Wednesday, November 13, 2013

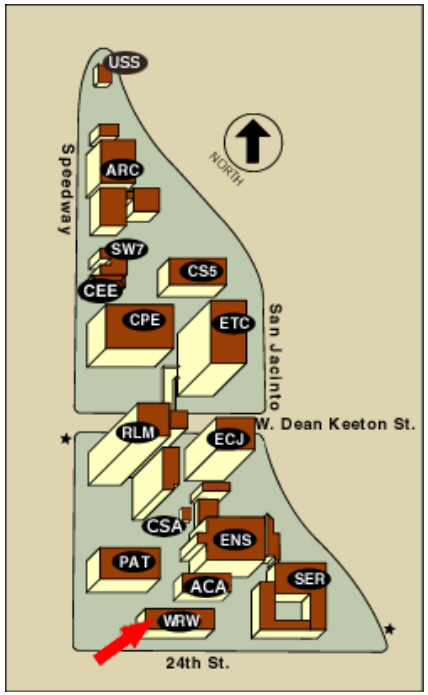
Exam 4 Friday. Review sheet posted.

Skywatch 4. Clear skies, but COLD! Bundle up!!

Review session Thursday, 5 – 6 PM, WRW 102

Reading: Chapter 9: all except 9.6.3, 9.6.4

Chapter 10, Sections 10.1-10.6, 10.9



Astronomy in the news?

GOCE crashed, last heard from over Antarctica Sunday evening. Still no word of where landed? Probably ocean.

Goal:

To understand how we search for real black holes and why binary systems with mass transfer and accretion disks are so important.

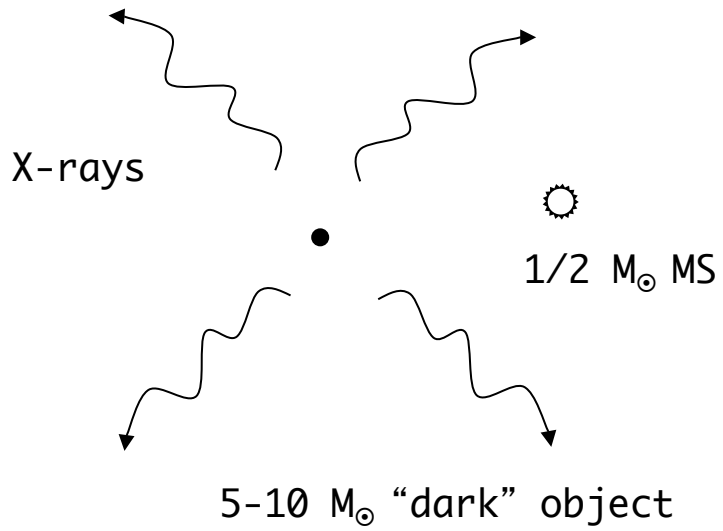
Expect only two or three systems like Cygnus X-1 in our Galaxy.

Bright, massive, short-lived companion

Maybe only one, and we found it!

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

Observe ~45 such systems and guess there may be ~1000 in the Galaxy



For systems with small mass companions cannot hide a 3rd star in the system

$\Rightarrow$ best black hole candidates.

Evidence still circumstantial but virtual proof of black hole

Not sure how these binary systems form.

Would have expected massive stars that can make black holes in core collapse to have massive companions, like Cygnus X-1.

Need to have black hole very close to small mass companion, current separation smaller than size of the star that made the black hole.

Possibilities:

Black hole progenitor swallows small mass companion while a red giant?

Companion forms from left-overs of collapse that formed the black hole?

Proving Black Holes

Astronomers search for ways to directly determine that the dark object producing X-rays is a black hole, not a neutron star.

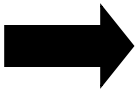
How would you identify a black hole of 1 solar mass?

Evidence that in some circumstances black holes, but not neutron stars, can produce very hot, rarified inner accretion regions, making gamma-rays, but few X-rays.

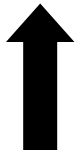
This is evidence that the object has **no surface**.

One Minute Exam

The best candidate for a binary star system with black hole is:


One with a 30 solar mass ordinary star


One with a 1/2 solar mass ordinary star


One with two black holes in orbit


Cygnus X-1

Goal:

To understand how we have discovered supermassive black holes and how they affect galaxy formation and evolution.

