11/6/06

Reading- Chapter 9 sections 6 - 8

News? Vote Tomorrow

Pic of the day - Comet tail, wafted in the solar wind.

One Minute Exam

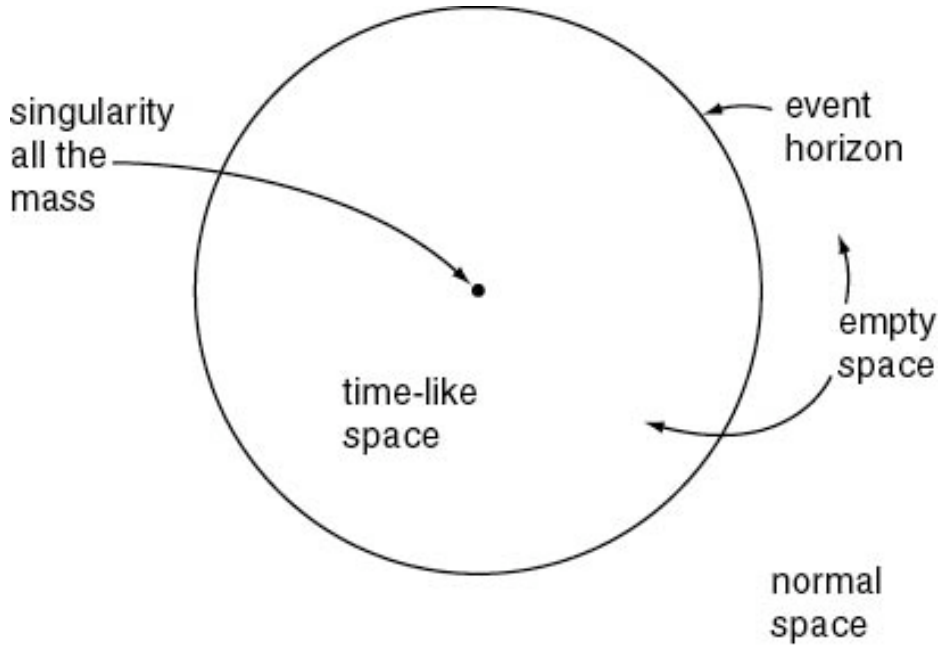
From the point of view of a distant observer, a volunteer who falls into a black hole

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

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

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 precise 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).

§ 7 Fundamental Properties of Black Holes

The fundamental properties of black holes are electrical charge (usually taken to be zero), mass, and spin (angular momentum).

All other properties, radius of event horizon, Hawking temperature come from that.

No other properties like mountains, structure, DNA,

Not even number of protons, electrons and neutrons that fell in (profound information loss).

Thought experiment: one neutron star, one anti-neutron star.

$$n + \bar{n} \longrightarrow \text{explosion}$$

$$\searrow \text{2 BH -> One large Black Hole}$$

Black holes transcend ordinary physics of matter/anti-matter

Information Loss??

Deep issue.

What happens to the ***information*** about all the stuff that fell into the black hole?

Quantum theory insists there must be no loss of information.

Maybe it is in the radiation (Hawking) or maybe it is still somehow in the singularity (string theory).

Does the singularity evaporate and disappear? Don't know in absence of theory of ***Quantum Gravity***