Monday, April 22, 2015

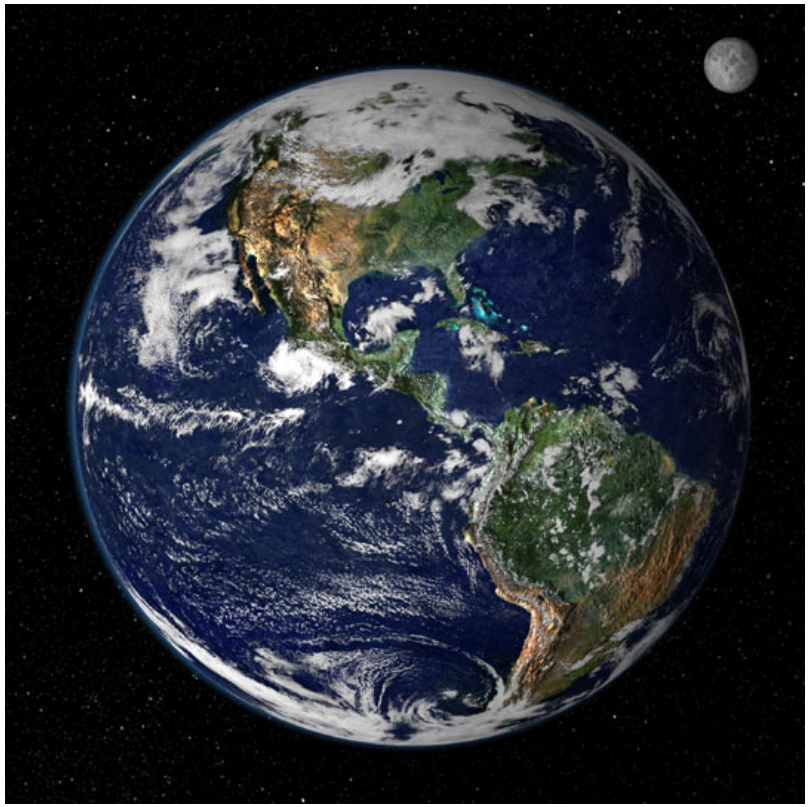
Fifth exam and sky watch, FRIDAY, May 8.

Reading for Exam 5:

Chapter 9 – Sections 9.6.1, 9.6.2, 9.7, 9.8; Chapter 10 - Sections 10.1-10.4, 10.9; Chapter 11 - all except Section 11.6 (abbreviated, focus on lectures); Chapter 12 - all; Chapter 13 (TBD); Chapter 14 - all

Astronomy in the news?

Earth Day



Goal:

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

Chapter 10 - Finding Black Holes for Real

Reading: Chapter 10, Sections 10.1-10.4, 10.9

We know that massive stars evolve to form iron cores that absorb energy and collapse. A compact object must be left behind.

Some explode and leave rotating, magnetic pulsars

Some explode and leave highly magnetic magnetars

Some explode but leave black holes or completely collapse to leave black holes

We don't know which massive stars do which! Tendency to think that more massive stars are more prone to making black holes, but the rotation of the star, the presence of a binary companion, and other factors may influence the outcome.

We do know that black holes exist, so some stars make them.

Black Holes for Real

There may be 1 - 100 million black holes in the Galaxy made by collapsing stars over the history of the Galaxy.

That means that the nearest black hole may be only a few tens of light years away. How do we find them?

Black holes made from stars are really black! (Negligible Hawking radiation).

Those alone in space are not impossible to find, but very tough.

Event horizon of 10 solar mass black hole has a radius of 30 km ~ 20 miles, somewhat bigger than size of Austin, easily fit between Georgetown and San Marcos

Very black

None yet identified.

