ASTR 1120: Stars & Galaxies

Stefan's Quintet

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Lecture 35 Fri 8 Apr 05

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Today's Topics

- Today begin looking at *Chap 21 Galaxy Evolution*, especially at *active galaxies*
- Particularly important is that *galaxies can experience collisions: "interacting galaxies"*
- Read *21.4 Starburst galaxies* and *21.5 Quasars and active galactic nuclei* in detail for Monday
- *Third Mid-Term Exam* next Fri 15 April (tax day!) *Review Sheet 3* available today; *Homework 8* returned graded + answers

Measuring big distances to galaxies

"STANDARD CANDLES" -- important ones in `distance ladder', or `chain'

REMINDER

- *1. Main-sequence fitting*
- *2. Cepheid variables*
- *3. Tully-Fisher relation*
- *4. White dwarf supernovae*

Brightness ~ Luminosity / (Distance)^2

DISTANCE ESTIMATE 5

Use Hubble's Law itself to estimate vast distances D

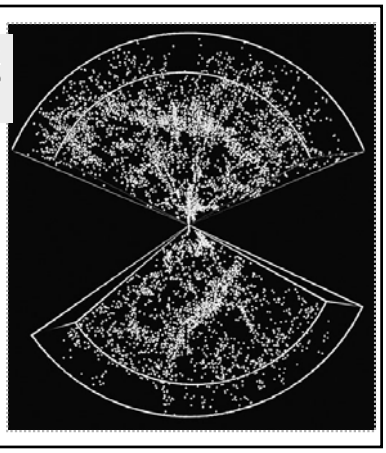
- *Measure velocity, then:* $D = v / H_o$
- *Example: using* H_o *= 70 km/sec/Mpc, and finding that v = 700 km/sec*

D = 700 km/sec / 70 km/sec/Mpc = 10 Mpc

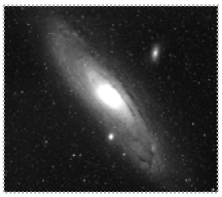
= 32 million light years

Knowing distances reveals large-scale galaxy clustering

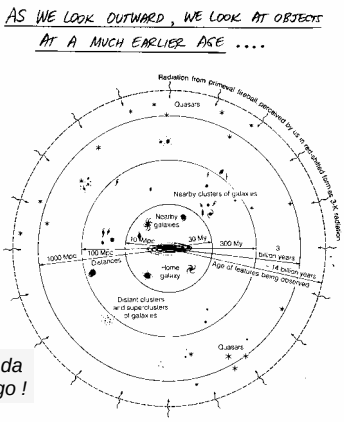
Find clusters + super-clusters : sheets and voids like `bubble bath'



Telescopes are "lookback" time machines

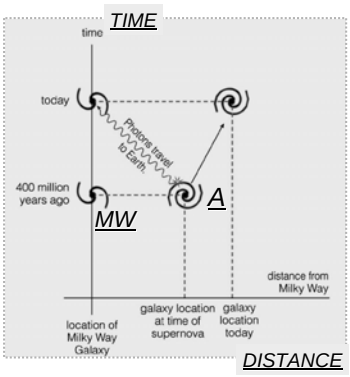


Today, we see Andromeda as she was 3 M years ago !



Lookback time (in expanding universe)

- *Say it takes 400 million years for light to get from galaxy A to us in Milky Way*
- *Yet during travel in spacetime, both A and MW have changed positions by expansion*
- *Thus "distance" is a fuzzy concept – LOOKBACK TIME is better*

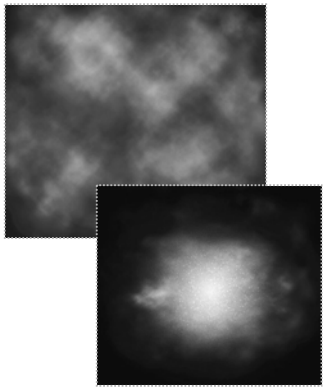


Clicker on reading ahead D.

- *What do we mean by a protogalactic cloud?*
- *A.* It is a cloud-like halo that surrounds the disks of spiral galaxies
- *B.* It was a term used historically to refer to any galaxy
- *C.* It is a cloud of hydrogen gas that we detect by looking at light from quasars
- *D.* It is a cloud of matter that contracts to become a galaxy

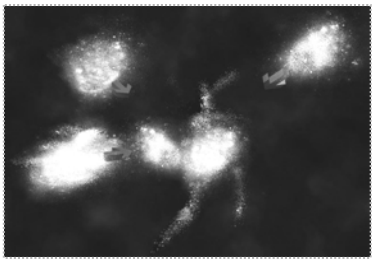
Making of a spiral galaxy

- *Start with a fairly uniform cloud of hydrogen*
- *Gravitational collapse forms protogalactic clouds*
- *First stars are born in this spheroid (such stars are billions of years old → "fossil record")*