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! John Kormendy, UT) 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 $\Rightarrow$ orbital period, separation

3.7 million $M_\odot$ black hole in our Galaxy [UCLA link - movie]

Center of Milky Way Galaxy in direction of constellation Sagittarius – (find Sagittarius for sky watch)

Up to billion $M_\odot$ black holes in quasars.

Jet from billion $M_\odot$ 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,

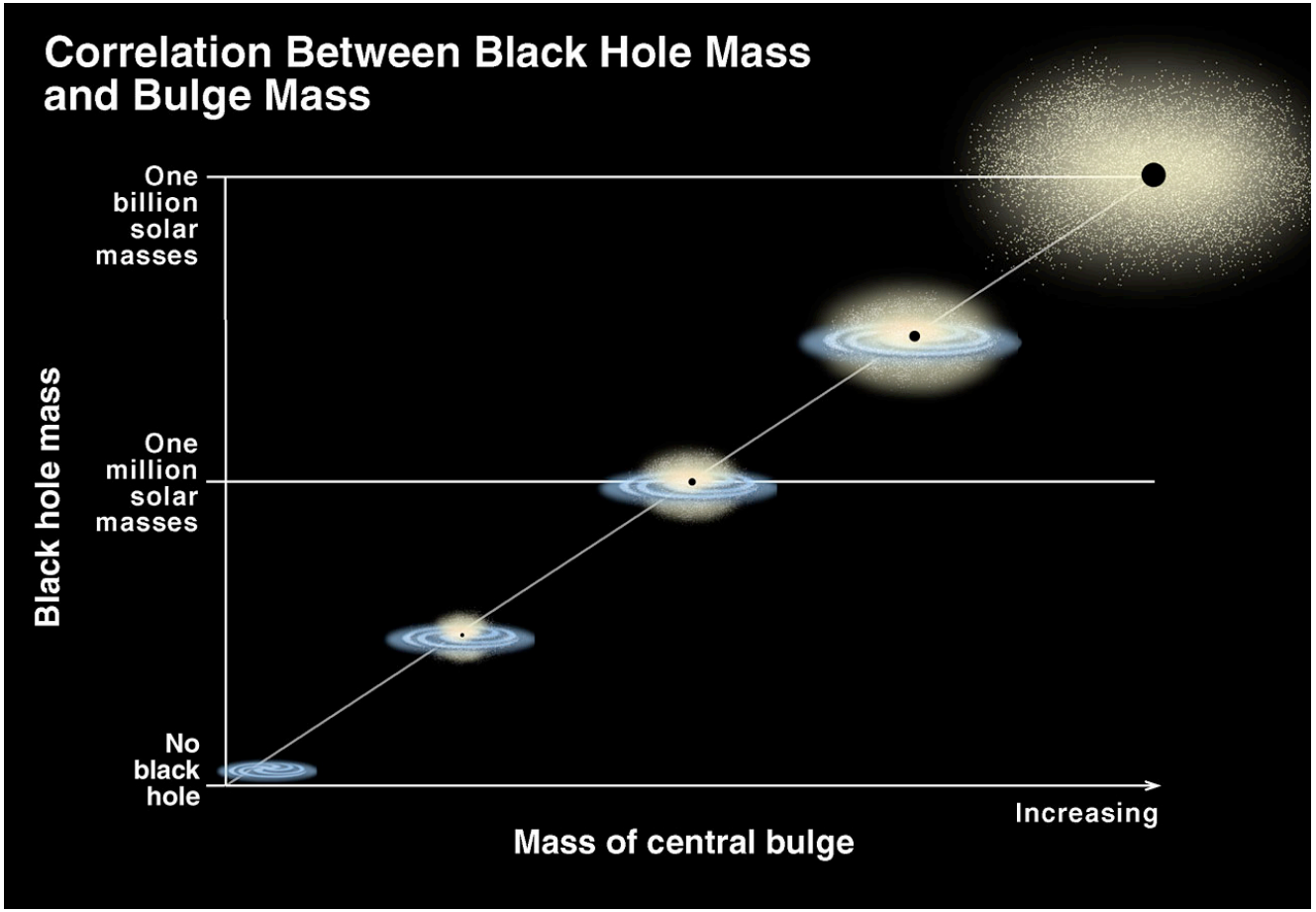
Formed of matter that somehow drained into the center of the galaxy, so galaxy could have large mass or small mass black hole depending on circumstances.

