11/05/04

News?

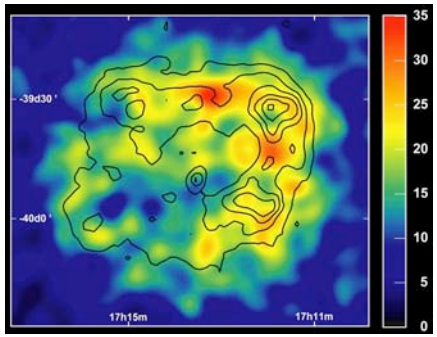
Sky watch: Betelgeuse in late evening, early morning. Also Cassiopeiae (Cas A) easy to find in early evening,

Taurus (Crab Nebula) later evening.

Jupiter and Venus very close in morning sky.

Extra credit possible 5 points, half a grade.

Pic of the day: Gamma Rays from Supernova Remnant



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 $\Rightarrow$ orbital period, separation

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

Up to billion $M_\odot$ in quasars.

Jet from billion $M_\odot$ black hole in center of M87, large elliptical galaxy in the Virgo cluster (find Virgo!)

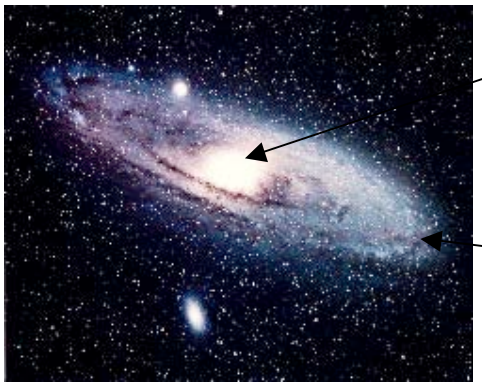
Surprising discovery:

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) 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 100 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?

The latest chapter in the story:

Intermediate mass black holes, of order 1000 - 10,000 $M_{\odot}$

First suspected from very bright X-ray sources,

Even the gravity of a neutron star would not be enough to bind the mass (see Eddington limit luminosity, Chapter 2, Section 2).

This remains controversial.

Gebhardt and co-workers have apparently found intermediate mass black holes in ***globular clusters*** using stellar velocities.

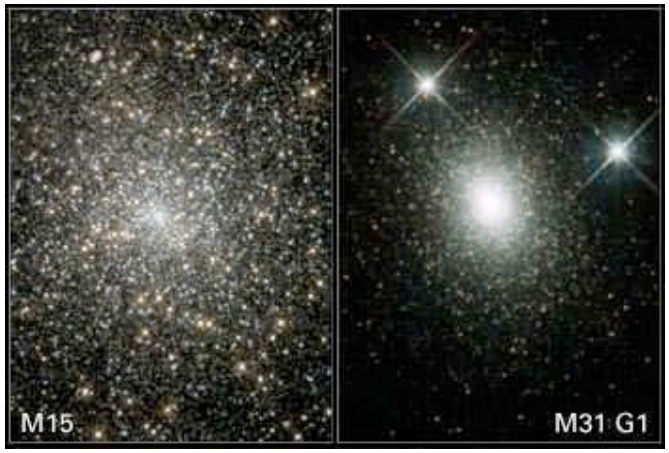
Globular clusters are old, nearly spherical clusters containing about 100,000 stars.

Remarkably, these black holes follow exactly the same bulge mass, black hole mass as galaxies, the black hole is about 1% of the mass of the globular cluster!

These star clusters also "know" how big a black hole to form!

Maybe a clue to how the process works in whole galaxies.

M 15 in our Galaxy, 4000 $M_\odot$ black hole



G1 in Andromeda galaxy, 20,000 $M_\odot$ black hole

Chapter 11 Our Expanding Universe

Expanding Universe - we observe all distant galaxies (so far away we cannot sense their individual gravity) moving away from us with speed proportional to distance: as if we were in the center of an explosion.

Our Universe is not a bomb in pre-existing empty 3-D space!

Lesson from Einstein - ***space itself can expand carrying the*** (almost motionless***) galaxies***

All distant galaxies move away from all other distant galaxies.
No galaxy, certainly not us, is in the center.

The result: speed proportional to distance