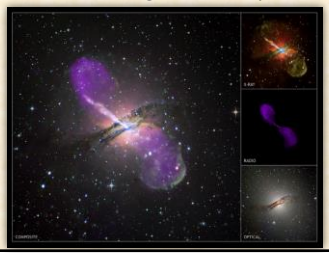
ASTR 1020: Stars & Galaxies

November 11, 2013

- Reading: Chapter 23, sections 23.1 – 23.2.
- *Mastering Astronomy* Homework on Galaxy Evolution is due Nov. 15th.
- SBO extra credit observing on Tuesday, Nov. 12 at 7 pm.



Astronomy Picture of the Day

HST Picture of Spiral Galaxies in Collision
NGC 2207 and IC 2163

Reading Clicker Question: What is the lookback time of the most distant galaxies we can observe?

A. 400 million years
B. 1.3 billion years
C. 4.5 billion years
D. 13 billion years

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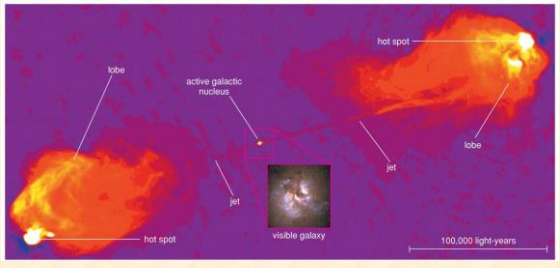
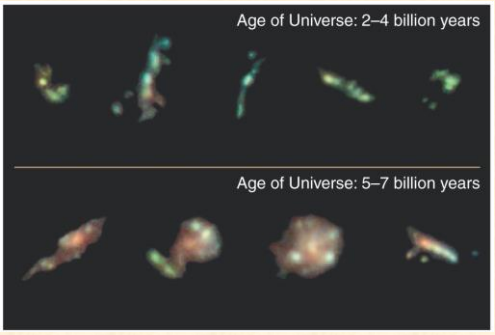
Today

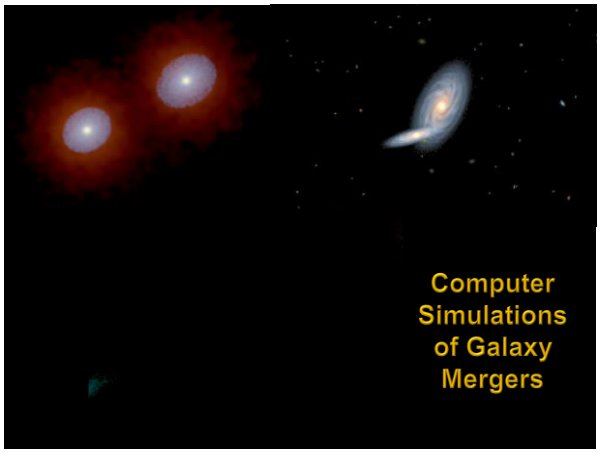
- Galaxy Evolution
- Active Galaxies & Quasars



- The collisions we observe nearby trigger bursts of star formation.

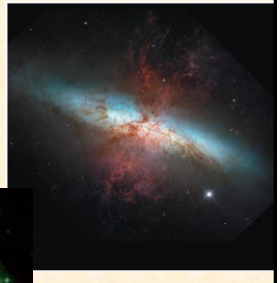


- Many of the galaxies we see at great distances (and early times) do look violently disturbed.



Starburst Galaxies

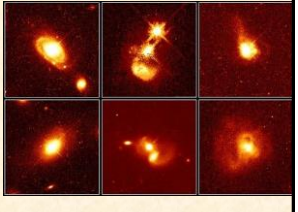
- Milky Way forms about 1 new star per year
- Starburst galaxies form 100's of stars per year



- Heats dust to very hot temps: glows strongly in the infrared.
- Much evidence for giant supernova-driven winds
- ?Triggered by galaxy collisions?

"Active Galactic Nuclei = Active Galaxies"

- Galaxies with strange stuff going on in their cores
- Bright "nuclei" as bright as the rest of the galaxy



Quasars

- Quasi-stellar Radio Source
- Nuclei so bright that the rest of the galaxy is not easily seen
- First discovered as radio sources- then they were found to have high redshifts!

Clicker Question: What is the most likely source of the light from bright nuclei (radio, visible, X-rays) in active galaxies?

a) Thermal radiation from a massive star cluster
b) Emission lines from hot gas
c) 21 cm from hydrogen
d) Synchrotron radiation from a black hole

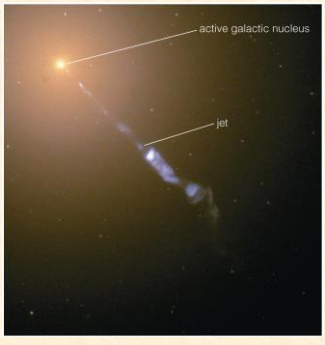
- **D: Synchrotron**

Only Synchrotron light is bright at both radio and X-ray wavelengths.

→ Active nuclei suggest a massive black hole in the center of the galaxy!

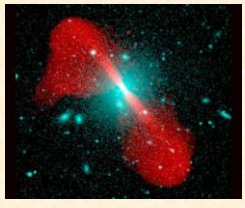
Galactic Jets

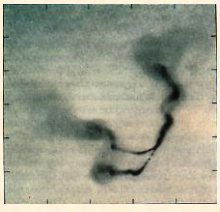
- Many show jets of optical and radio emission from accretion disks
- Billion solar mass black holes!

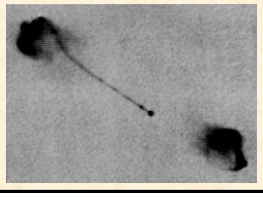


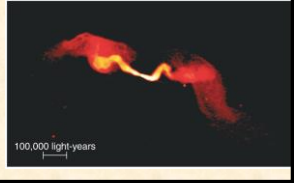
Centaurus A: The Closest Active Galaxy

More radio observations



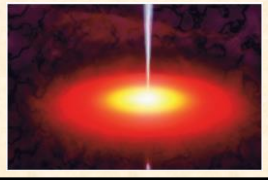


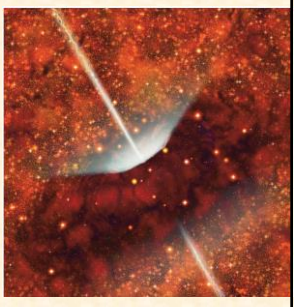




Artist's Conception

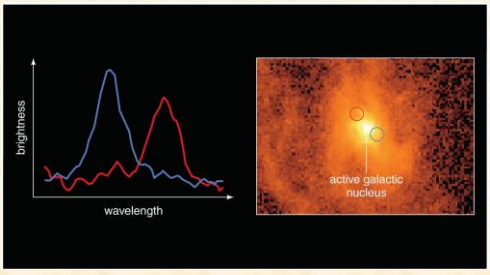
- Accretion disk around a massive black hole
- Disk itself may or may not be obscured by dust
- If bright nucleus is not visible, we'd call it a radio galaxy, but not a quasar





A real example

- Doppler shifts from orbiting material
- Suggest billion solar mass black hole



Do ALL galaxies have huge black holes?

- As of 2013: probably yes!
- Part of normal galaxy formation?
- More quasars seen in the distant (early) universe than now
- They grow, but can run out of available fuel and become relatively invisible (like in the Milky Way)