Recent work by Karl Gebhardt (UT) and others 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

Correlation Between Black Hole Mass and Galaxy Bulge Mass

Mass of Black Hole



Mass of Central Bulge of Galaxy

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.

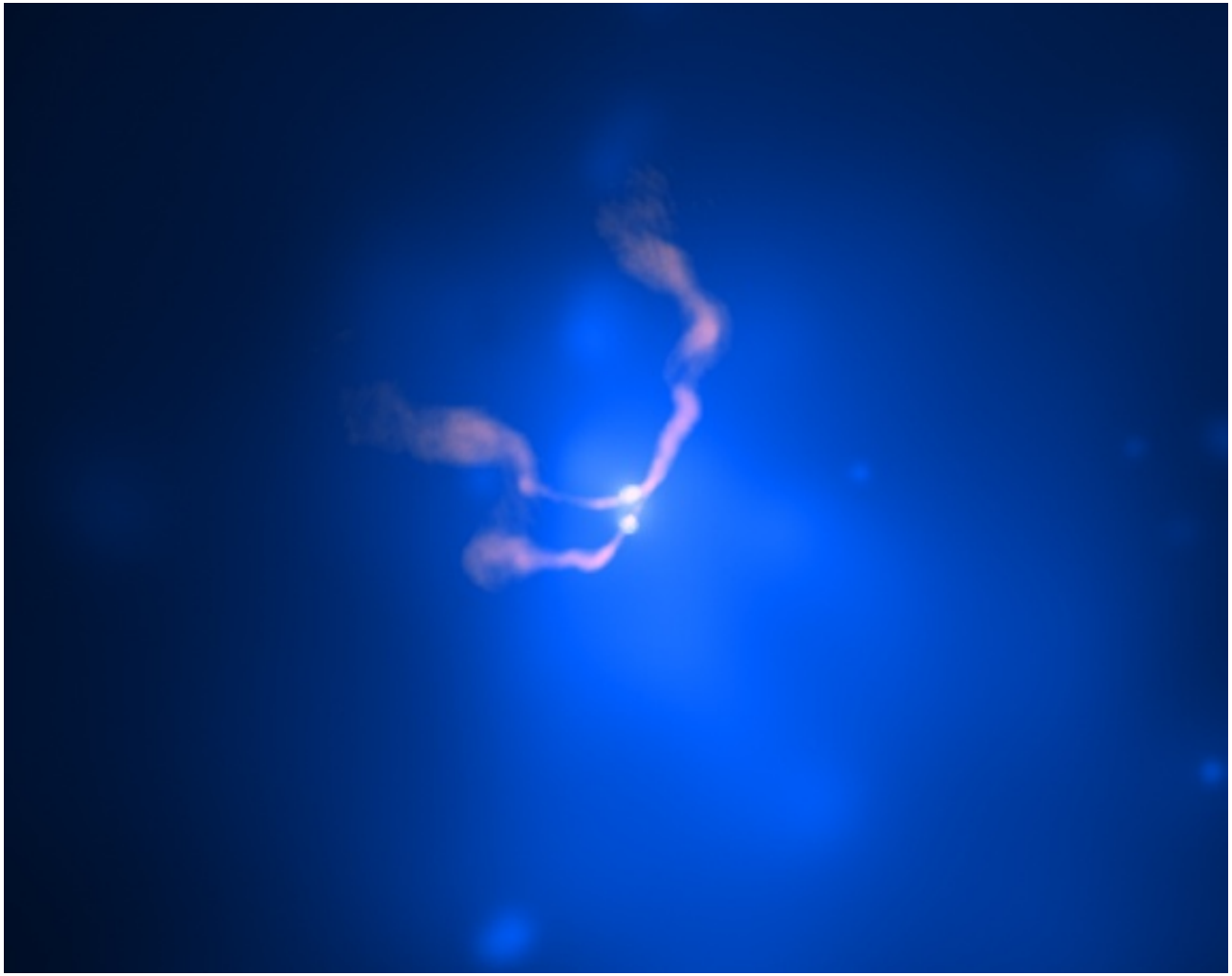
This means that ***the formation of the black hole is somehow intimately connected with the formation and structure of the whole galaxy.***

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?

