Wednesday, May 2, 2012

Wheeler office hours today 5 – 6 pm

Fifth Exam, Friday, May 4

Fifth sky watch due. You can do any object mentioned throughout the term that you have not done before.

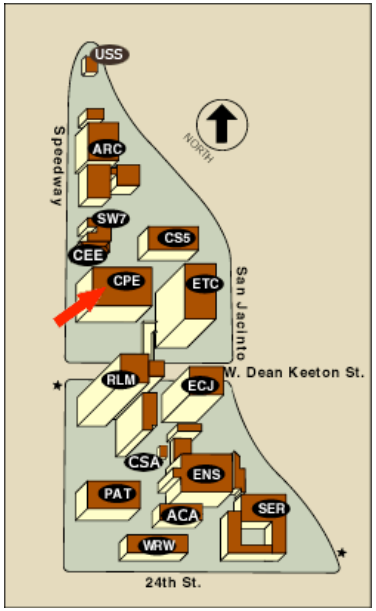
Review sheet posted.

Review Session Thursday, 5 – 6 PM, CPE 2.214

Reading: Chapters 11 (omit 11.6), 12, 13, 14

Electronic class evaluations. Please respond. This feedback is very valuable to me and to the TAs.

Astronomy in the news?



News:

Goal:

To understand how the notion of a large 4^{th} dimension led to notions of multiverses and what string theory has to say about black holes and information.

New insight: (Lisa Randall 1999) - Can have ***large extra dimensions*** and gravity will still leak only a little into those extra dimensions, still weaken very nearly as $1/r^2$. Had assumed extra dimension was "flat" - it needn't be.

Our 3D Universe could be a 3D brane in a large, extended, 4D bulk

Brane World cosmologies: exploring the theoretical possibility that our Universe is a 3D brane "surrounded" by a 4D bulk, with 6 wrapped-up dimensions, plus time

More Brane World ideas:

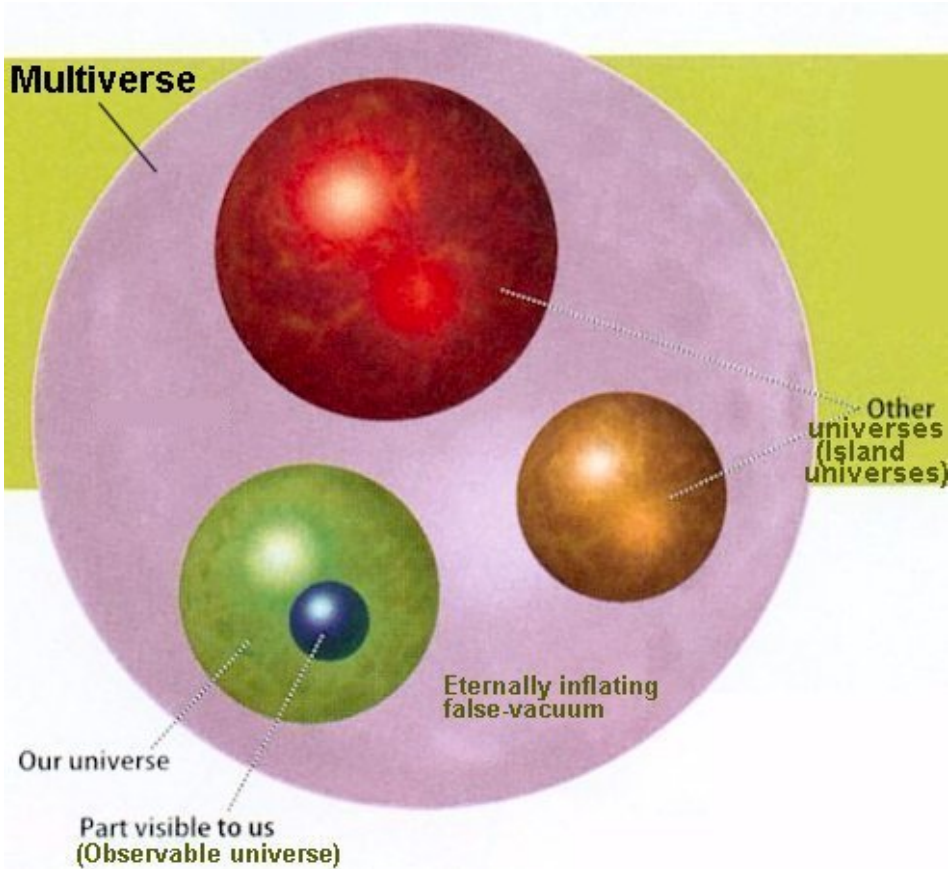
Singularity in black holes, quantum foam ⇒ nested "loops" of strings?

