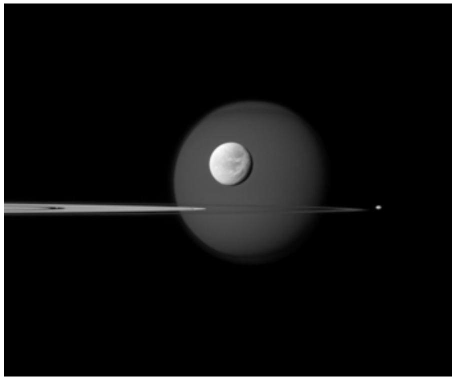
Wednesday, October 26, 2011

Exam 3 returned. Key posted.

Reading: Chapter 9, Sections 9.5.1, 9.5.2, 9.6.1, 9.6.2. 9.7, 9.8

Astronomy in the news? Earliest reported Chinese "new star" SN 185 is likely to be a Type Ia supernovae (X-ray and Infrared images). Near the direction of Alpha Centauri, between Circinus and Centaurus (not this time of year).

Big white blur last Sunday morning, not German ROSAT satellite, but likely an Orinid meteor, part of the tail of Halley's comet.



Pic of the day: From Cassini mission, Saturns rings and moons, Titan, Dione, Pandora, and Pan (in ring gap).

Goal:

To understand the “real” curved space of a gravitating object in three dimensions

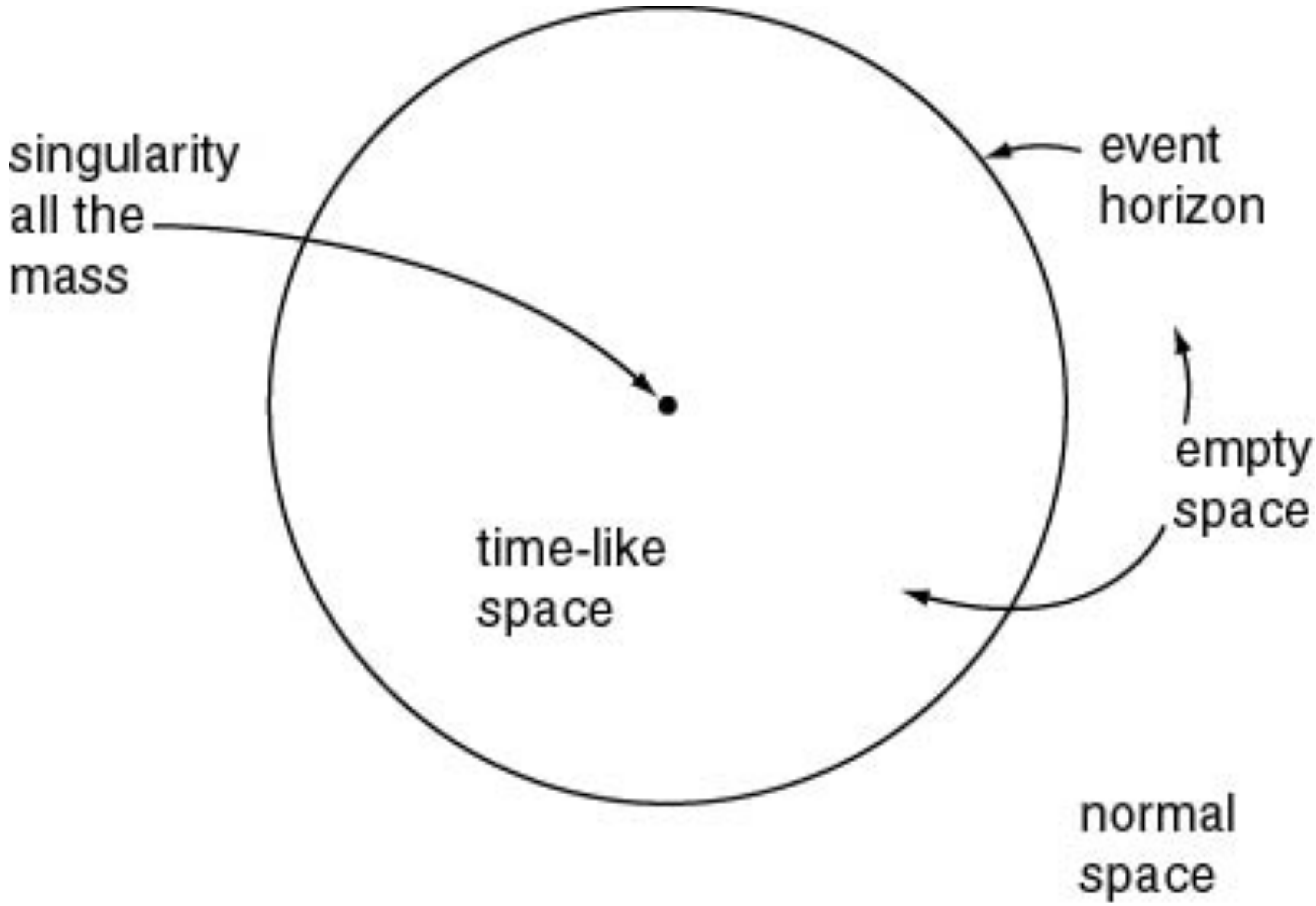
Footnote: the 3D space inside the neck of the cone in the embedding diagram is **hyperspace**, you cannot do the 2D geometry of the embedding diagram there.