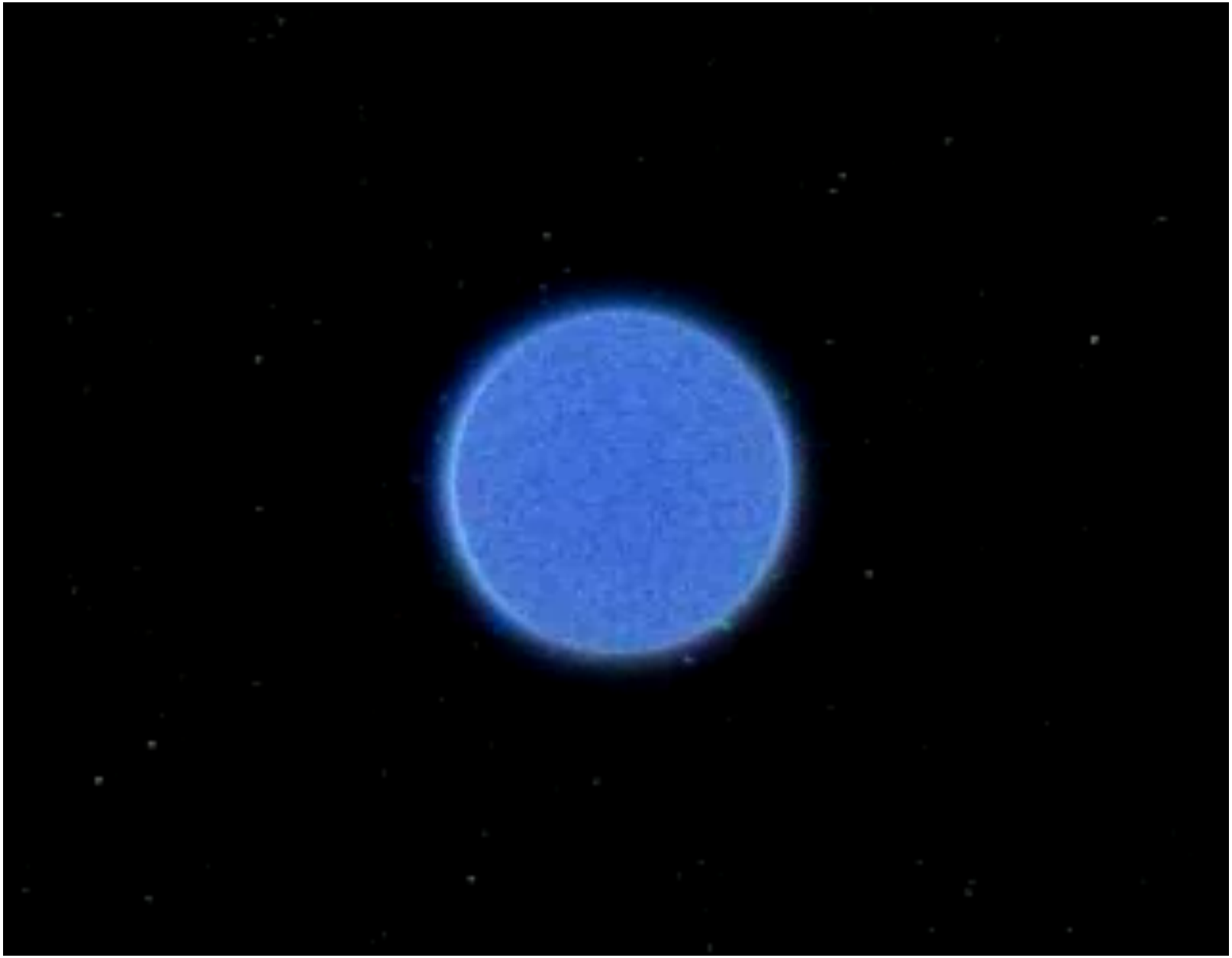
Black Holes for Real

Look for binary systems, where mass accretion occurs.

Will not see the black hole, do not yet have the technology to "see" a black spot.

