Monday, October 31, 2011

Reading: Chapter 9, Sections 9.5.1, 9.5.2, 9.6.1, 9.6.2. 9.7, 9.8

Astronomy in the news?

New Brian Greene series on PBS in November, The Fabric of the Cosmos, as we cover same topics in class.

Pic of the day: Boo! Halloween nebula

Goal:

To understand how Stephen Hawking added some quantum theory to Einstein's theory and revolutionized our understanding of black holes.

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 in practical terms.

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 $\downarrow$ T $\uparrow$

With energy loss, less mass, hotter, more radiation. Runaway process.

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 (but no hint in any observation)

Goal:

To understand the basic properties of black holes and why their simplicity is a great challenge to quantum theory.

§ 9.7 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.

They have no other properties like mountains, structure, chemical composition, DNA,

Not even the number of protons, electrons and neutrons that fell in
=> *profound information loss*.

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

Neutron star + Anti-neutron star => gigantic explosion!

Black Hole + Black Hole => One large Black Hole

Black holes transcend ordinary physics of matter/anti-matter

Information Loss??

Black holes have only three fundamental properties: mass, spin, and electrical charge (= 0 in practice)

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 or maybe it is still somehow in the singularity.

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

New book by Leonard Susskind - Black Hole Wars: My Battle with Stephen Hawking to Make the World Safe for Quantum Mechanics, will discuss later. You may be a hologram…

One Minute Exam

According to Stephen Hawking:

 Black holes are totally black

 Combining a neutron star and an anti-neutron star will make a black hole

 A singularity is a point

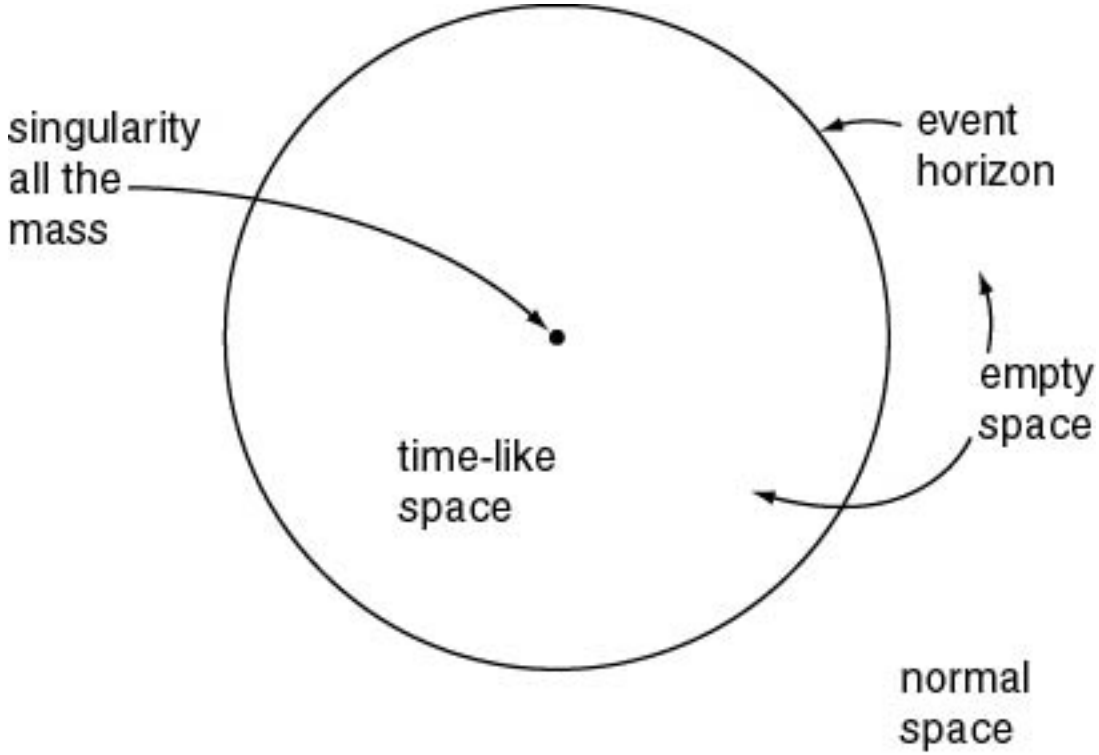
 Black holes can explode

Goal:

To understand the nature of time-like space inside a black hole.

§ 8 Time-like Space

Figure 9.1

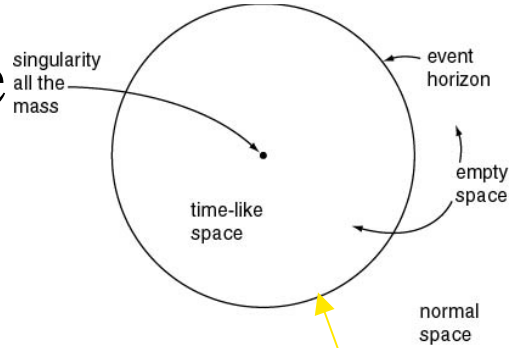


"Time-like" space forces motion in one direction. Space moves faster than the speed of light compared to a distant observer; the real reason black holes are black.

Goal:

To understand the full space-time associated with non-rotating black holes.

Non-rotating Schwarzschild Black Hole



Mass, but no spin, no electrical charge

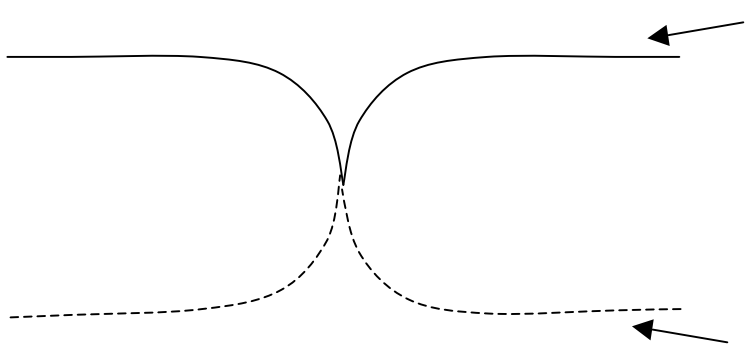
Assume all mass is in the singularity, no mass anywhere else (assumption necessary to solve equations)

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

Slice of embedding diagram



Somewhere else in hyperspace

Goal:

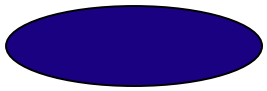
To understand the full space-time associated with rotating black holes.

Rotating Kerr Black Hole

Mass and spin, but no electrical charge

Assume all mass is in the 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!

(implicitly spread through hyperspace)