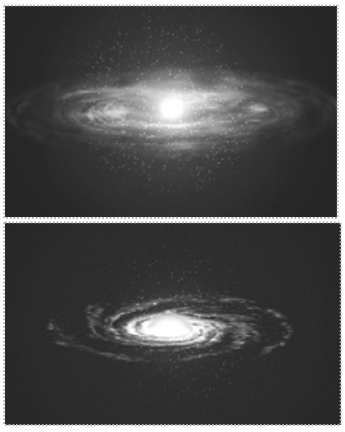
Small variant in spiral making …

- *Several smaller protogalactic clouds may have merged to form a single large galaxy*
- *May explain slight variations in stellar ages in the MW*



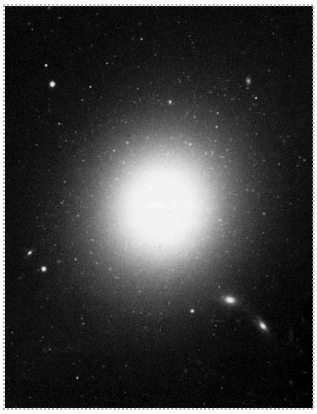
Forming a disk with spiral

- *As more material collapses, angular momentum spins it into a disk*
- *Stars now formed in dense spiral arms – disk stars are younger!*



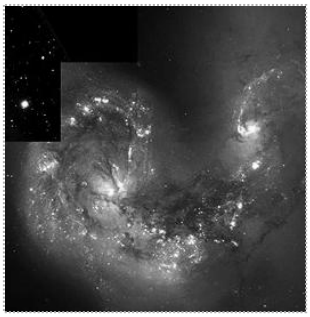
Making ellipticals

- *Higher density: much faster star formation uses up all the gas*
- *Nothing left to make a disk*
- *Now we see sphere of old stars*



Or now a different story….

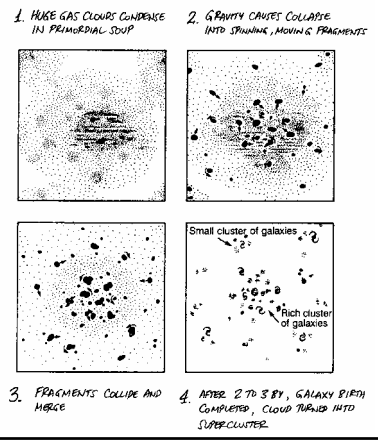
- *Spiral galaxy collisions destroy disks, leave behind elliptical*
- *Burst of star formation uses up all the gas*
- *Leftovers: train wreck*
- *Ellipticals more common in dense galaxy clusters*



NGC 4038/39 Antennae

Birth of galaxies in clusters

Few galaxies (none ?) BORN alone



Clicker: galaxy collisions

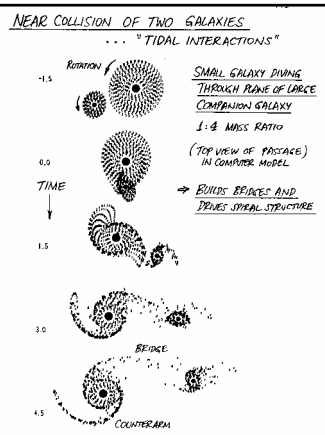
- *Why are collisions between galaxies more likely than between stars within a galaxy?*

C.

- *A.* Galaxies are much larger than stars
- *B.* Galaxies travel through space much faster than stars
- *C.* Relative to their sizes, galaxies are closer together than stars
- *D.* Galaxies have higher redshifts than stars

Collision of small galaxy with big one

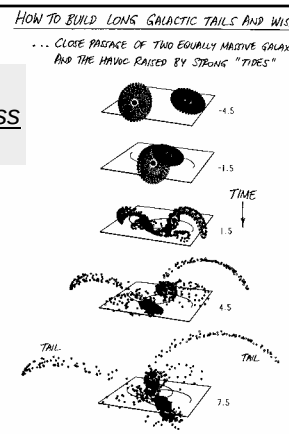
Builds "bridge" and "counterarm"



Close passage: M51 + companion

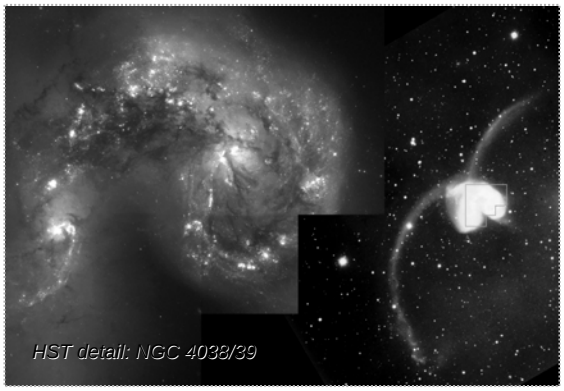
Close passage of two equal mass galaxies

