LECTURE 20: QUASARS

20.1 "COLLIDING" GALAXIES

Occasionally, two galaxies in a group can "run into" each other.

Collisions of individual stars would be very unlikely because of the vast spaces between them, but each galaxy can be distorted or disrupted by the gravity of the other.

Gravitational disturbances and collisions of giant gas clouds can trigger bursts of star formation.

Galaxy collisions can transform spiral galaxies into ellipticals, and at least some elliptical galaxies probably formed this way.

More generally, collisions and mergers may have played essential roles in shaping and transforming galaxies

20.2 THE DISCOVERY OF QUASARS

The first radio telescopes (1930's, 1950's) found emission from the Milky Way, from supernova remnants, and from other galaxies.

Some sources appeared to be stars, and were dubbed *quasars*, short for "quasi-stellar radio sources."

Spectra of quasars showed emission lines that were strong, very broad, and at incomprehensible wavelengths.

Maarten Schmidt was the first to realize (1963) that these were emission lines from normal atoms at very large redshifts.

20.3 THE NATURE OF QUASARS

We will learn (in lecture 23) that objects with large redshifts are very distant. For quasars to be detectable at these distances, they must be fantastically luminous ($f = L/4\pi d^2$).

The most luminous quasars are 100-1000 times brighter than the whole Milky Way galaxy. Many emit radio waves, visible light, X-rays, and gamma rays.

Some quasars vary in brightness over weeks or even days. The enormous luminosity must therefore be coming from a fairly small region, no more than a few light-weeks across.

"Standard" theory: quasars are powered by giant black holes, typically a billion times the mass of the sun, probably at the centers of galaxies. We see light from hot gas spiraling in towards the black hole.

An alternative theory, that quasars are powered by rapid star formation and frequent (~ 1 per year) supernovae, can account for many features of quasars, but probably not for the very rapid variability.

20.4 QUASAR EVOLUTION

Since light can only travel at 300,000 km/s, when we look at very distant objects we "look back in time" and see them as they were long ago.

Luminous quasars in the nearby universe are very rare.

Luminous quasars were much more common when the universe was about 1/4 of its current age.

Most quasars have died out. Since the black holes don't go away, it must be that the "monsters" are no longer being fed with gas.

We do observe "active galactic nuclei" — like quasars, but less powerful — at the centers of some nearby galaxies.

Astronomers are using Hubble Space Telescope and ground-based telescopes to
(1) search for "host galaxies" surrounding distant quasars
(2) search for evidence of giant black holes in the nuclei of nearby galaxies, by studying the motions of stars close to the center

20.5 SUMMARY

Gravitational "collisions" between galaxies can distort and transform them, causing bursts of star formation and merging spirals into ellipticals

Quasars ("quasi-stellar radio sources") are

- Compact sources of light at great distances
- Extremely luminous
- Probably powered by billion solar mass black holes

Looking to great distance $\longrightarrow$ looking back in time.

The age of quasars is over.