The 4D Bulk: is this where our Universe curves to when it curves, expands to when it expands – Maybe…

Is the Dark Energy that drives the acceleration of the Universe some manifestation of a "nearby" 3D Universe only a little distance away from our Universe in the 4D bulk?

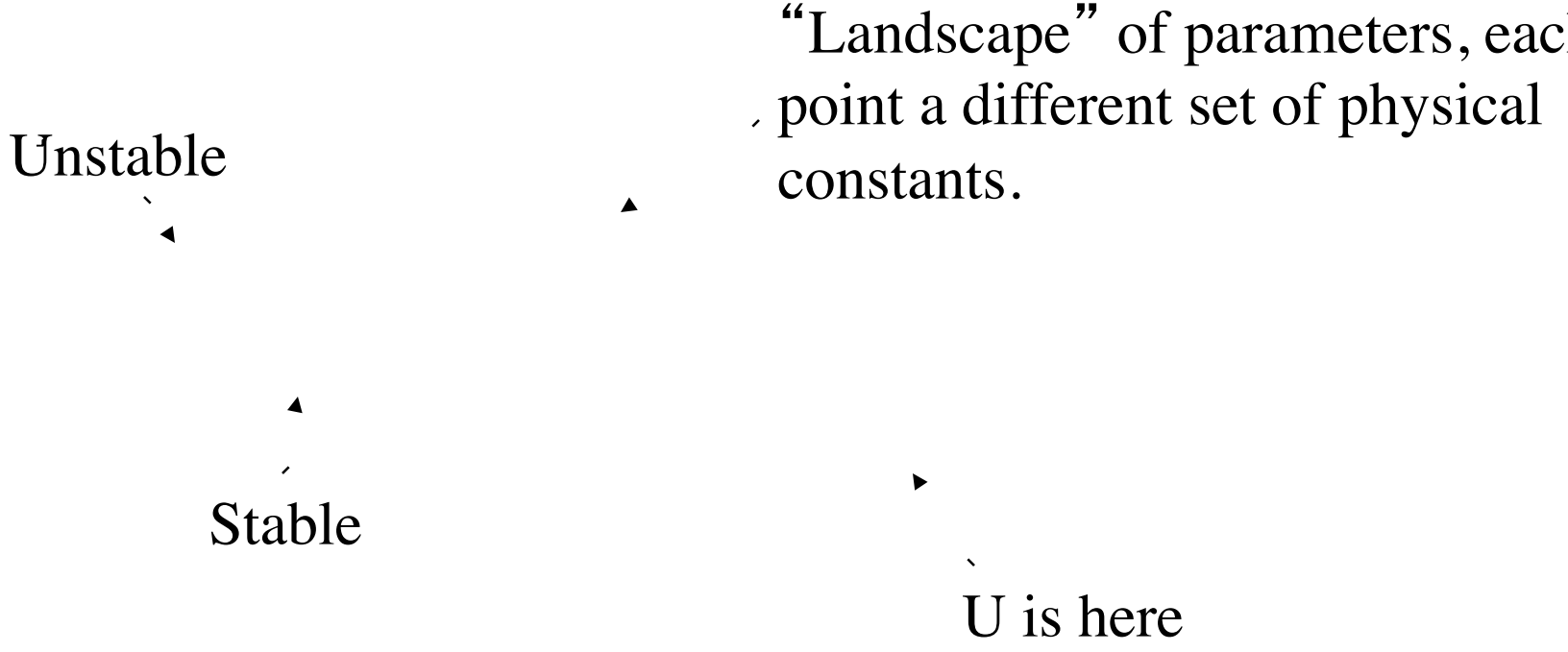
More current ideas:

The Multiverse - the idea that there could be many 3D universes separated in 4D hyperspace.



