4/18/05

Exam 4, Friday, April 29

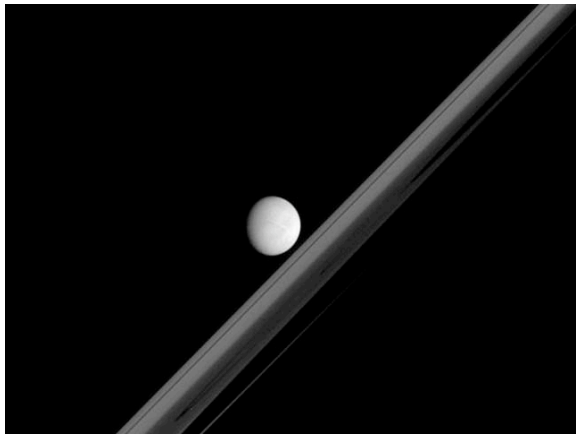
Extra Credit reports due last day of class, Friday, May 6

Final, Wednesday, May 11, 2 -5 PM

News:

Pic of the day:

Saturn's rings and Enceladus



Cygnus X-1

First X-ray source discovered in the direction of the constellation Cygnus.

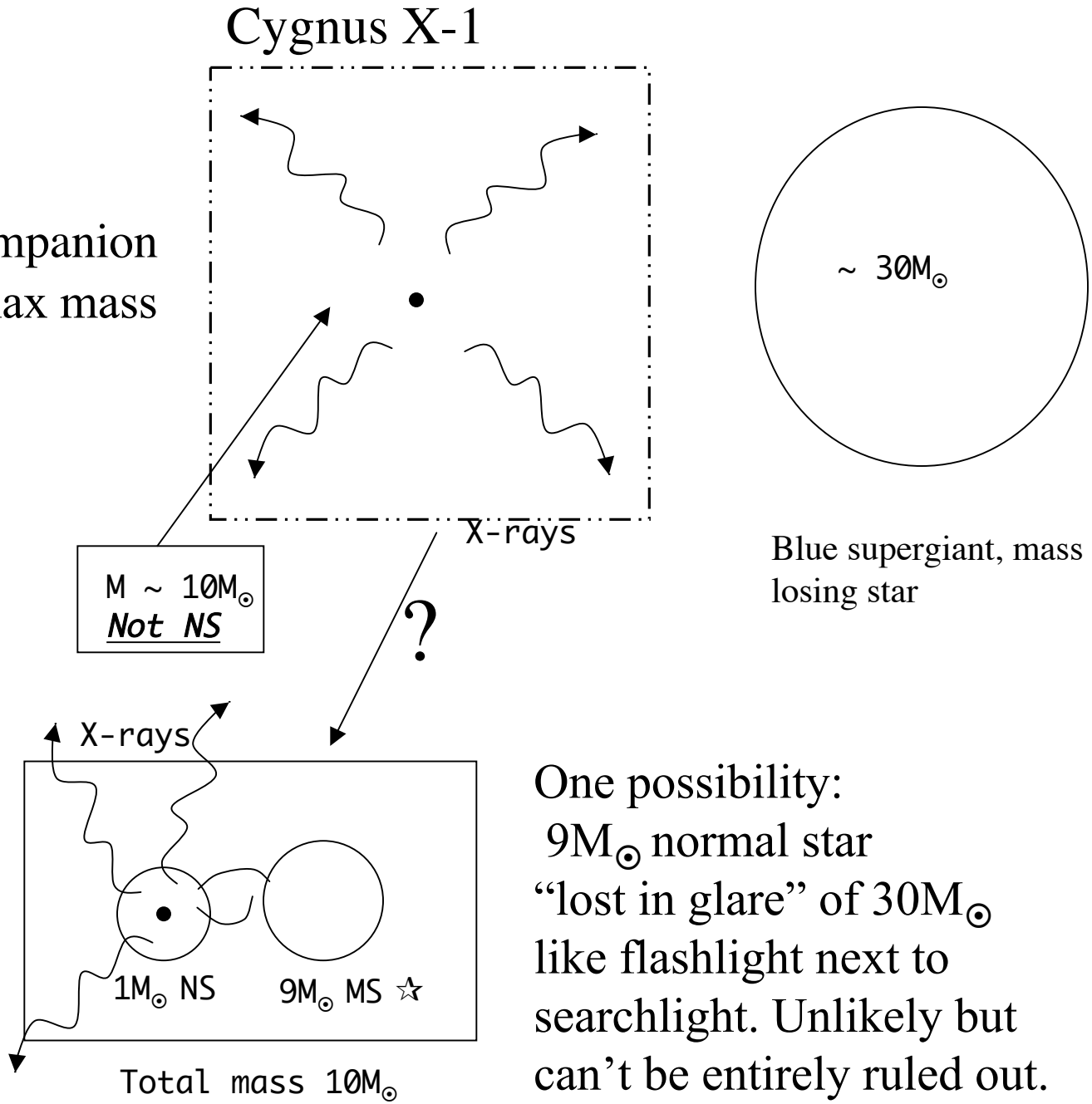
Discovered in 1970's by Uhuru Satellite (Swahili for Freedom).

