4/5/06

Test 3, this Friday, review sheet posted

Review Session Thursday, 5PM RLM 4.102

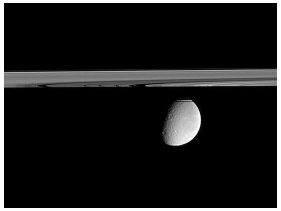
Chapter 7 - SN 1987A

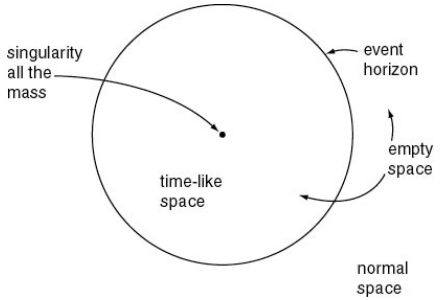
Chapter 8, Sections 1, 2, 5, 6, 7, 10 - Neutron Stars

Chapter 9, Sections 1, 2, 3, 4, 5 - Black Holes

News:

Pic of the day; Rhea and Saturn's rings.





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.

Falling to Einstein

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

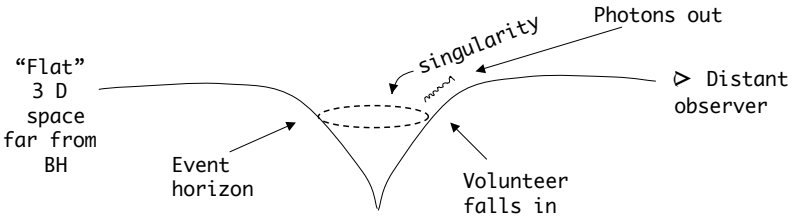
If object floats with ***no force*** in space (free fall), it will move toward the center of gravitation

⇒ 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 never cross the event horizon

D) B and C

GPS

END OF MATERIAL FOR TEST 3

Chapter 9, Section 5

Black Hole Evaporation
Hawking Radiation § 6

Quantum Fuzzy Event Horizon

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

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

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Hawking Radiation

Loss of energy is not arbitrary, it comes out in a very precise form…

Black Holes radiate Hawking radiation as if they had a temperature that depends (inversely) on the mass.

Black holes are not totally black

Given enough time, black holes will evaporate!

Hawking Radiation

If the black hole has the mass of a star, the time to evaporate will be ***much*** longer than the age of the Universe, so unimportant.

If the black hole has the mass of a mountain or asteroid, it can evaporate in the age of the Universe (13.7 billion years).

As mass ↓ T ↑ with energy loss, less mass, hotter, more radiation.

Small mass black holes can explode, disappear within the age of Universe.

Theories that mini-black holes might be created in the Big Bang (no hint in any observation).