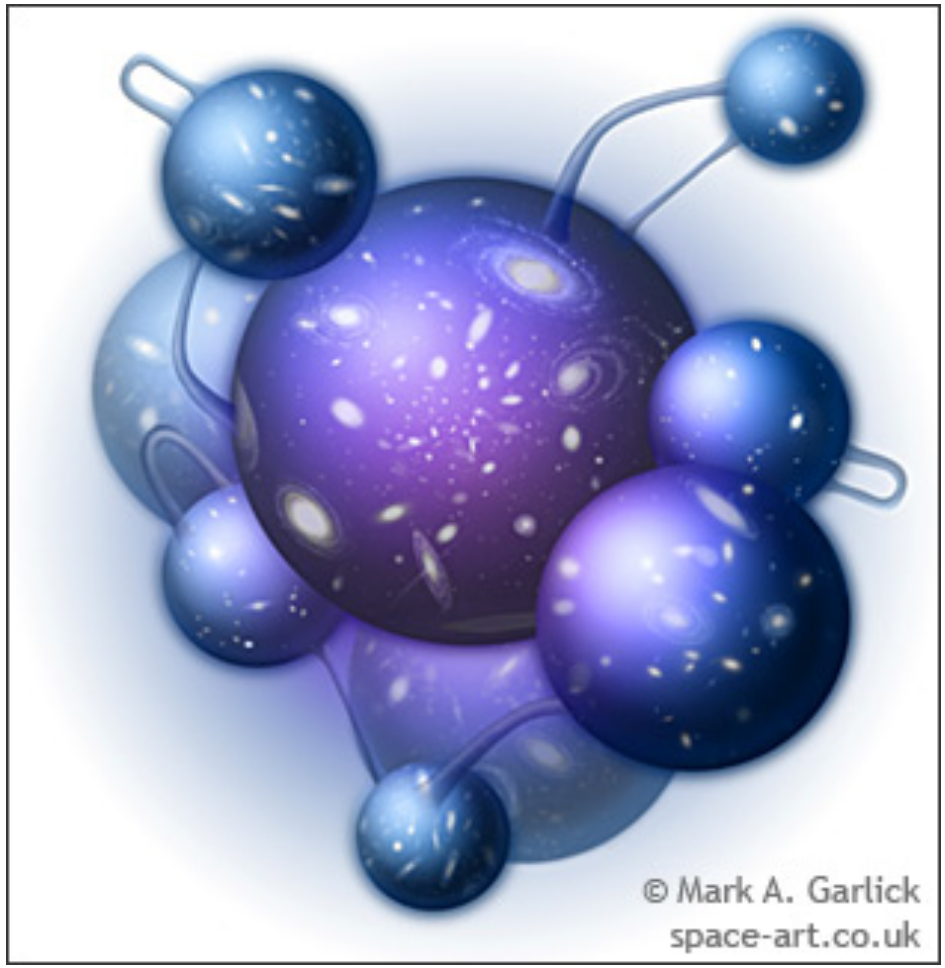
The String Landscape - current estimates are that string theory might provide 10^{500} different solutions, "universes," each with a different set of values of the physical constants, speed of light, the gravitational constant, Planck's constant that determines the size of quantum uncertainty, Einstein's Cosmological Constant, masses and charges of particles.

Only some universes could make stars, galaxies, and life.



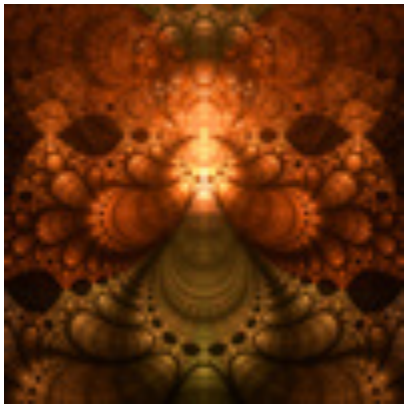
Bubble Universes - the individual universes created from the parameters of the String Landscape that populate the Multiverse.

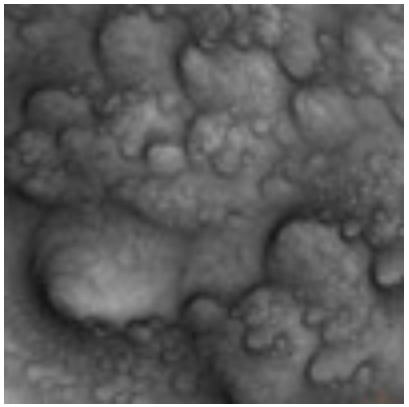
One idea: when a black hole forms a "singularity" in one universe, a new universe is born "elsewhere" in hyperspace.