First book cover.

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 travelling at or less than the speed of light can get out.

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

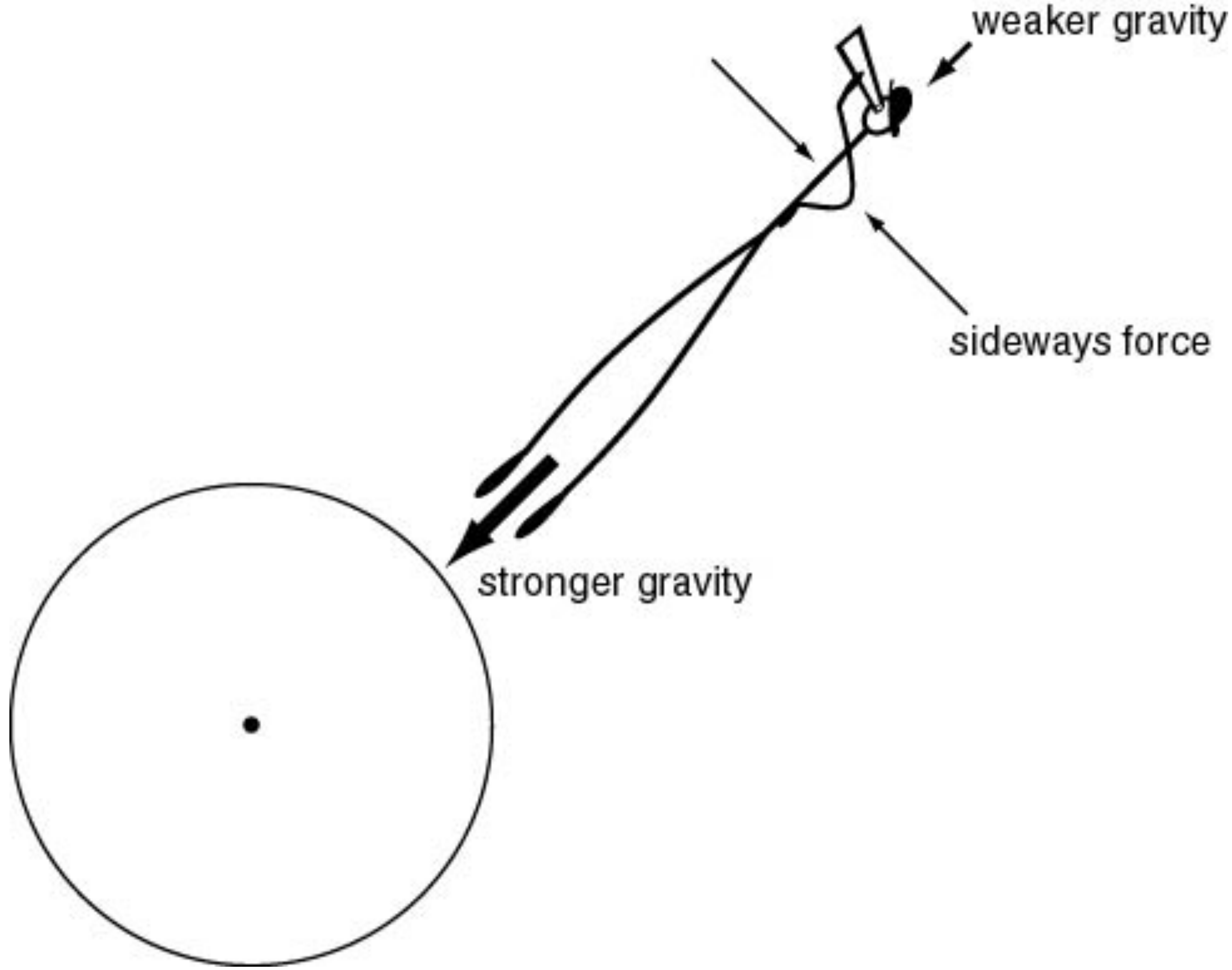
Singularity: Finite mass, zero radius, zero volume