First and still most famous stellar-mass binary black hole candidate.

Can't see this system with the naked eye, but can find constellation Cygnus - look for it!

Optically dark
X-ray emitting companion
$\geq 10M_\odot$ >> NS max mass
$\Rightarrow$ BH

Could nature be tricking us? All we really know is that there is a $10M_\odot$ "thing" emitting X-rays



One possibility:
$9M_\odot$ normal star
"lost in glare" of $30M_\odot$
like flashlight next to searchlight. Unlikely but can't be entirely ruled out.

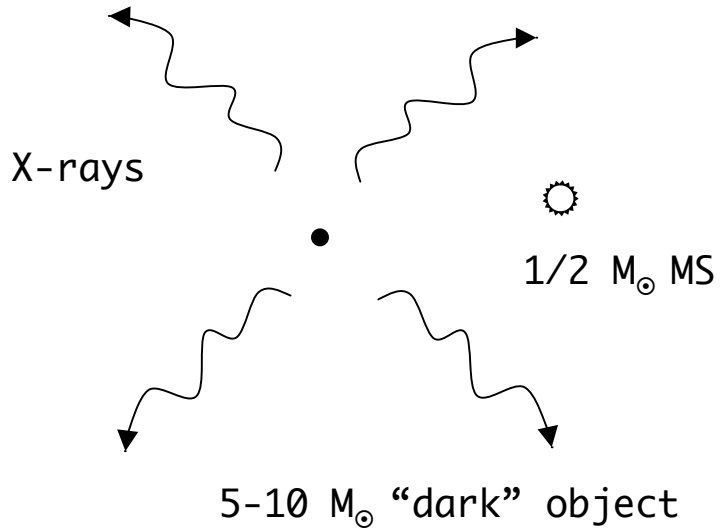
Expect only two or three systems like Cygnus X-1 in our Galaxy.

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 ~20 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

Candidates in the directions of Sagittarius, Ursa Majoris, Perseus, Scorpius, Ophiuchus, Vulpecula, Monoceros, Lupus, Cygnus (2) (Find and observe the constellations for extra credit)

AO620-00 = Nova Mon 1975 = V616 Monocerotis - one of the first and best studied with a small mass companion, black hole about 5 solar masses.

V404 Cygni - somewhat evolved companion, but one of the best cases for a black hole with “dark’ mass of about 12 solar masses.

Two candidates in the Large Magellanic Cloud:
LMC X-1, LMC X-3

Total number of such systems known, about 20.

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, separation smaller than size of the star that made the black hole.

Possibilities:

Common envelope swallows small mass companion?

Companion forms from left-overs of collapse?