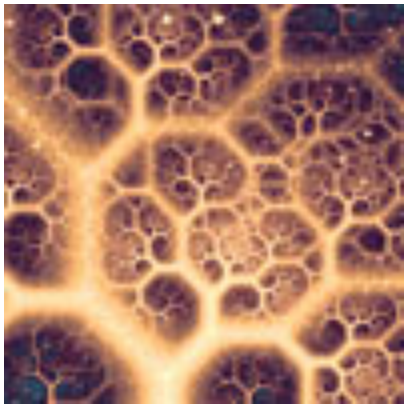


Eternal Inflation - the notion that new bubble universes are constantly being born, "inflated" from the quantum foam or stringy space-time.

Chaotic Inflation - a variation on eternal inflation in which new bubble universes are constantly being born and the multiverse is fractal on large scales.







Latest String Landscape idea:

10^{500} different solutions is a lot, but if the universe is infinite, then every solution must be repeated an infinite number of times.

$\Rightarrow$ An exact copy of us is having this lecture elsewhere in hyperspace.

Can you spot a potential flaw in this argument?

New insights into information

Derivation of the temperature of a black hole from string theory got exactly Hawking's answer.

But string theory is a quantum theory and exactly preserves information.

The implication is that Hawking was wrong that information is destroyed in a black hole and that black holes have only mass, charge and spin.

The information must be retained in string vibrations **at the event horizon** (not within the black hole).

Surfaces are the true repository of information, not volumes.

In a hologram, the information is stored as patterns on a 2D surface. With exposure to a laser, a 3D representation of the 2D information can be restored.

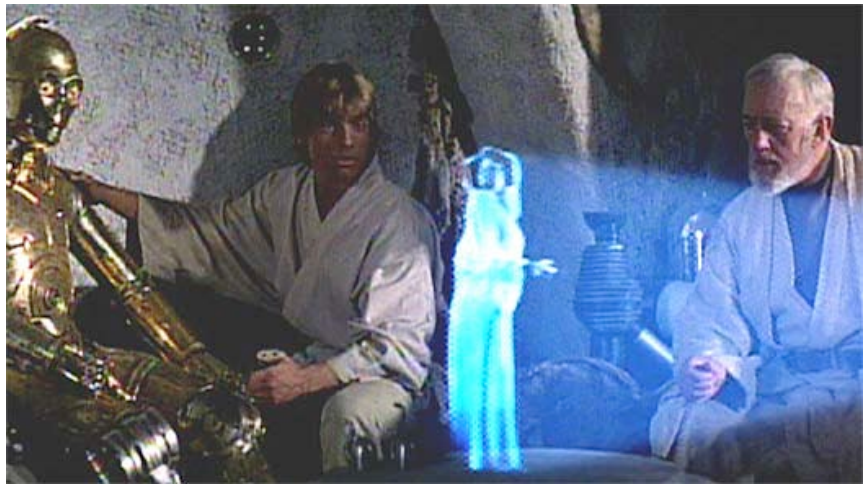
All this led to the idea that we live in a ***Holographic Universe***.

The Holographic Universe - the notion that the real information content is imprinted in quantum bits on the surface, the event horizon, of the observable universe.

What we regard as the physics (and chemistry and biology) in our 3 dimensions, is fundamentally set and controlled by information and physics on the 2D surface around us.

Closely related to the understanding that the information of what fell into a black hole is retained in string vibrations at the event horizon surface of a black hole.

We are just 3D hologram projections from the 2D surface.



The origin of space and time

In principle, a true "theory of everything" should tell us the nature of space and time.

String theory assumes the existence of 10 dimensional spaces and time, so the fundamental question of how and why space and time exist remains elusive.

Is this real, or just mathematical fantasy?

Must be able to test: Physicists are straining to devise such tests.

Does gravity behave a little differently than $1/r^2$, for instance like $1/r^{2.0001}$, that would be hint of higher dimensions?

