

ASTR 1020: Stars & Galaxies

April 4, 2008

- Reading: Chapter 22, sections 22.1 – 22.2.
- *MasteringAstronomy* Homework on Galaxies and Hubble's Law is due April 7th.
- Extra credit observing at SBO & for attending Fiske Planetarium shows!

Astronomy In the News

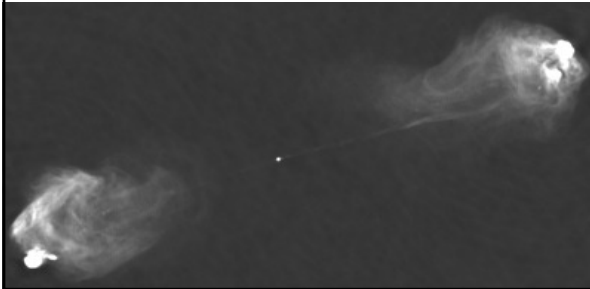
Rosey Stuurmans

Many, Perhaps Most, Nearby Sun-Like Stars May Form Rocky Planets



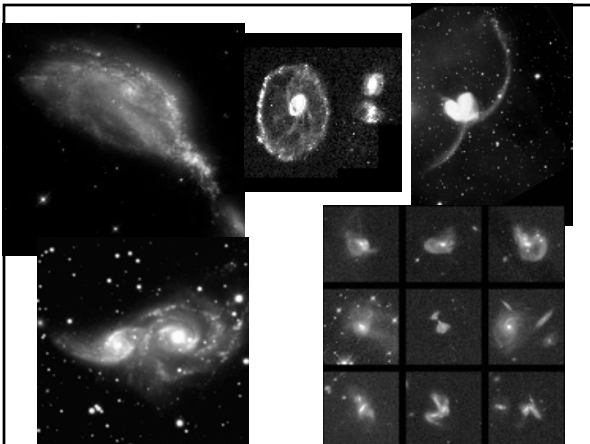
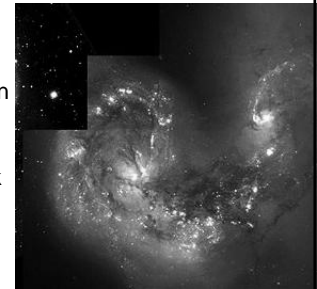
Today

- Galaxy Evolution
- Active Galaxies & Quasars



Last Time: Galaxy Collisions

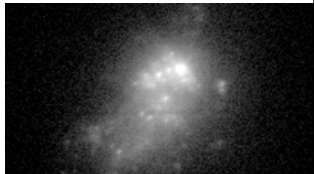
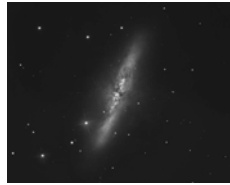
- Galaxy collisions destroy disks
- Burst of star formation uses up all the gas
- Leftovers: train wreck
- Ellipticals more common in dense galaxy clusters



Computer
Simulations
of Galaxy
Mergers

Starburst Galaxies

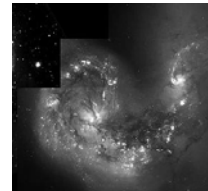
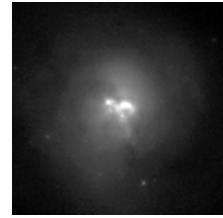
- Milky Way forms about 1 new star per year
- Starburst galaxies form 100's of stars per year



- Heats dust to very hot temps: glows strongly in the infrared

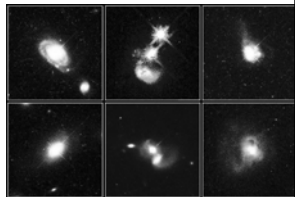
Much evidence for giant supernova-driven winds

?Triggered by galaxy collisions?



