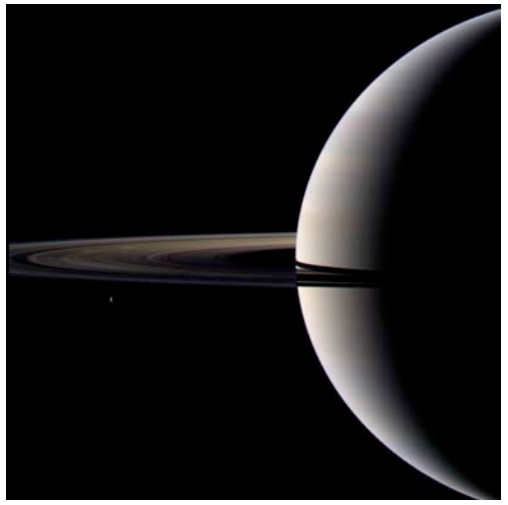
Tuesday, November 10, 2009

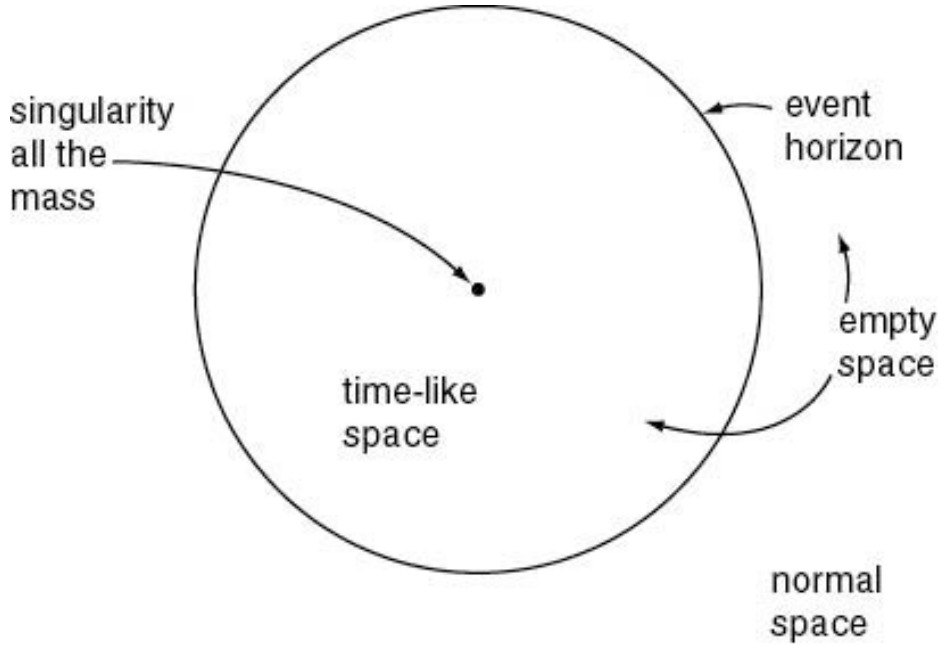
Third Exam Thursday, Chapters, 8, 9. Review Sheet Posted

Review Wednesday, 5:00 PM Room WEL 2.308
Chapter 8: 8.1, 8.2. 8.5, 8.6, 8.7, 8.10
Chapter 9: all except 9.6.3, 9.6.4

Astronomy in the News?

Pic of the Day - Saturn and its rings
from the Cassini spacecraft





Einstein's theory does not incorporate any of the tenets of the quantum theory.

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

affect behavior of electrons in atoms - measured to high accuracy

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

One particle in a pair can be swallowed, the 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.

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.

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).

§ 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, 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.

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

↘ 2 BH -> 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 (Hawking) or maybe it is still somehow in the singularity (string theory).