All low companion mass systems are ***X-ray Novae***

Flare every few years to decades for months, like neutron star X-ray transients

Dwarf Nova-like accretion disk flushing instability

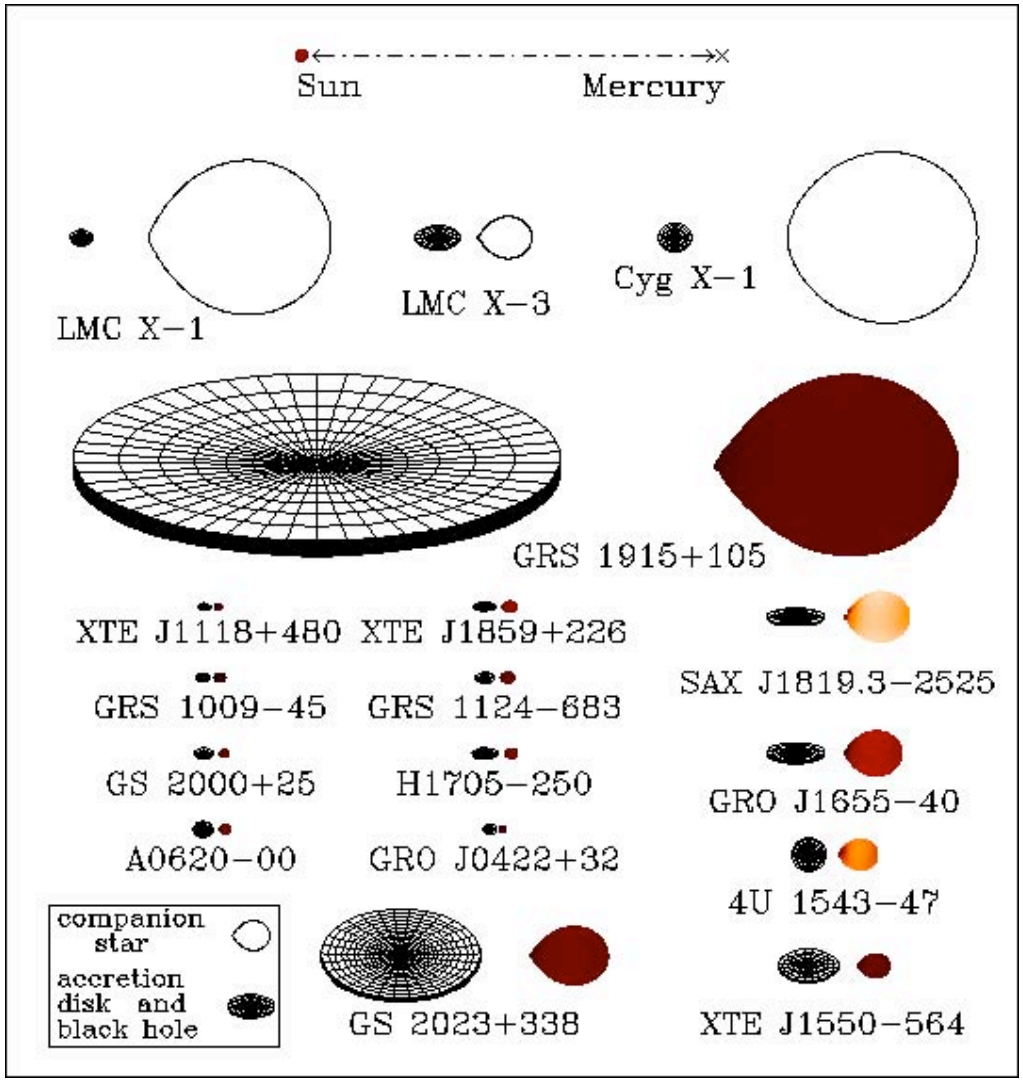
No black hole analog of nova or X-ray burster. Why not?

The black hole is black and the disk does not produce X-rays in the "off" state. There are billions of small mass stars in the Galaxy.

Do not notice these systems until they erupt!

There are probably 100 "sleeping" black hole systems that we have not discovered for every one we have. Perhaps 1000 such systems in the Galaxy (but 100 million more black holes!)

Examples of Black Hole Binary System Candidates



Often see jets during X-ray flare

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.