3/26/08

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 -

The NGC 3576 Nebula



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 the 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.

 $n + \overline{n} \rightarrow explosion$ 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*

One Minute Exam

According to Stephen Hawking:

- A) Black holes are totally black
- B) Combining a neutron star and an anti-neutron star will make a black hole
- C) A singularity is a point
- D) Black holes can explode



"Time-like" space forces motion in one direction. Space moves faster than the speed of light compared to a distant observer; the real reason black holes are black.



Non-rotating Schwarzschild Black Hole

(assumption necessary to solve equations)

Find two Universes, each of infinite space, connected at one instant by singularity.

Cannot pass from one to the other if travel at less than the speed of light



Event horizon is also surface of infinite redshift

Rotating Kerr Black Hole

Mass and spin, but no electrical charge

Assume all mass in singularity, no mass anywhere else (assumption necessary to solve equations)

Find *singularity is a ring* (not a point)



0 thickness, ∞ density, still uncertainty problem

Infinite Universes!

Cross-sectional view of rotating Kerr black hole

