

May 4, 2011

Exam 5, Friday. Review Thursday, 5 – 6 PM, room WEL 1.308.

Review Sheet posted.

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

Reading: Chapters 12, 13, 14

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

Astronomy in the news:

Pic of the day: Globular star cluster M15.
May host black hole in the center.



We failed to record some grades for 4th sky watch. Please check your grade online. If it is incorrect, return your sky watch and we'll fix it.

If you have a “zero” but did a skywatch, please return it.

The grades are written in the lower right hand corner of the first page.

Goal:

To understand why physicists argued that any “extra” dimensions had to be tiny and wrapped up, how that restriction was removed, and what that means for our view of the Universe.

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

Example: Ekpyrotic Theory (Greek *ekpyrosis* = conflagration)

Two 3D branes collide in 4D bulk

hot, dense “Big Bang” but not infinite density

no singularity

different gravity waves than standard “inflation” theory - could be a test.

More Brane World ideas:

Singularity in black holes, quantum foam \Rightarrow nested “loops” of strings?

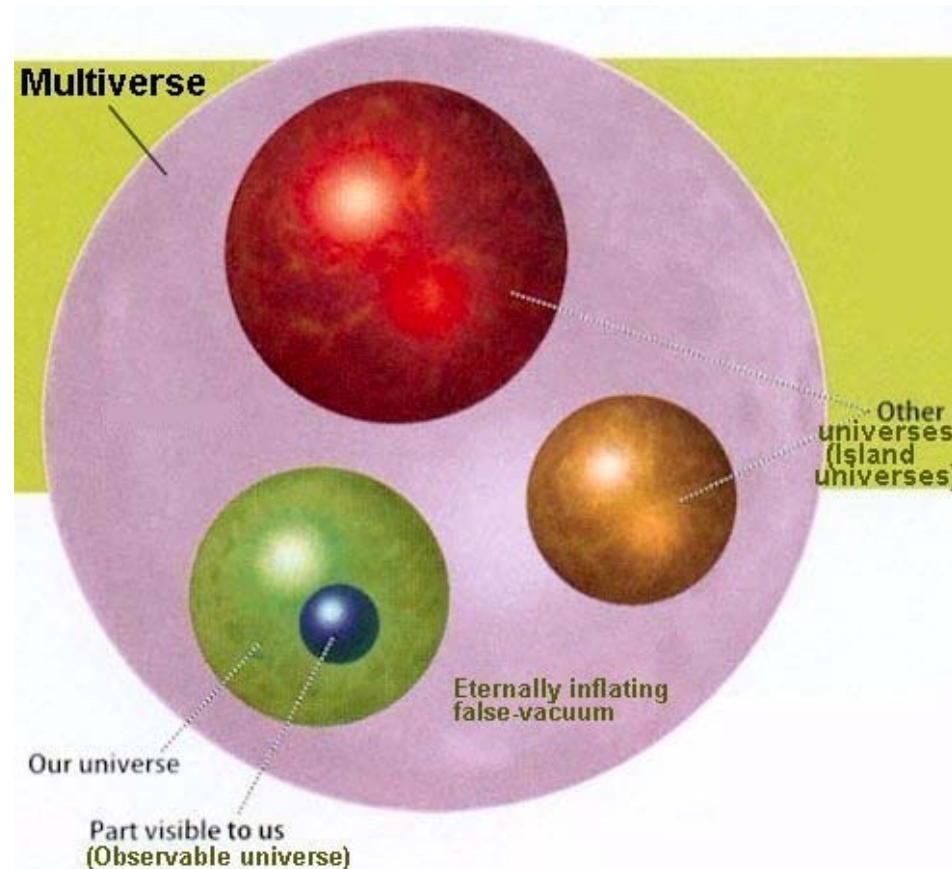
The 4D Bulk: is this where our Universe curves to when it curves, expands to when it expands - Maybe...

Bubble Universes: When a black hole forms a “singularity,” does a new Universe spring into existence “elsewhere” in 4D hyperspace?