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

One Minute Exam

According to Stephen Hawking:


Black holes are totally black

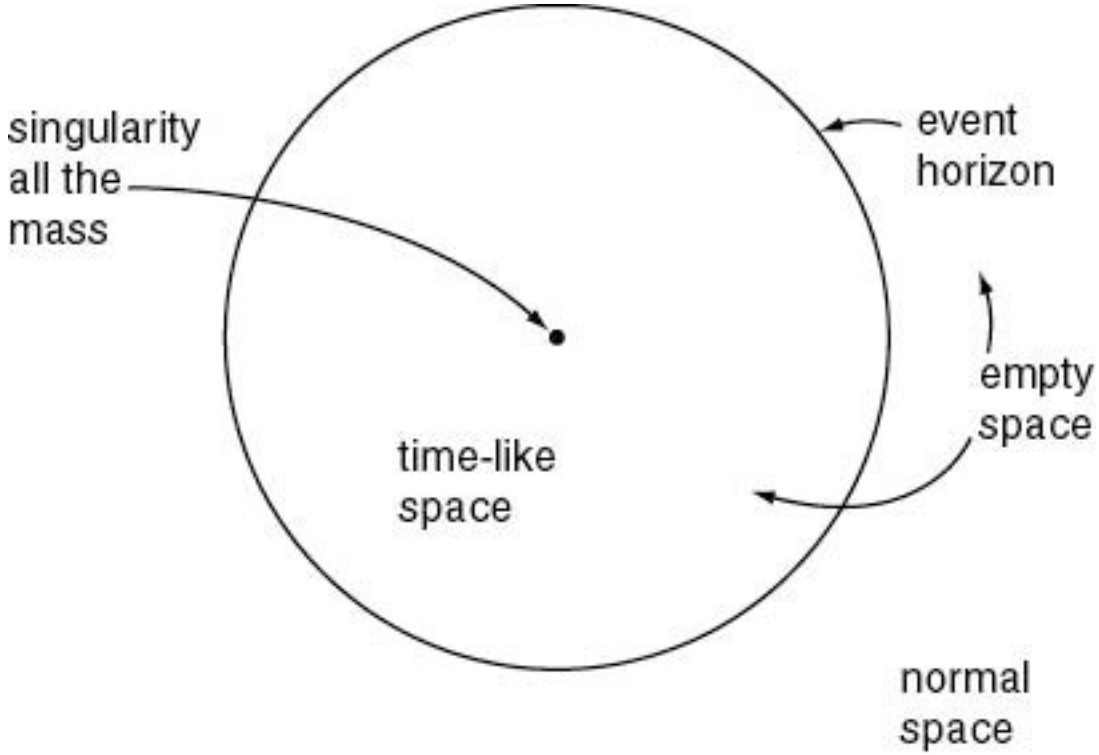

Combining a neutron star and an anti-neutron star will make a black hole


A singularity is a point


Black holes can explode

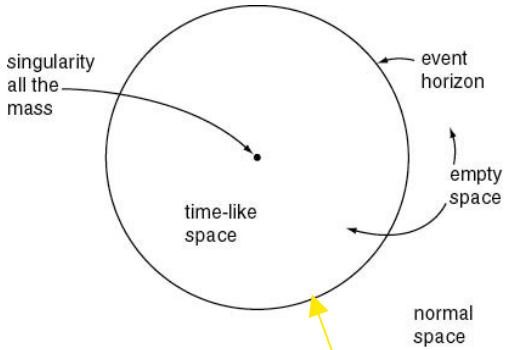
§ 8 Time-like Space

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.