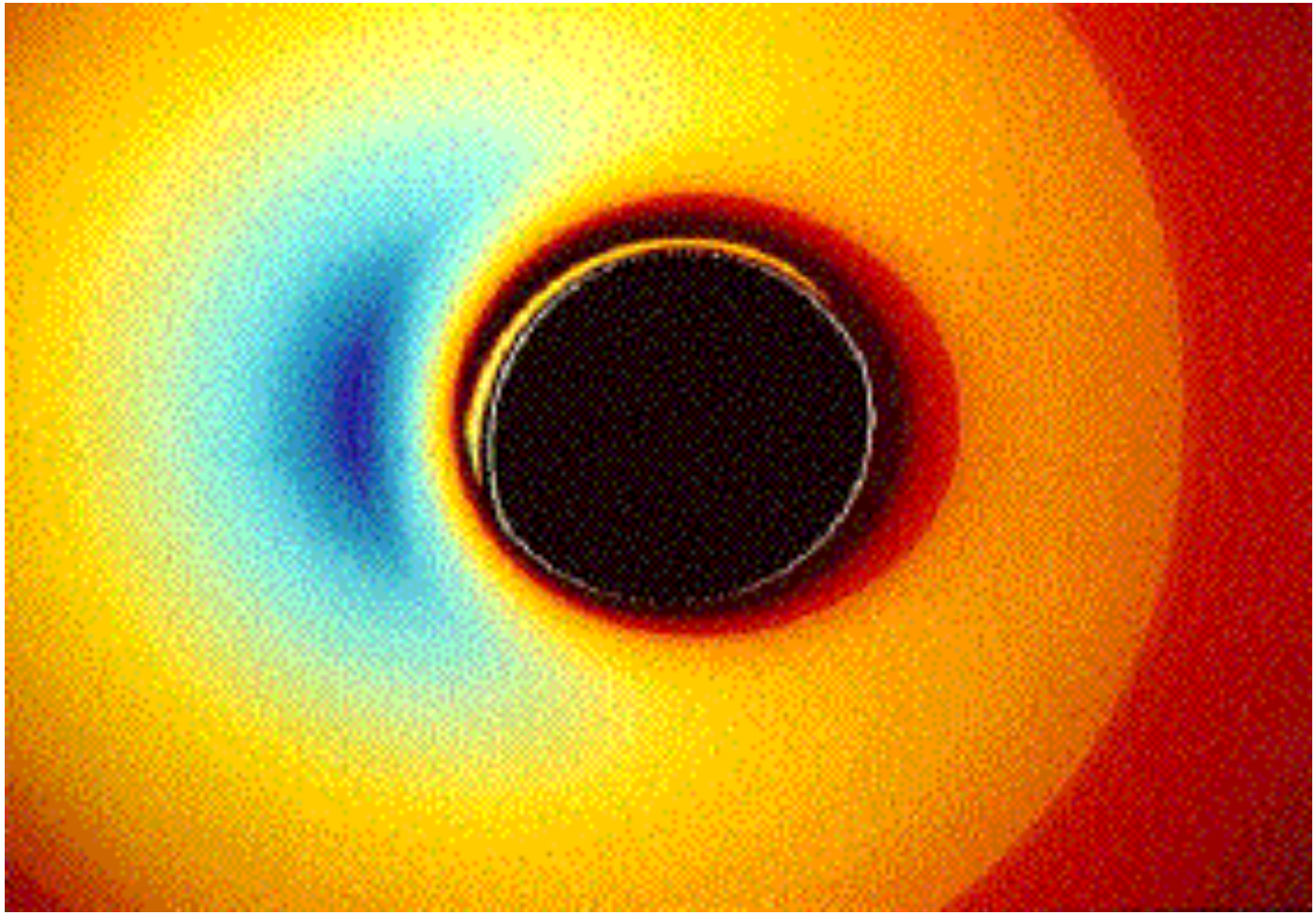
Can detect the ***halo of X-rays*** from orbiting matter, the accretion disk, near the event horizon that will reveal the presence and nature of the black hole.

Look in accreting binary systems!



Goal is to get close-up study of strongly warped space:

Event Horizon Telescope, array of radio telescopes plans to examine the massive black hole in the center of the Milky Way



Perez and Wagoner, Stanford: computer simulation of radiation from inner black hole accretion disk

Black holes are so weird and so important that the standards of evidence have to be high!

Current evidence is still primarily circumstantial, but very strong:

Stellar mass black holes (several to ~ 10 solar masses), in binary systems in our Galaxy or nearby galaxies

Intermediate mass black holes (~ 1000 - 10,000 solar masses)??, in binary systems or stellar clusters in our Galaxy or nearby galaxies

Supermassive black holes (million to a billion solar masses) in the middle of our Galaxy and in the middle of many, many others.

Circumstantial arguments for presence of black hole in a binary system:

Only neutron stars and black holes have the high gravity necessary for intense X-rays.

Use Kepler's laws to measure the total mass of the system, astronomy to determine the mass of the mass-losing star, subtract to get mass of "unseen" companion emitting X-rays.

Maximum mass of neutron star is ~ 2 solar masses

Intense X-ray source in binary star system with mass exceeding 2 solar masses is, by a process of elimination, a candidate black hole.

There are about 20 binary star black hole candidates in our Galaxy and in the Large Magellanic Cloud (near enough to detect the X-rays) that have masses measured to be greater than 3 solar masses, and hence too massive to be a neutron star.

