4/17/06

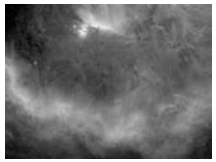
Exam 4, Friday, April 28

Final, Saturday, May 13, 2 - 5 PM Comprehensive

Extra Credit Report due Midnight, Friday May 5.

News:

Pic of the day; Bernard's loop, "bubble" around the horsehead nebula



Reading:

Chapter 9, Sections 6 - 8

Chapter 10, black holes, updated material posted.

Next topic: Cosmic Gamma-Ray Bursts, part of old Chapter 11 in book, new separate Chapter 11 posted.

Then Supernovae and Cosmology, part of old Chapter 11 in book, new separate Chapter 12 posted.

Surprisingly, most binary black hole candidates have small mass main sequence companions, typically ~ 1/2 solar mass.

Observe ~20 such systems and guess there may be ~1000 in the Galaxy

They are X-ray novae, most plausibly resulting from the accretion disk storing and flushing matter down near the black hole. Event horizon, no surface, no analog of Classical Novae for white dwarfs or X-ray bursts for neutron stars.

Often see jets during X-ray flare from black hole X-ray novae.

Some show "superluminal" motion

An optical illusion that occurs when the source of light moves near the speed of light, so chases its own emission.

These systems are called "microquasars" since some quasars with supermassive black holes have show the same effect.

Another hint that these binary X-ray nova systems contain black holes.

In quiescent "off" state of X-ray novae, a hot, low-density ~ spherical region may form, ***Despite heat, little radiation is emitted because of low density.*** Heat is carried (advected) inward with the flow of gas toward the event horizon, rather than radiated away as for an accretion disk.

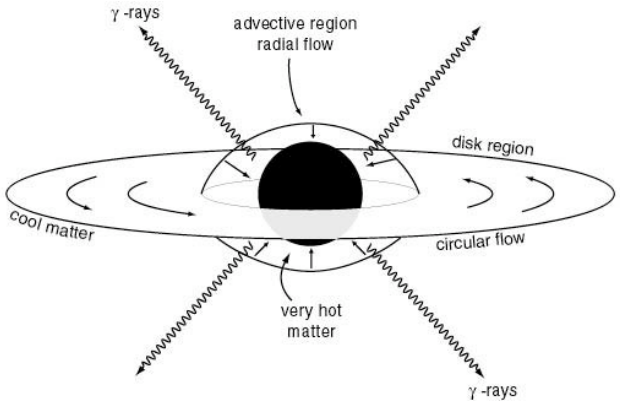
Very hot, $e^{\pm}$ electron/positron matter/anti-matter pairs may form (energy to mass, $E = mc^2$), annihilate to produce ***gamma-rays.***

Low density => low efficiency to produce radiation
=> ***low X-ray luminosity***

Only works for black hole, not for neutron star, X-ray radiation from ***surface*** of a neutron star would spoil the hot region.

Low X-ray luminosity, gamma-rays, ***clues that there is no surface***
=> ***possible proof of black hole!***

Fig. 10.1



Supermassive Black Holes

Long suspected in quasars, active galactic nuclei: huge power from small volume, billion solar mass black hole could do it.

More recently, proof that many (even most!) ordinary galaxies also have a supermassive black hole in their centers (dead quasar).

Again, do not yet see a "dark spot" but use Kepler's Laws, motion of many stars, gas ⇒ orbital period, separation

3.7 million M☉ black hole in our Galaxy UCLA [link - movie]

Up to billion M☉ black holes in quasars.

Jet from billion M☉ black hole in center of M87, large elliptical galaxy in the Virgo cluster (find Virgo!)

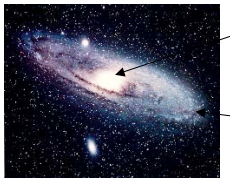
Surprising discovery:

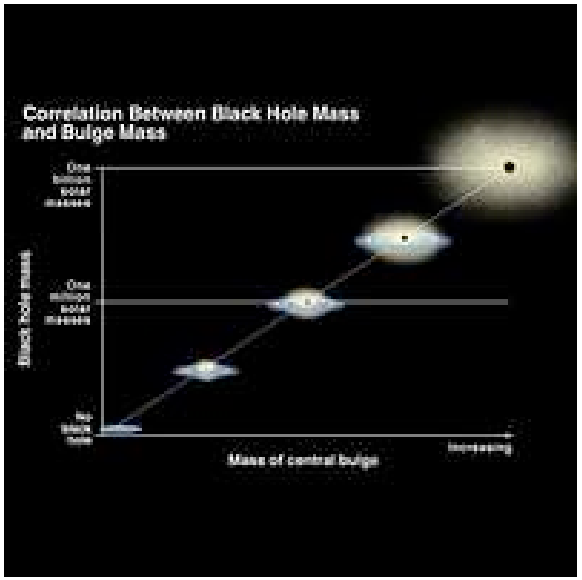
It was long thought that supermassive black holes were somewhat incidental to galaxies,

Formed of matter that somehow drained into the center of the galaxy, so galaxy could have large mass or small mass black hole depending on circumstances.

Recent work by Karl Gebhardt (UT) has shown that even stars so far from the center that they cannot possibly feel the gravity of the black hole *now* are moving in such a way that ***the larger the mass black hole, the higher the speed of the stars!***

Andromeda
M31





The implication is that the mass of the galaxy (at least the inner portions, the Bulge) is always close to 800 times the mass of the black hole.

This means that ***the formation of the black hole is somehow intimately connected with the formation and structure of the whole galaxy.***

Galaxies "know" how big a black hole to make.

Mechanism uncertain: Does the galaxy control the black hole or the black hole somehow control the galaxy?

Most popular current idea: energy from accretion of matter into disk around black hole feeds back to the surrounding galaxy, blowing excess galaxy gas away when galaxies are young and growing.

Colliding black holes in 3C75, feed energy back into the stars and gas of the colliding galaxies.