Wednesday, April 5, 2017

Exam, Skywatch back, key posted.

Exam 4, Skywatch 4, Friday, April 21.

Reading for Exam 4:

Chapter 8 Neutron Stars - Sections 8.1, 8.2, 8.5, 8.6, 8.10;
Chapter 9 Theory of Black Holes: 9.1 to 9.5, ***9.8*<=**

Astronomy in the news

Data collection starts today on the *Event Horizon Telescope*, a set of radio telescopes designed to actually see the supermassive black hole in the center of the Milky Way galaxy.

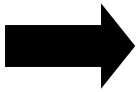
Goal:

To understand the nature of curved space, and hence of gravity, in the vicinity of a massive object, a planet, star, or black hole.

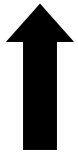
To understand the role of an “embedding diagram” in helping to explain that curved space.

One Minute Exam

An astronomer fires two laser beams so they will pass near a distant black hole. The beams are initially parallel. An astronaut on the far side of the black hole tracks the two beams and finds that they are diverging, but that they never crossed. This means that:


one of the beams entered the black hole


the beams passed on opposite sides of the black hole


the beams passed on the same side of the black hole


one of the beams had more energy than the other

Black hole candidates in the directions of Sagittarius, Ursa Majoris, Perseus, Scorpius, Ophiuchus, Vulpecula, Monoceros, Lupus, Cygnus (2) (Find and observe the constellations for sky watch)

Cygnus X-1

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.

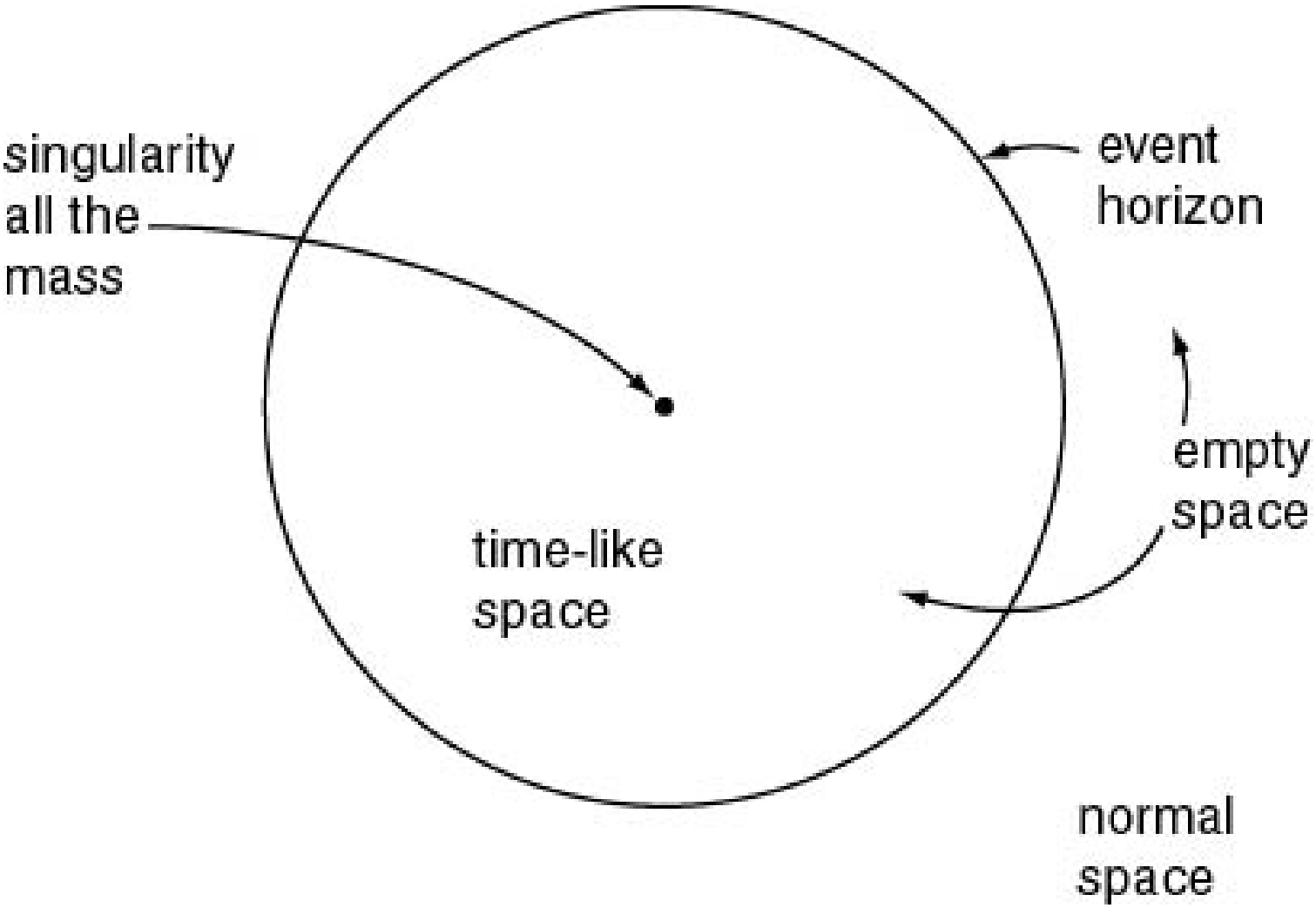
Two candidates in the Large Magellanic Cloud:
LMC X-1, LMC X-3

Total number of such systems known, about 45.