Builds very long "tails" and wisps

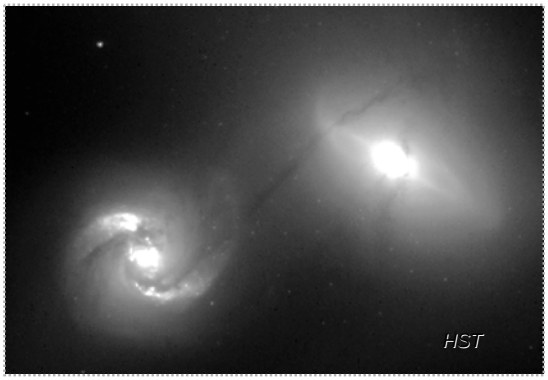


Two galaxies form "The Antennae"

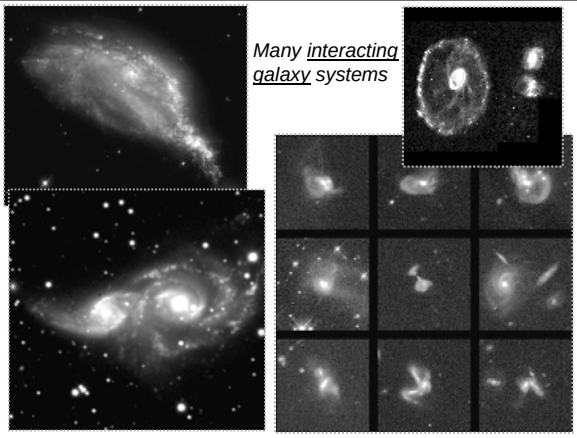
Colliding galaxies – "The Antennae"



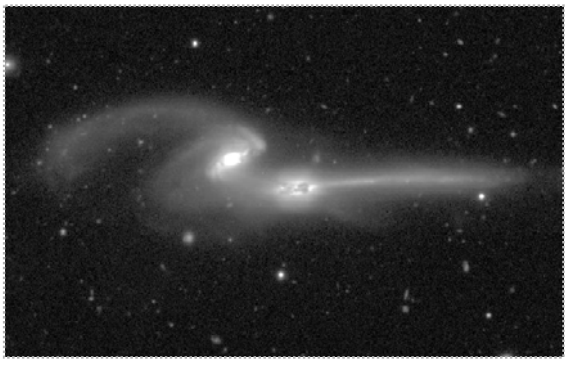
Tidal streams between galaxies



Many interacting galaxy systems

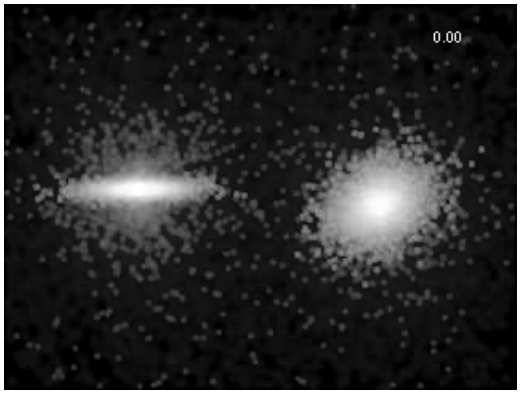


A major puzzle: "The Mice" NGC 4676



"Mice" with HST Advanced Camera for Surveys

"Mice" in simulation 1 *Josh Barnes*



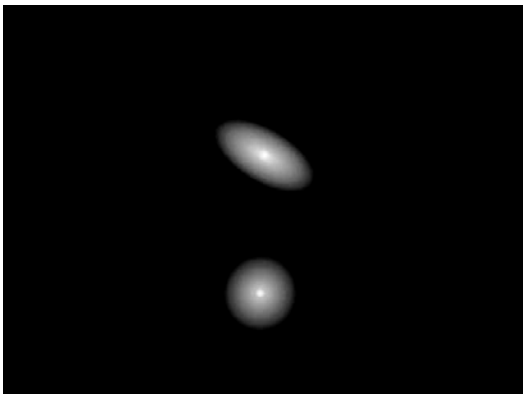
Rotate the "Mice"

Latest simulation 2 of "Mice" *John Dubinski*

Stefan's Quintet in HST detail

It may happen to us in future!

M31 and Milky Way in future collision *Dubinski*



Quasars

- *Quasi-Stellar Radio Source (QSO) – arise from early galaxy collisions feeding BH?*
- *Nuclei so bright that the rest of the galaxy is not easily seen*
- *First discovered as radio sources - then found to have very high redshifts !*