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

Goal:

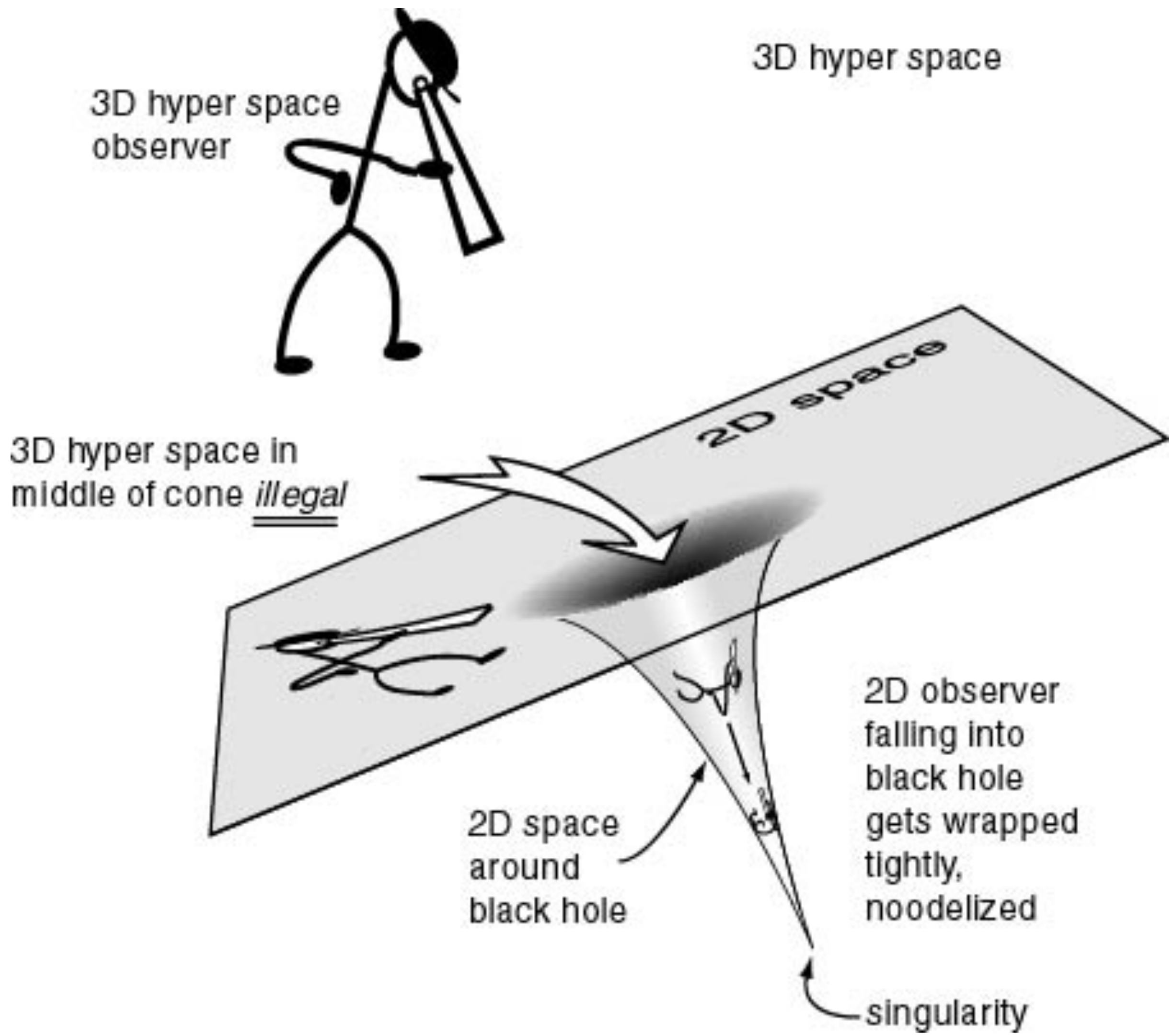
To understand what it is like to die falling into a black hole.