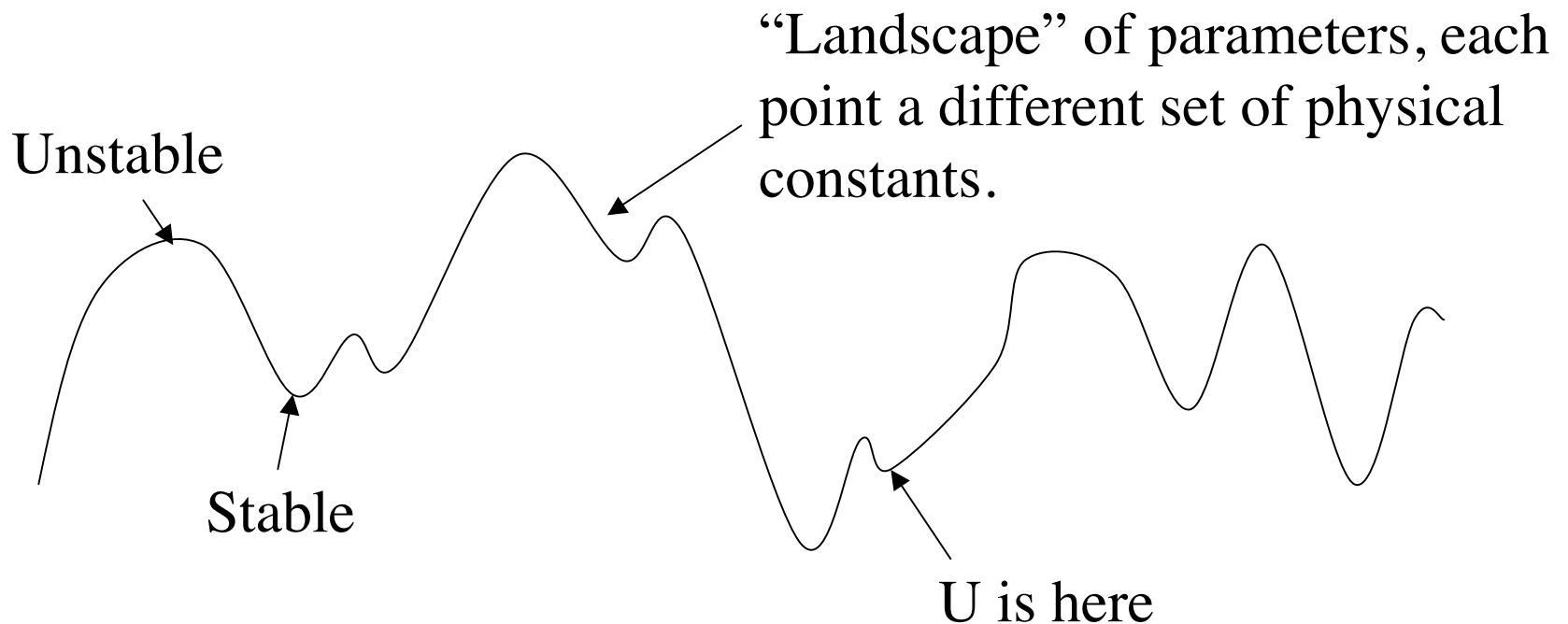
Is the Dark Energy that drives the acceleration of the Universe some manifestation of a “nearby” 3D Universe only a little distance away from our Universe in the 4D bulk?

More current ideas:

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

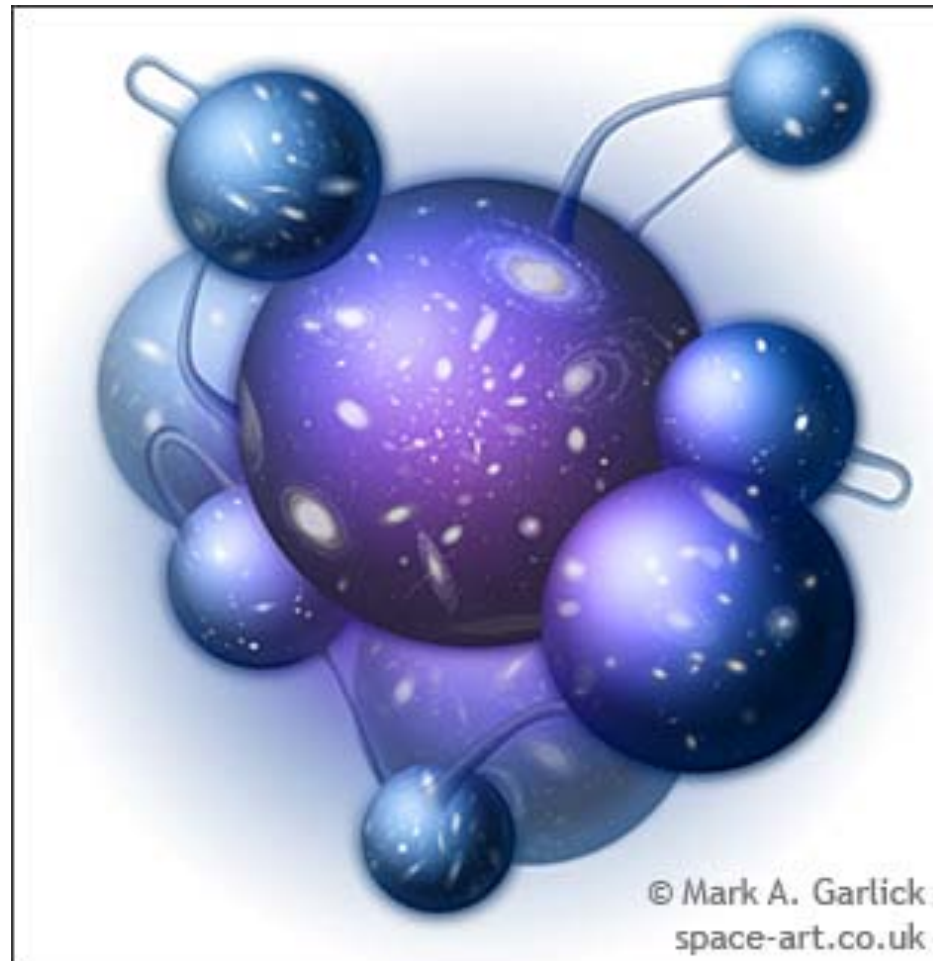


The String Landscape - current estimates are that string theory might provide 10^{500} different solutions, “universes,” each with a different set of values of the physical constants, speed of light, the gravitational constant, Planck’s constant that determines the size of quantum uncertainty, Einstein’s 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.

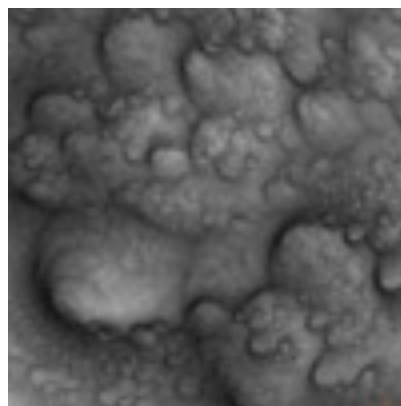
One idea:
when a black
hole forms a
“singularity”
in one
universe, a
new universe
is born
“elsewhere” in
hyperspace.



© Mark A. Garlick
space-art.co.uk

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.



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.

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.

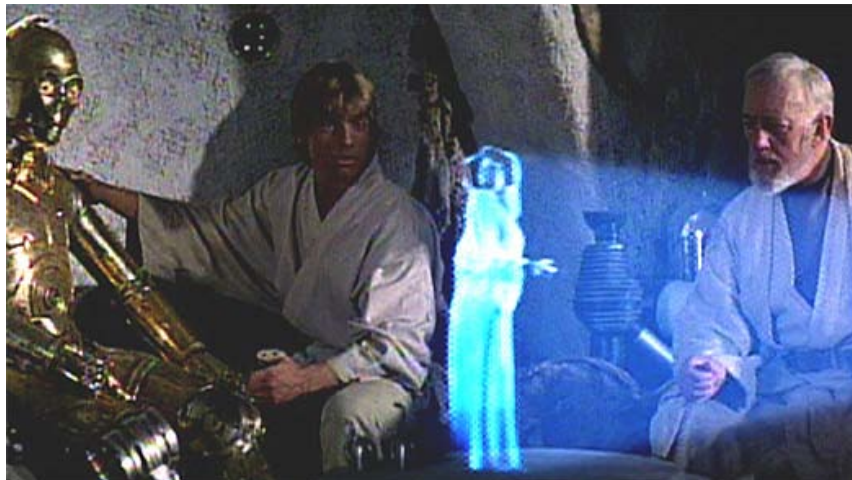
All this led to the idea that we live in a *Holographic Universe*.

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.