Goal:

To understand the basic features of a black hole

Figure 9.1



Basic properties of a (non-rotating) black hole

In Einstein’s theory of gravity, black holes are predicted to have an *event horizon* and a *singularity*

Event horizon: the surface within which nothing traveling at or less than the speed of light can get out.

=> No event within the event horizon can be witnessed from outside

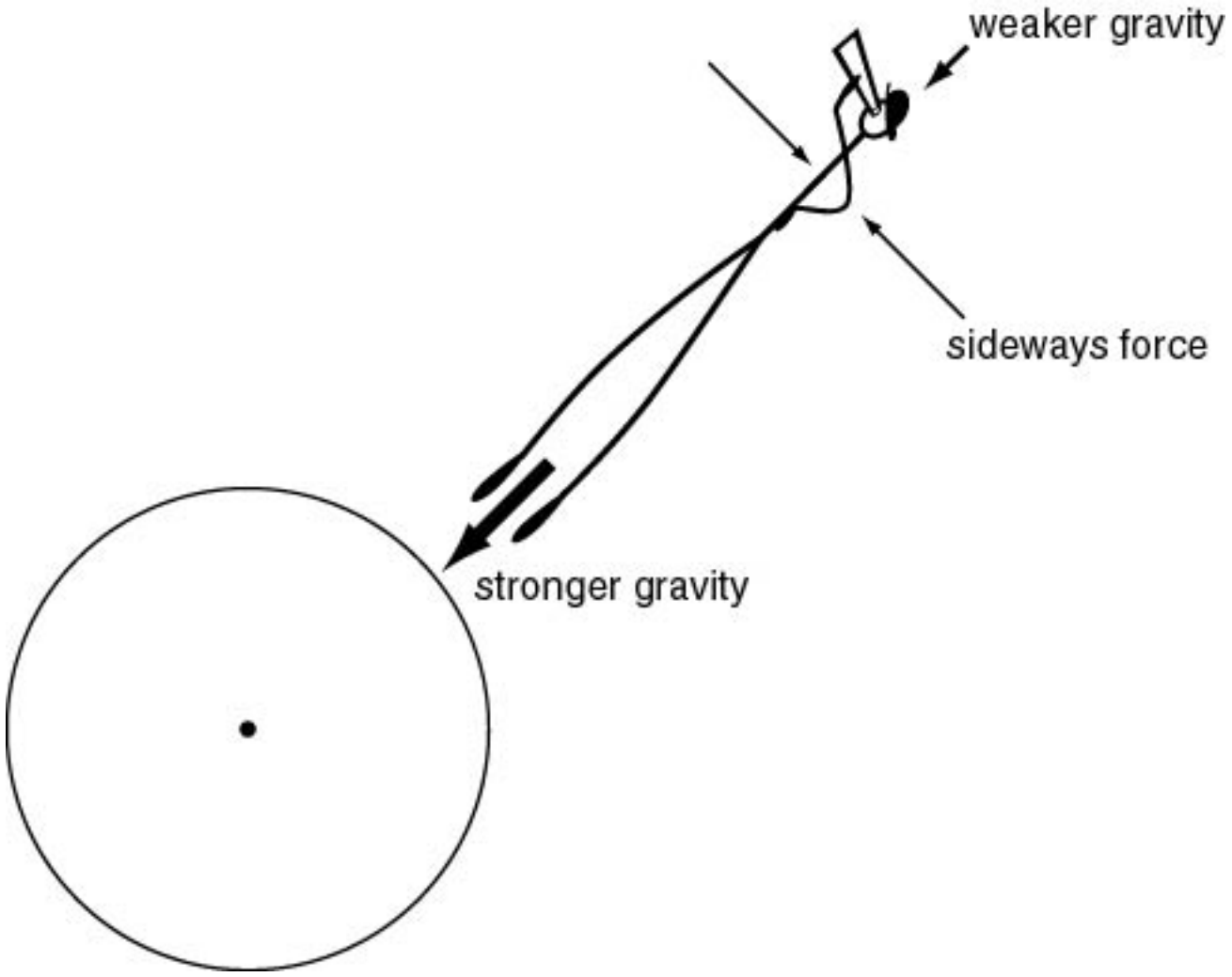
Singularity: Finite mass, zero radius, zero volume

=> infinite density, infinite tidal forces, the end of space and time.