Non-rotating Schwarzschild Black Hole



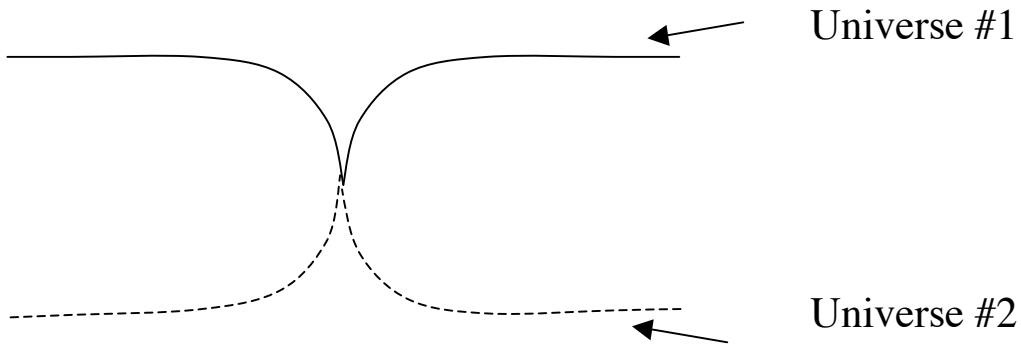
Mass, but no spin, no electrical charge

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

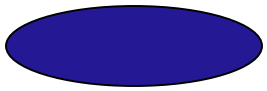


Rotating Kerr Black Hole

Mass and spin, but no electrical charge

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

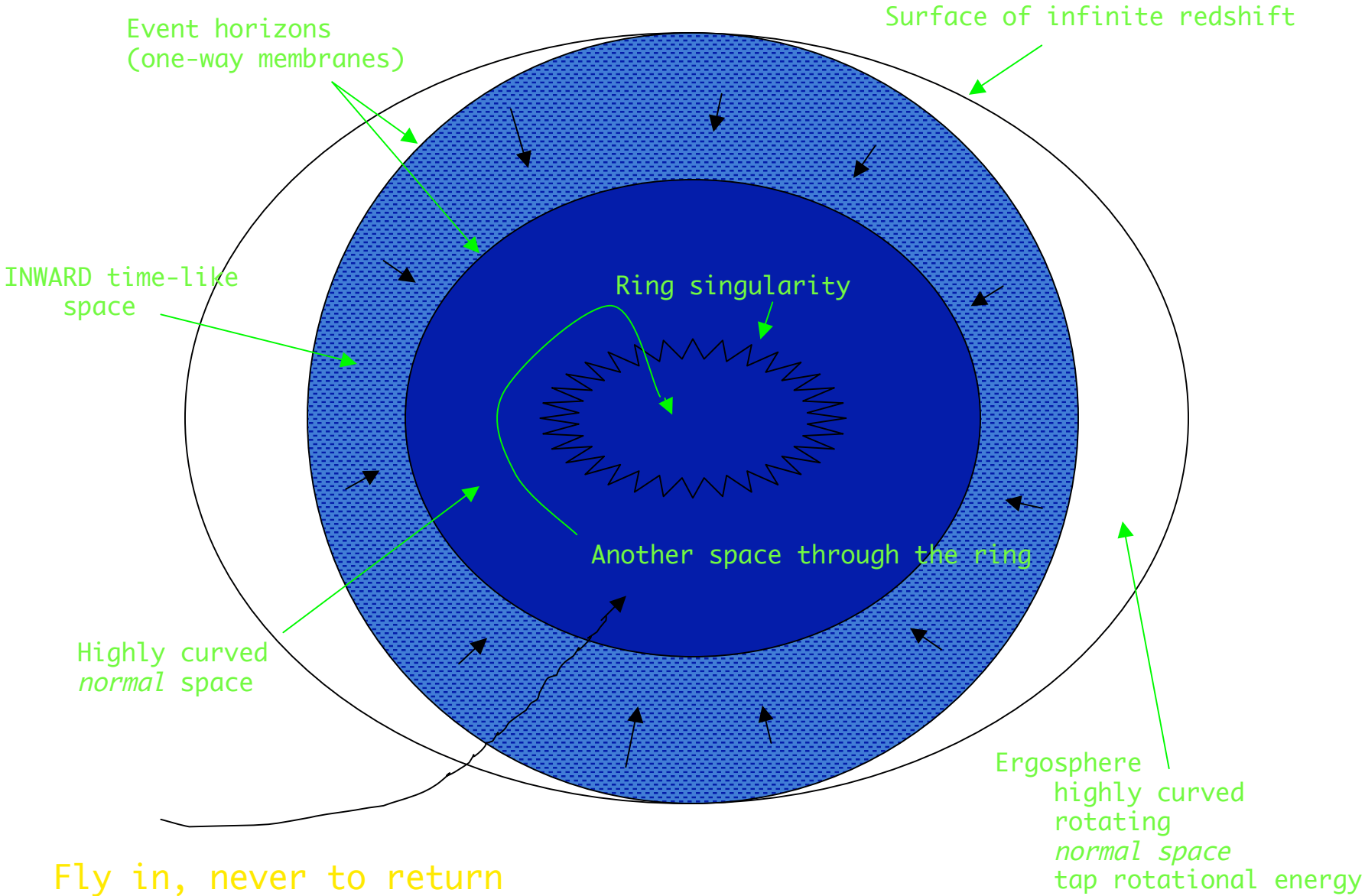
Find ***singularity is a ring*** (not a point)



