3/24/08

Wheeler on travel next week (meeting on deflagration to detonation transitions in Type Ia supernovae), films on black holes, gamma-ray bursts, Monday, Wednesday.

Astronomy in the News -

Pic of the day - Saturn and Titan from Cassini mission

Black holes and Time (Section 5.2)

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).

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

Drop things, fall at same rate…

Falling to Einstein

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

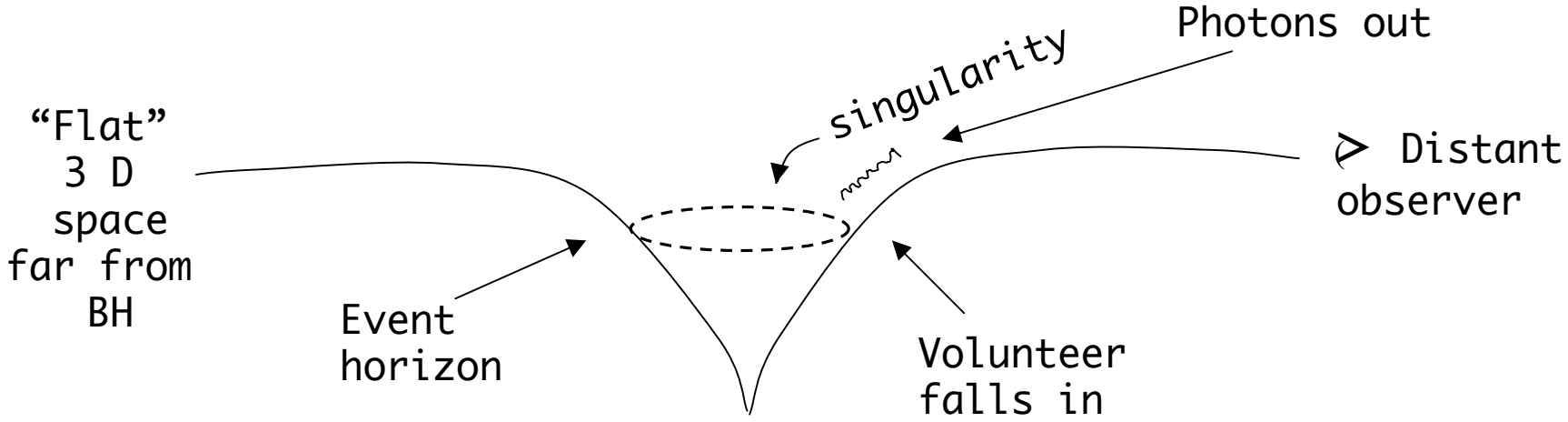
If object floats with ***no force*** in space (free fall), it will move toward the center of gravitation

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

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

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

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

⇒***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.**

One Minute Exam

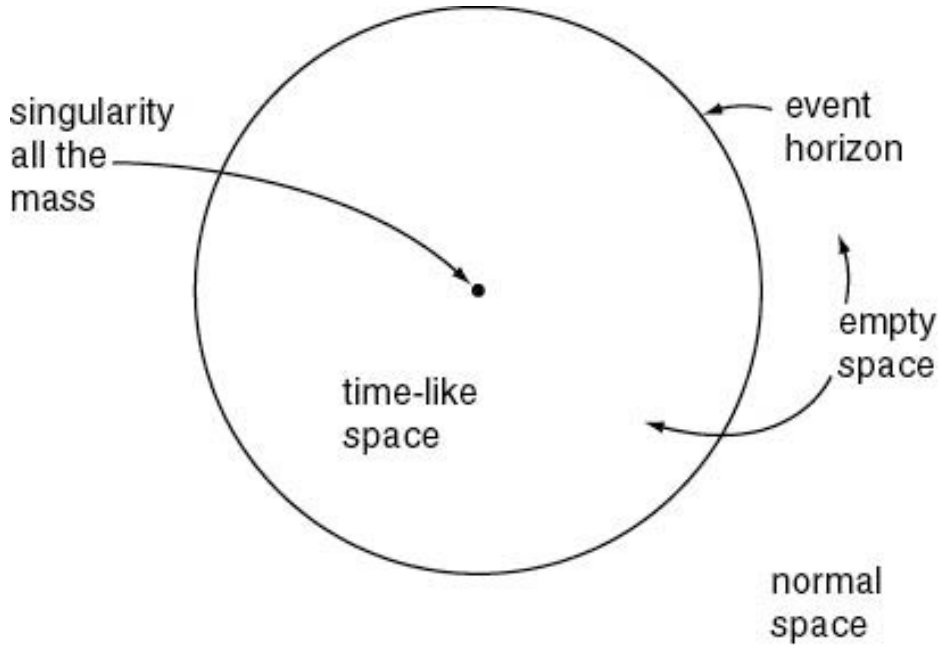
From the point of view of a distant observer, a volunteer who falls into a black hole

A) Will be noodelized and die

B) Will turn black before arriving at the event horizon

C) Will age more rapidly

D) Will shrink to a point



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**.

Black Hole Evaporation
Hawking Radiation - Chapter 9 § 6

Nature of vacuum in Quantum Theory - cannot specify the energy of anything precisely, even "zero" in a vacuum:

Vacuum "boils" with creation/annihilation of particles/anti-particles

easiest to make photon = anti-photon (no mass)

but also e^- e^+, p^+ p^-, neutron anti-neutron, neutrino anti-neutrino

Quantum Fuzzy Event Horizon - at event horizon - position of event horizon and of particles is *quantum uncertain*

One particle in pair can be swallowed, other escapes - carries mass, energy - pure quantum effect.

Black holes are not just one-way affairs, with quantum effects they will lose mass and energy - Stephen Hawking's dramatic discovery.