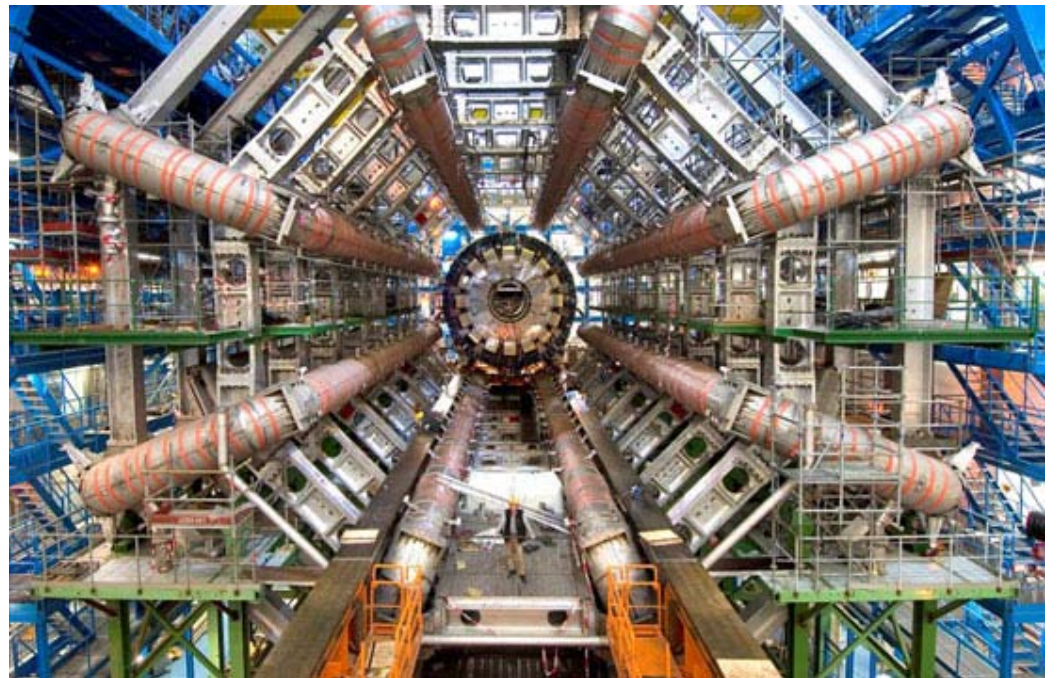
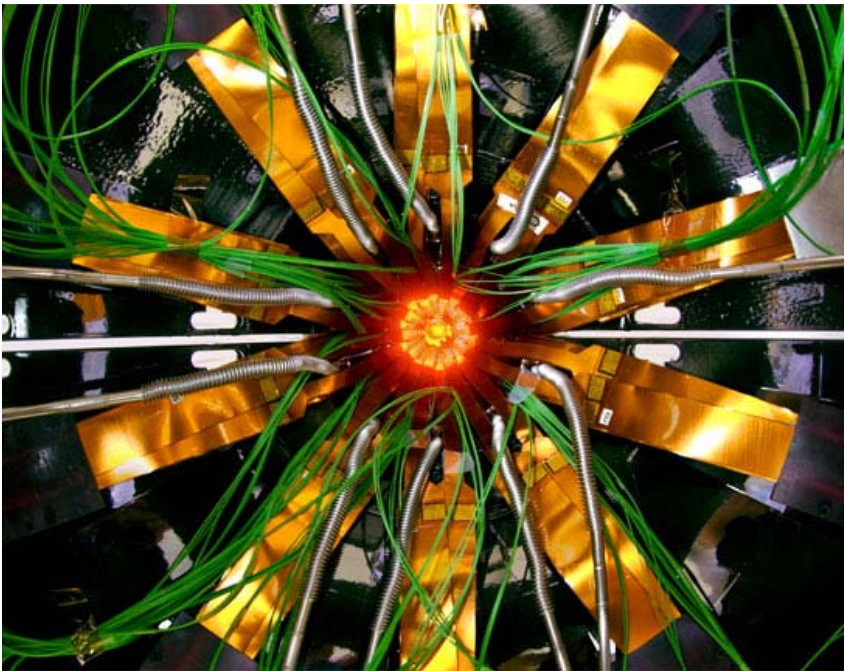
Does gravity behave a little differently than $1/r^2$, for instance like $1/r^{2.0001}$, that would be hint of higher dimensions?

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.

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.

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!)