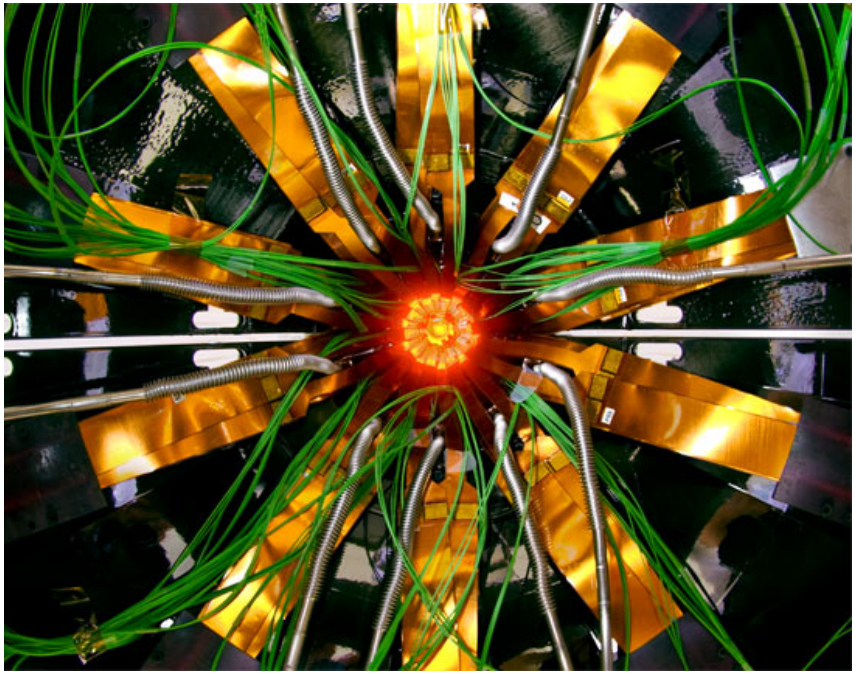
Curved space near event horizons of black holes might be different than standard Einstein gravity - can that be measured with X-rays?

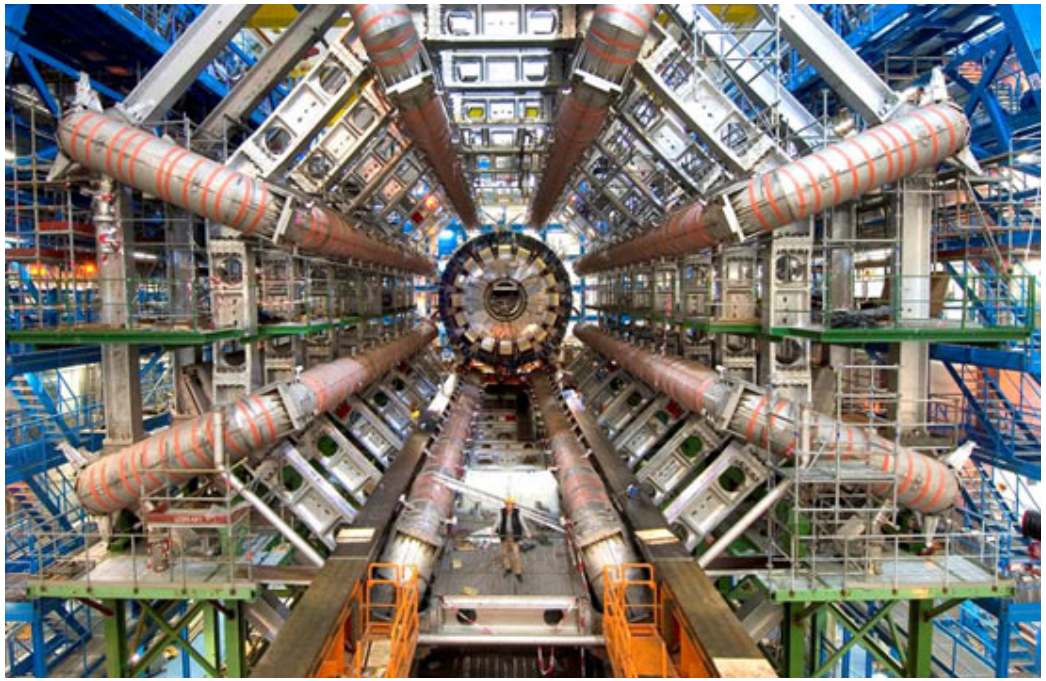
Interactions in particle accelerators could be different if some energy disappears into the 4D bulk (as closed string gravitons).

The Large Hadron Collider (LHC) at CERN, near Geneva, is beginning to operate. Strong expectation that evidence for new physics, confirming or denying string theory ideas, will be seen.

Not yet, the physics community is holding its collective breath…

The New **Large Hadron Collider** at CERN in Switzerland may see the first hints of extra dimensions.





Take Away Message:

Hyperspace might be real…

Stay tuned!

(and remember to keep an eye on Betelgeuse!)