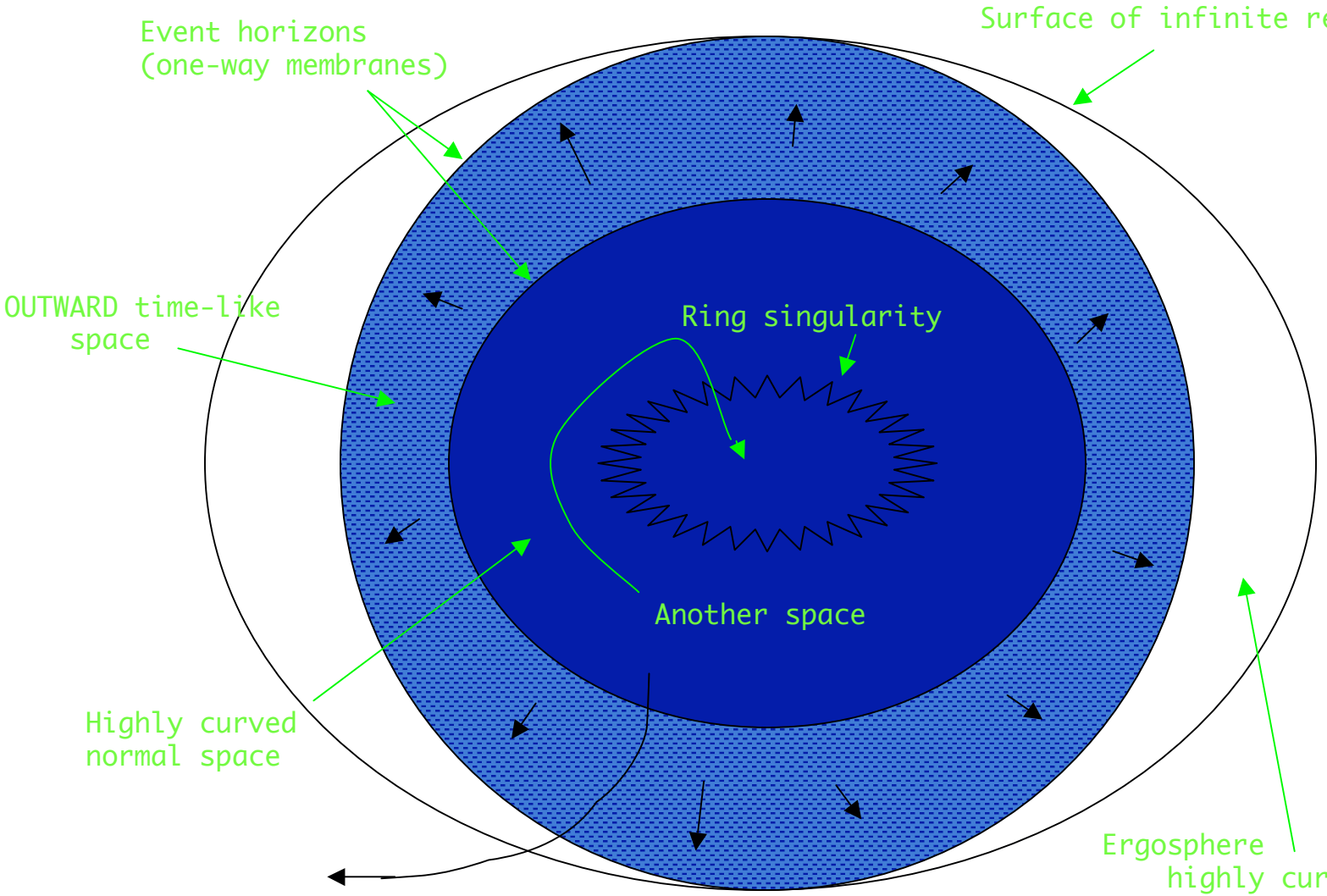
0 thickness, ∞ density, still uncertainty problem

Infinite Universes!

Cross-sectional view of rotating Kerr black hole



In future



Access to Universe different
than original one

Are Different Universes Real?

In Real Universe:

Light falls into the black hole

Photons are Doppler blue shifted, accelerated to higher energy, compacted into a thin shell: ***Bluesheet***

the blue sheet warps the space

changes the mathematical, hence the physical solution

So, probably not in this case, but stay tuned…

One Minute Exam

In the mathematical solution for a rotating black hole:

The surface of infinite redshift is identical to the event horizon.

You can escape the black hole back to the universe from which you entered.

There are exactly two universes.

The space entered through the ring singularity is different than the space surrounding the singularity.

END OF MATERIAL
FOR TEST 3