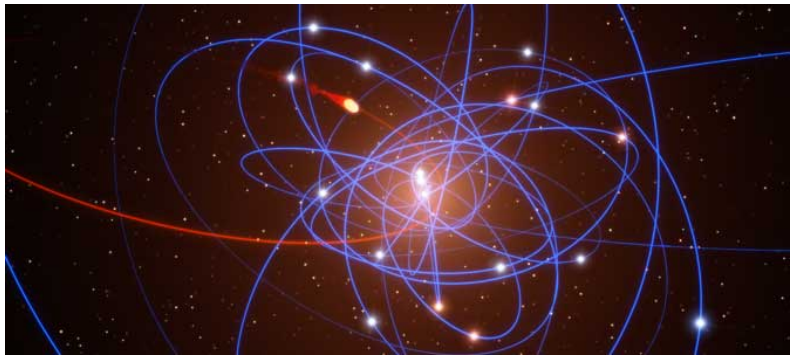
Most popular current idea: energy from accretion of matter into disk around black hole feeds back to the surrounding galaxy, blowing excess galaxy gas away when galaxies are young and growing.

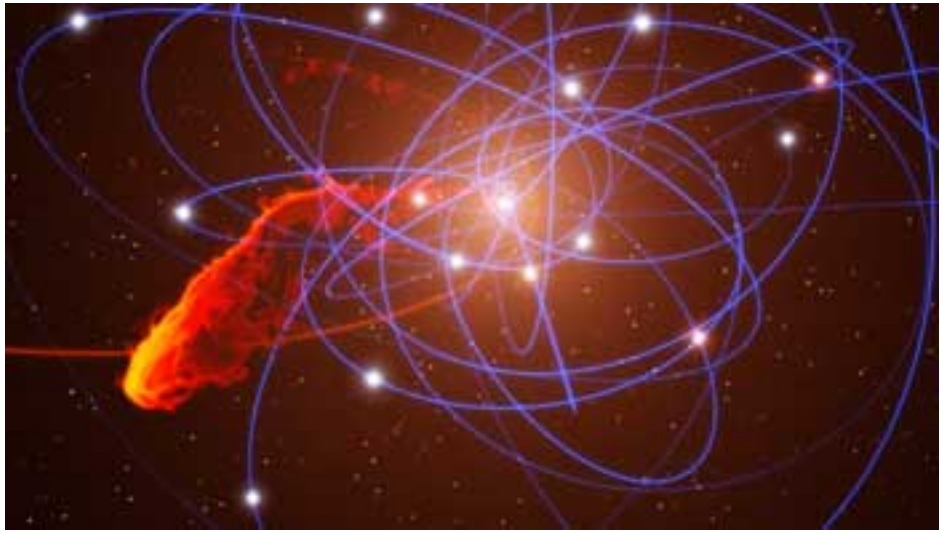
Colliding black holes in 3C75, feed energy back into the stars and gas of the colliding galaxies.



Late news- astronomers have discovered a cloud of gas being pulled into the black hole in the center of the Milky Way. Should hit in 2013.

Cloud trajectory in red



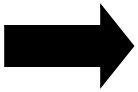


Cloud after interaction, noodleized

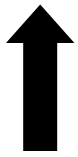
Video at http://www.space.com/13933-monster-black-hole-gas-cloud-milky.html 4 minutes

One Minute Exam

How can we discover a stellar mass black hole that has no accretion disk around it?

 Look for X-rays

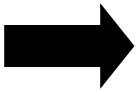
 Look for gamma-rays

 Look for jets

 We can't

One Minute Exam

What is the relation between the mass of a supermassive black hole and the galaxy in which it resides?


There is none, the black hole can be big or small, depending on how it grew and for how long


The larger the mass of the galaxy, the smaller the mass of the black hole


The larger the mass of the galaxy, the larger the mass of the black hole


The larger the radius of the galaxy, the larger the mass of the black hole

End of Material for Test 4