Figure 9.2



Tidal Forces

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

⇒ 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.

Gravity and Time

Predictions of Einstein:

For an object moving away from an observer, all frequencies, including the rate of aging are lower (Doppler red shift).

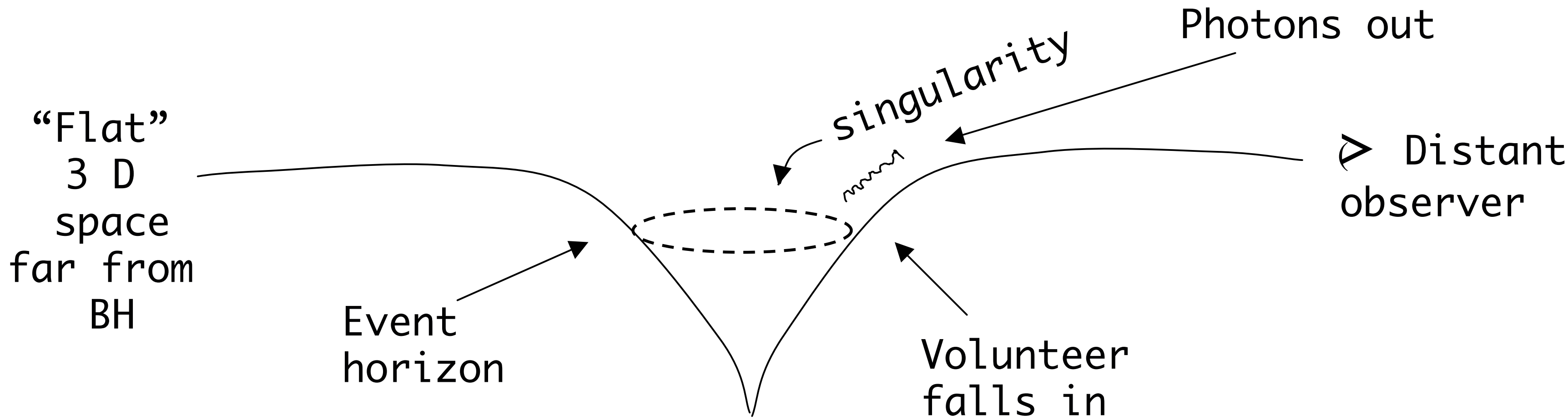
If a clock moves away from an observer it ticks more slowly.

If a clock is deep in a gravity well (the curved space around a gravitating object) it ticks more slowly according to an observer at large distance where gravity is absent (flat 3D space). Gravitational red shift.

Get both effects if you drop a “clock” into a gravity well and watch it fall in from a safe distance where gravity is weak (flat 3D space).

A distant observer will see every aspect of time slow down for an object falling into a gravity well, including the ageing of a volunteer, and the rate at which they are falling.

Specifically for Black Holes



Volunteer finds herself rapidly falling through event horizon, she is noodleized, and dies

Distant observer sees Doppler and gravitational redshifts

Received photons get longer, longer wavelength

Time between photons gets longer and longer

Infinite time for last photon emitted just as volunteer reaches the event horizon; space is moving inward at the speed of light compared to distant observer

⇒Distant observer never sees volunteer cross the horizon

⇒Photons get undetectable, very long wavelength, most of the time is between photons - absolutely black **- why black holes are black.**