There are another 25 binary star black hole candidates with simlar X-ray properties, but no measured mass.

Cygnus X-1

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

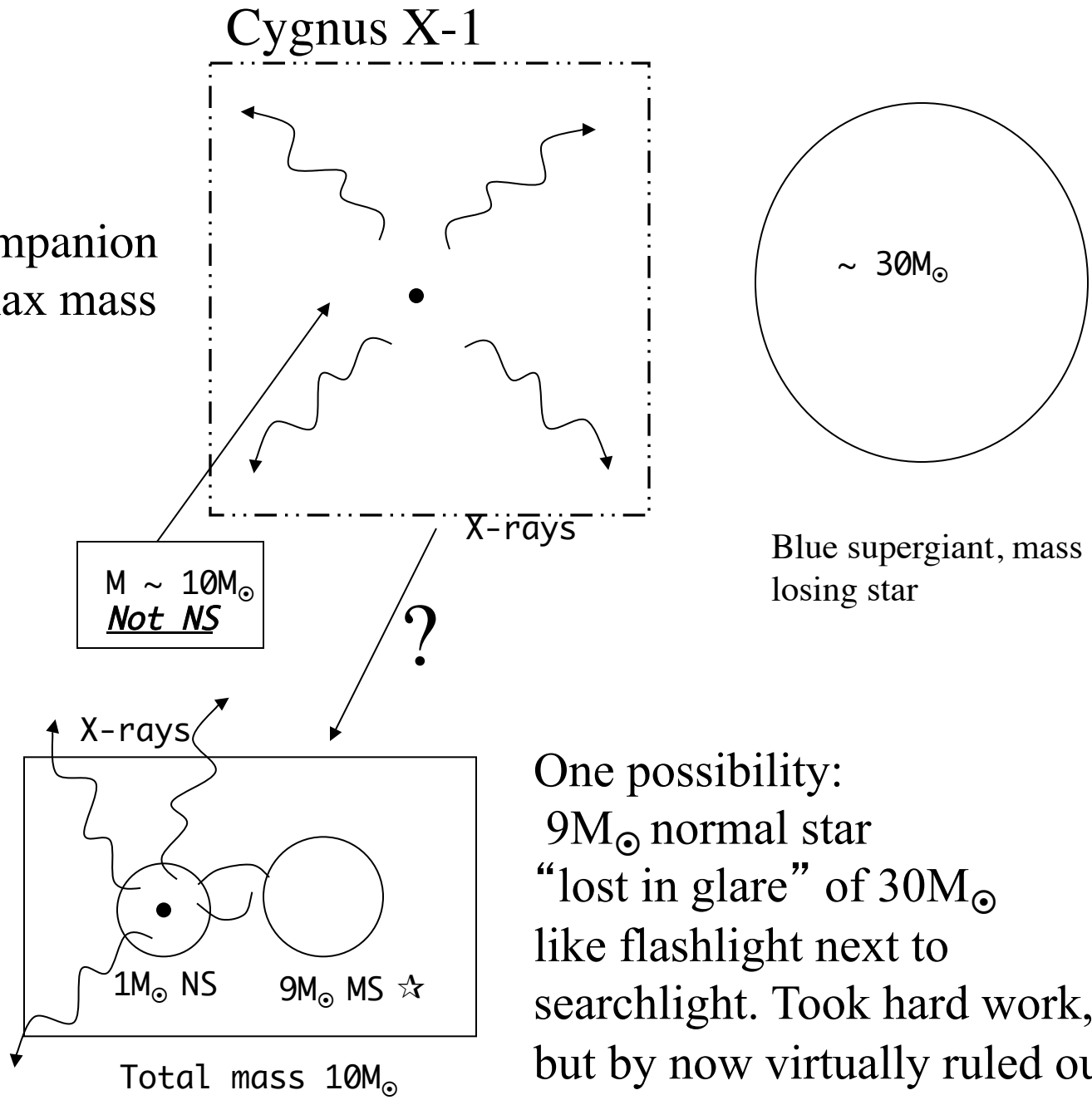
Discovered in 1970's by Uhuru Satellite (Swahili for Freedom).

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 for sky watch!

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



Blue supergiant, mass losing star

One possibility:
$9M_\odot$ normal star
"lost in glare" of $30M_\odot$
like flashlight next to searchlight. Took hard work, but by now virtually 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 ~45 such systems and guess there may be ~1000 in the Galaxy