Friday, April 18, 2014

Exams returned, key posted

Fifth exam and sky watch, FRIDAY, May 2.

Reading for Exam 5: Chapter 9 – Sections 9.6.1, 9.6.2, 9.7, 9.8; Chapter 10 - Sections 10.1-10.4, 10.9; Chapter 11 - all except Section 11.6 (abbreviated, focus on lectures); Chapter 12 - all; SKIP Chapter 13; Chapter 14 – all

Astronomy in the news:

Kepler 186f (fourth planet + the star) is the first to have the mass and radius of the Earth and to be in the habitable zone where there could be liquid water. Host star is a red dwarf about half the mass of the Sun. Planet is "Earth Cousin" if not Earth Twin.

Evidence for the Universe when it was a trillionth of a trillionth of a trillionth of a second old may be marred by intervening dusty supernova remnants. Stay tuned.

Update on new “nearby” supernova SN 2014J in M82

I’m proof reading a paper led by an Italian colleague working in Munich on the polarized light from the supernova. We hope to submit next week and beat rumored competition.

Are different universes in Schwarzschild and Kerr solutions to non-rotating and rotating black holes real?

In Real Universe:

Light (at least!) falls into the black hole

Photons are Doppler blue shifted, accelerated to higher energy, compacted into a thin shell: ***Bluesheet***
=>the energy/mass of 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.

The story so far:

Look up at the sky and wonder about the stars.

Betelgeuse is a red supergiant about to collapse.

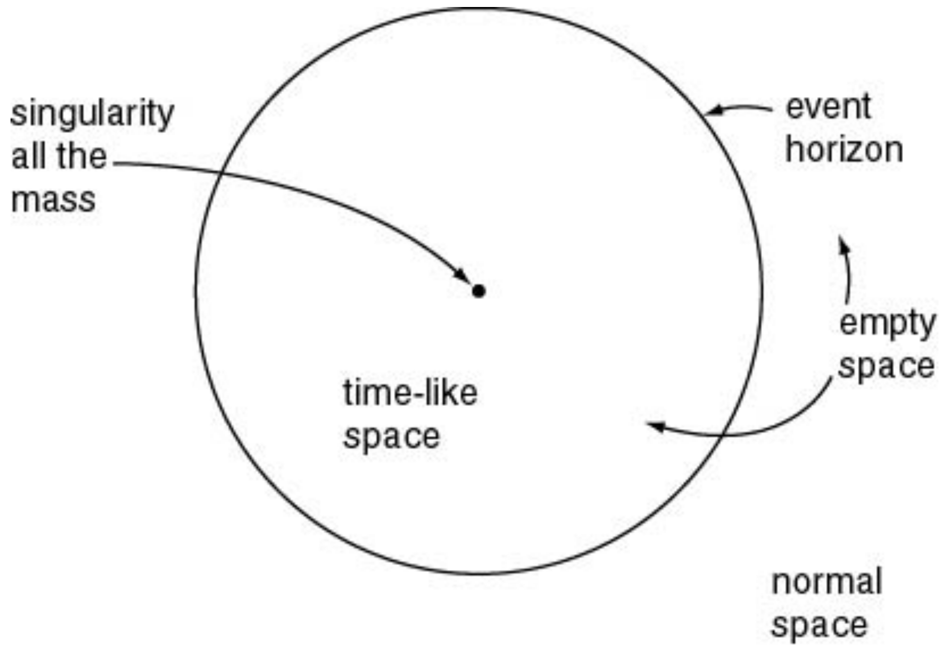
Collapse can lead to supernova explosions and the production of neutron stars, but also of black holes.

Black holes are predicted by Einstein to have a singularity, infinite density, infinite tidal forces, the end of space and time.

We need a new all-embracing Quantum Gravity to know what the "singularity" really is.

Goal:

To understand the conflict between Einstein’s theory of gravity and the Quantum theory.



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**.

Goal:

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

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
=>affects 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 off 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 may come out in a very precise form…

According to Hawking, 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 (13.8 billion years).

As mass $\downarrow$ T $\uparrow$

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

Small mass black holes can disappear within the age of the Universe, ending in a final explosion of gamma-ray radiation.

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

§ 9.7 Fundamental Properties of Black Holes

According to Einstein, 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 the information is in the Hawking 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.***

The problems get ever deeper.

With *quantum entanglement*, you can't cleanly differentiate the observer who watches the volunteer turn black at the event horizon and the volunteer who rapidly plunges in and dies. With Hawking radiation, the volunteer may hit a blazing "firewall" and die that way.

Hawking recently suggested that maybe event horizons are not permanent.

Total confusion in physics as to the correct way to think about all this.

Thinking about black holes remains on the intellectual frontiers.

A proper theory of quantum gravity may reconcile these issues.

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…