March 29, 2010

Reading: 9.5.2, 9.6.1, 9.6.2, 9.6.3, 9.7, 9.8.

Exams back Wednesday

Astronomy in the News? π-day, March 14, 3/14

Lauren Moore

http://www.youtube.com/watch?v=bUGjUCHSKLM

Pic of the Day - Maine sunset vista, with Betelgeuse

Goal:

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

Black holes and Time (Section 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.

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

If a clock is deep in a gravity well it ticks more slowly according to an observer at large distance where gravity is absent.

Get both effects if you drop a "clock" into a black hole 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.

Falling According to Einstein

According to Einstein - curved space around gravitating objects “flows” inward - ***inward escalator.***

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

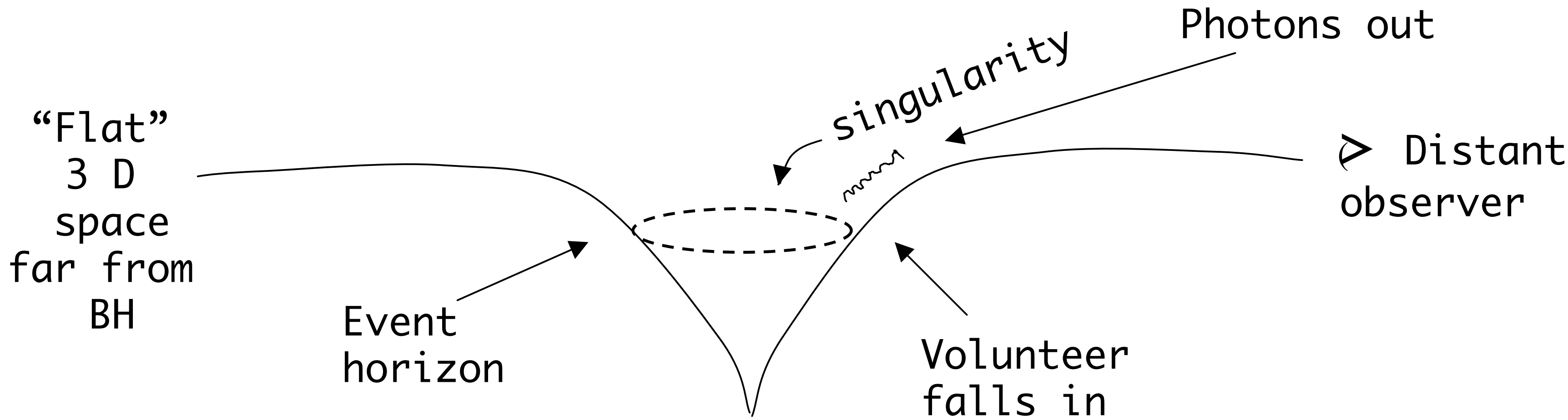
$\Rightarrow$ falling - all objects respond to the same curvature, have the same acceleration

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.

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

Specifically for Black Holes



Volunteer finds herself rapidly falling through event horizon, noodleized, 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.**

A distant observer watching an object falling into a black hole will see it getting dimmer and dimmer and ageing more and more slowly.

A distant observer will perceive an object to turn black, stop ageing, and stop falling and never see the object fall inside the event horizon.

One Minute Exam

From the point of view of a distant observer, a volunteer who falls into a black hole

➡ Will be noodleized and die

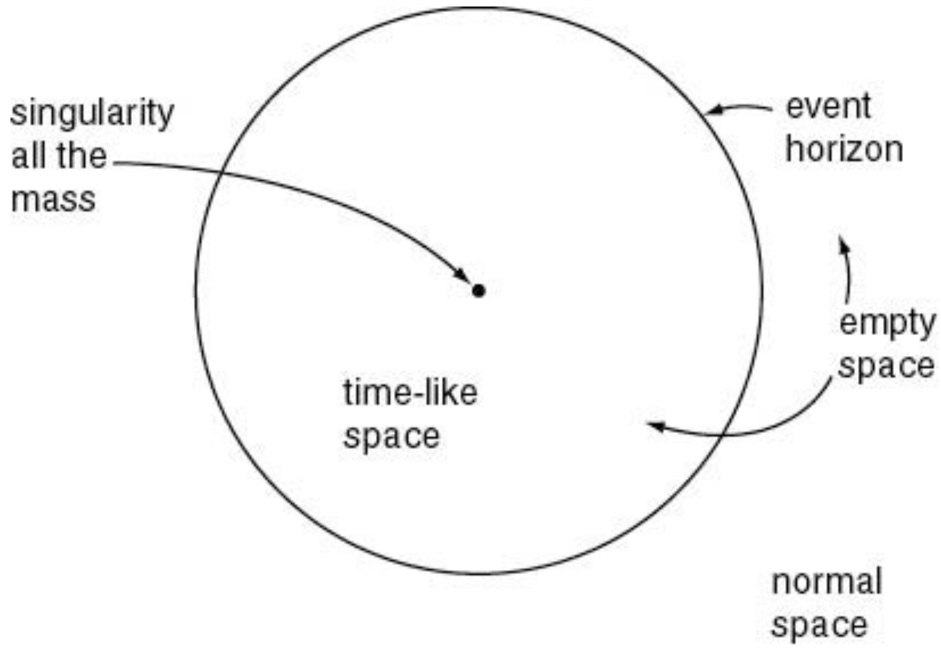
⬅ Will turn black before arriving at the event horizon

⬆ Will age more rapidly

⬇ Will shrink to a point

Goal:

To understand the conflict between Einstein's theory of gravity and the Quantum theory.



Einstein’s theory does not incorporate any of the tenets of the quantum theory.

Singularity - all the mass is in a zero volume point in Einstein’s theory.

Violates the Uncertainty Principle of Quantum Theory: cannot specify the position of anything exactly.

Need theory of ***Quantum Gravity*** to rectify, to understand what the “singularity” really is. **Deepest issue in modern physics**.