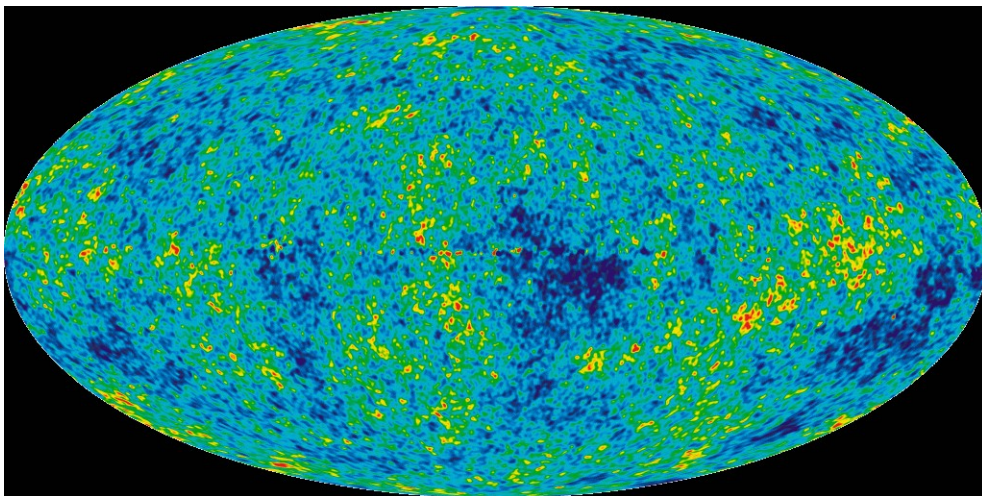
STIS

NGC 4528

$$M_{BH} = 4 \times 10^7 M_{sun}$$

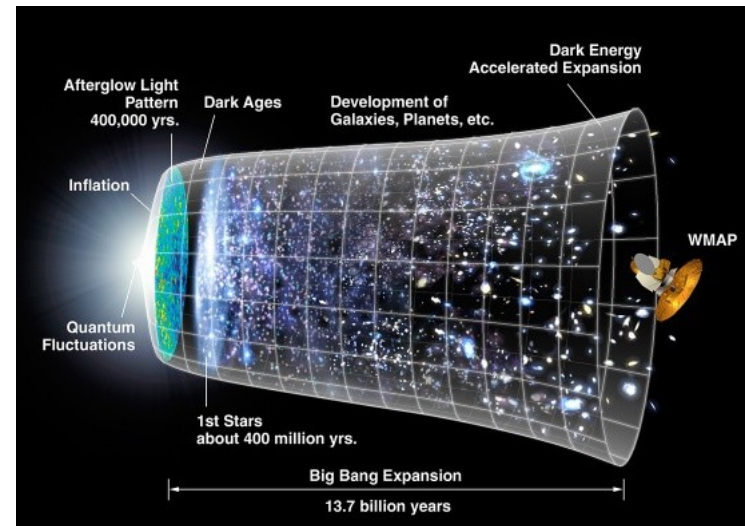


Cosmic Microwave Background



Differences in density: a few in 100,000!

Formation of Structure



Structure forms hierarchically:
small things merge into big ones