Goal:

To understand what it is like to die falling into a black hole.

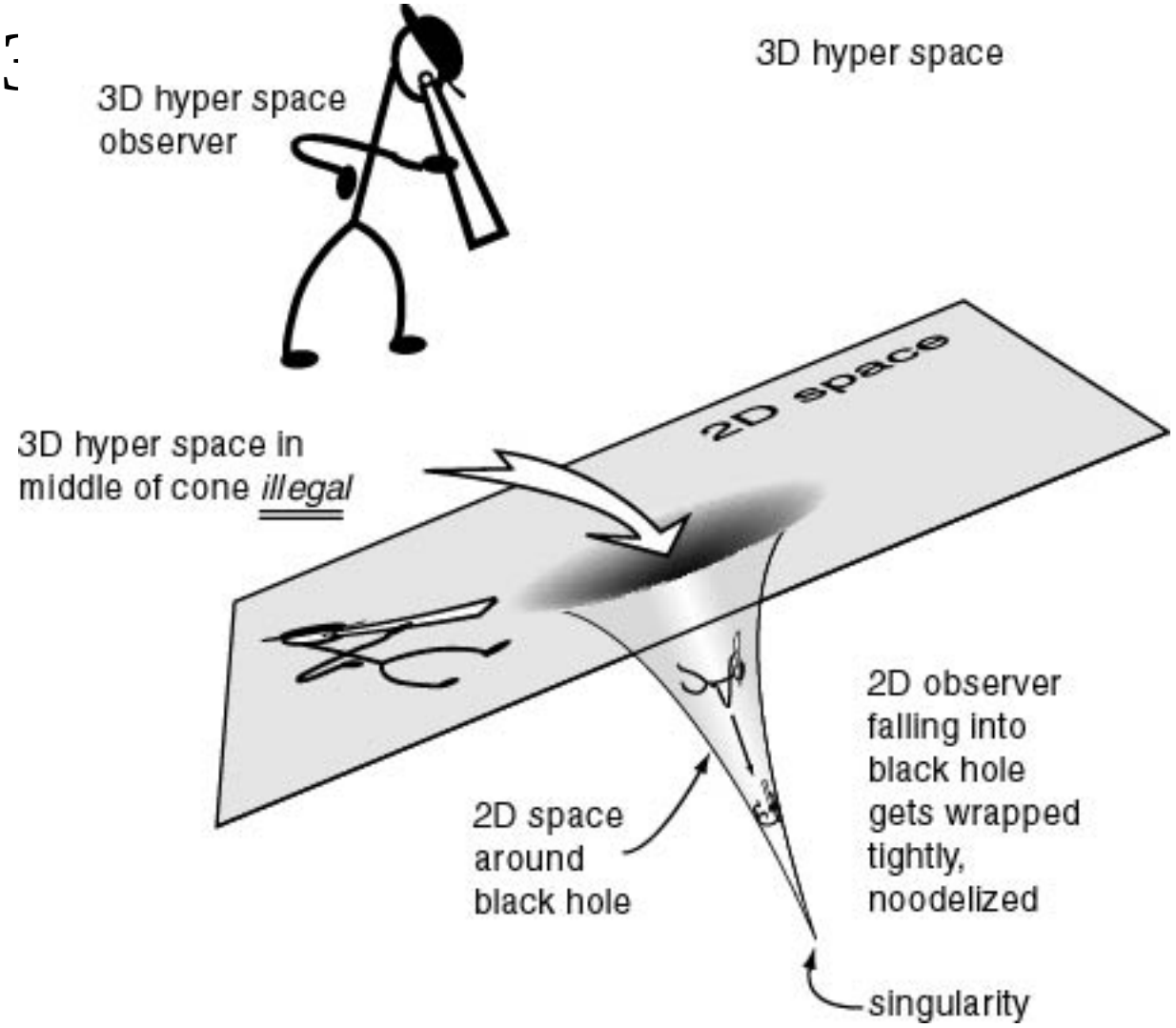
Figure 9.2



Tidal Forces – Death by Noodle-ization

Figure 9.3

Figure 9.3



2D embedding diagram of 3D curved space around a black hole

Goal:

To understand how time works in curved space and near black holes.

Black holes and Time (Section 9.5.2)

What does it mean to fall? Rather deep and strange phenomenon!

Drop things, fall at same rate…

Falling involves the passage through time as well as space.

Falling According to Einstein

According to Einstein - curved space around gravitating objects "flows" inward - ***inward escalator.*** Necessary to truly understand orbits.

If an object floats with ***no force*** in space (free fall), it will move toward the center of gravitation

$\Rightarrow$ falling - all objects respond to the same curvature, have the same acceleration

Like water down a drain - sit still in the water, but go down the drain.

Must exert a force to resist, to avoid free fall, to avoid the flow of space inward toward the center of the gravitating object.

Freely falling object has no force on it. You, sitting there, do.