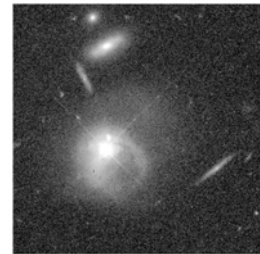
“Active Galactic Nuclei = Active Galaxies”

- 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

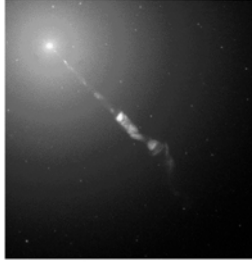
- **D: Synchrotron**

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

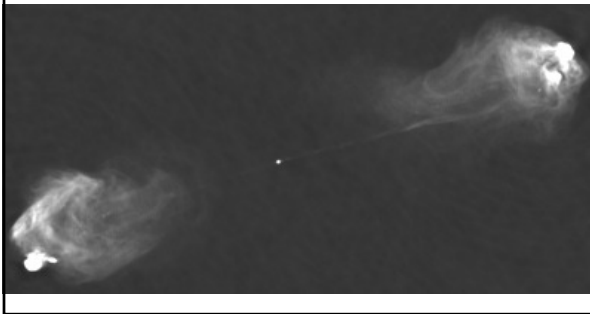
- Many show jets of optical and radio emission from accretion disks
- Billion solar mass black holes!



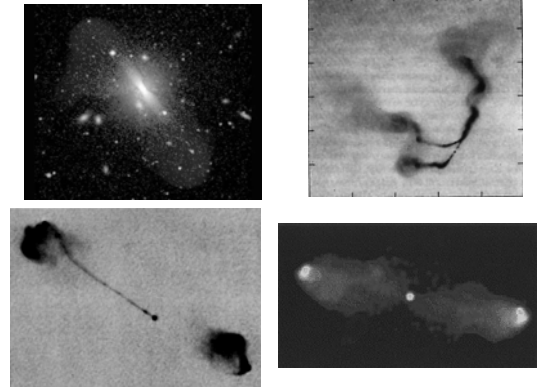
Centaurus A: The Closest Active Galaxy



Cygnus A Radio Jets



More radio observations



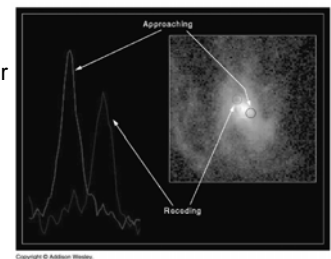
Artist's Conception

- 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



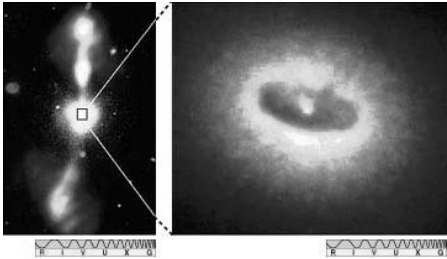
A real example

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



Another example

- 400 light year wide disk of material in core of an elliptical galaxy with radio jets

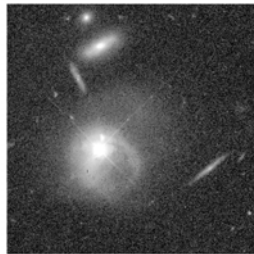


Do ALL galaxies have huge black holes?

- As of 2008: 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)

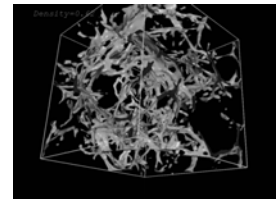
Resurrected by galaxy collisions?

- Many galaxies with bright nuclei show signs of being disturbed
- Expect more such collisions in denser early universe: explain why fewer quasars today

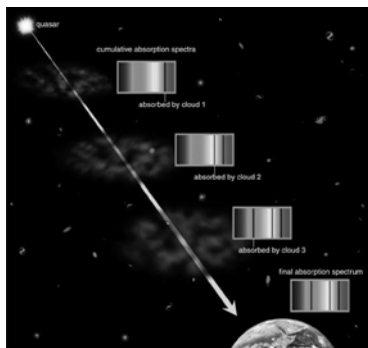


Proto-galactic Clouds

- Looking for gas between the galaxies
- Cold, invisible, too dim even at 21cm



Use quasars as beacons- see absorption lines from gas



Surveys for absorption by inter-galactic gas

- Hydrogen absorption at different redshifts- all less than the quasar!
- General rise in heavy elements as time goes on- fountains from galaxies!

