4/30/2008

Fourth, Last Exam, This Friday, May 2

Review sheet posted, review Thursday, 5 PM RLM 15.216B

Reading: Chapter 11 - all except 11.6, 11.7, Chapters 12, 13, 14 - all

Fourth and last SkyWatch extra credit due by Sunday midnight.

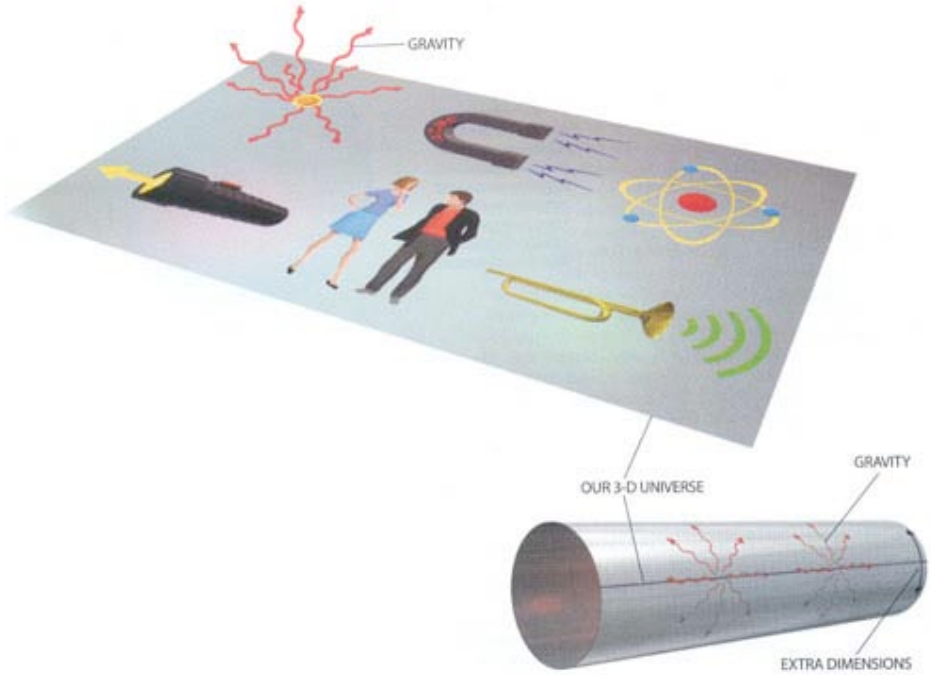
Astronomy in the News - Friday, 3:00 P.M. WEL 2.224, Kip Thorne, Feynman Professor of Theoretical Physics, California Institute of Technology "The Warped Side of the Universe: From the Big Bang to Black Holes"

Pic of the day - colliding galaxies

In this picture, ordinary forces, electromagnetism, nuclear forces, correspond to “open” strings that have ends stuck on the 3D brane,

These strings cannot “go” into the 4D bulk, we cannot “see” the 4D bulk.

Balls on 2D brane, sound into 3D bulk



Gravity corresponds to closed loops of strings that are not stuck on the brane, they can float off into the bulk, but in a way that gravity still weakens very nearly like $1/r^2$.

One minute exam

In string theory, our Universe is pictured as a

A) 2 brane

B) 3 brane

C) 10 brane

D) 3D bulk

One minute exam:

If gravity reached into the 4D bulk as easily as it penetrates our ordinary three-dimensional space, then it would get weaker with distance from the source as

A) $1/(\text{distance})^2$

B) $1/(\text{distance})^3$

C) $1/(\text{distance})^4$

D) Our 3D brane expands

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: Ekypyrotic Theory (Greek *ekypyrosis* = conflagration)

Two 3D branes collide in 4D bulk
hot, dense "Big Bang" but not infinite density
no singularity
different gravity waves - could be a test.

Brane world ideas:

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

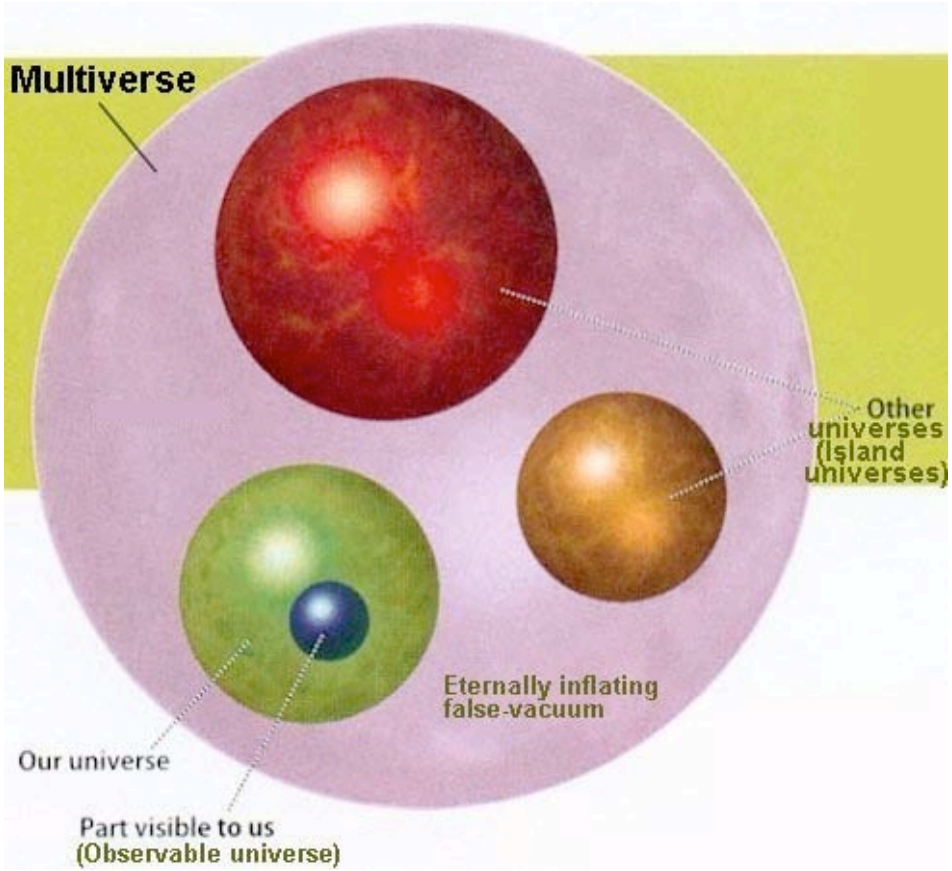
The 4D Bulk: is this where our Universe curves to when it curves, expands to when it expands - Maybe…

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

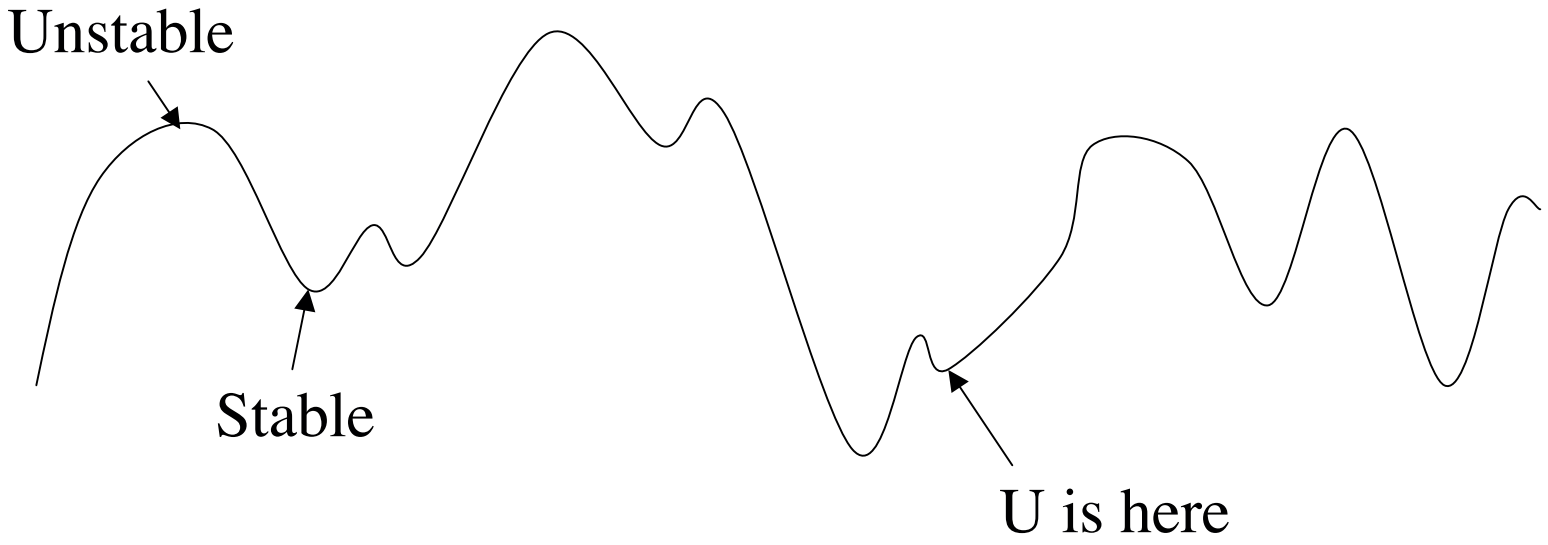
Is the Dark Energy that drives the acceleration of the Universe some manifestation of a "nearby" 3D Universe only a little distance away from our Universe in the 4D bulk?

More current ideas:

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

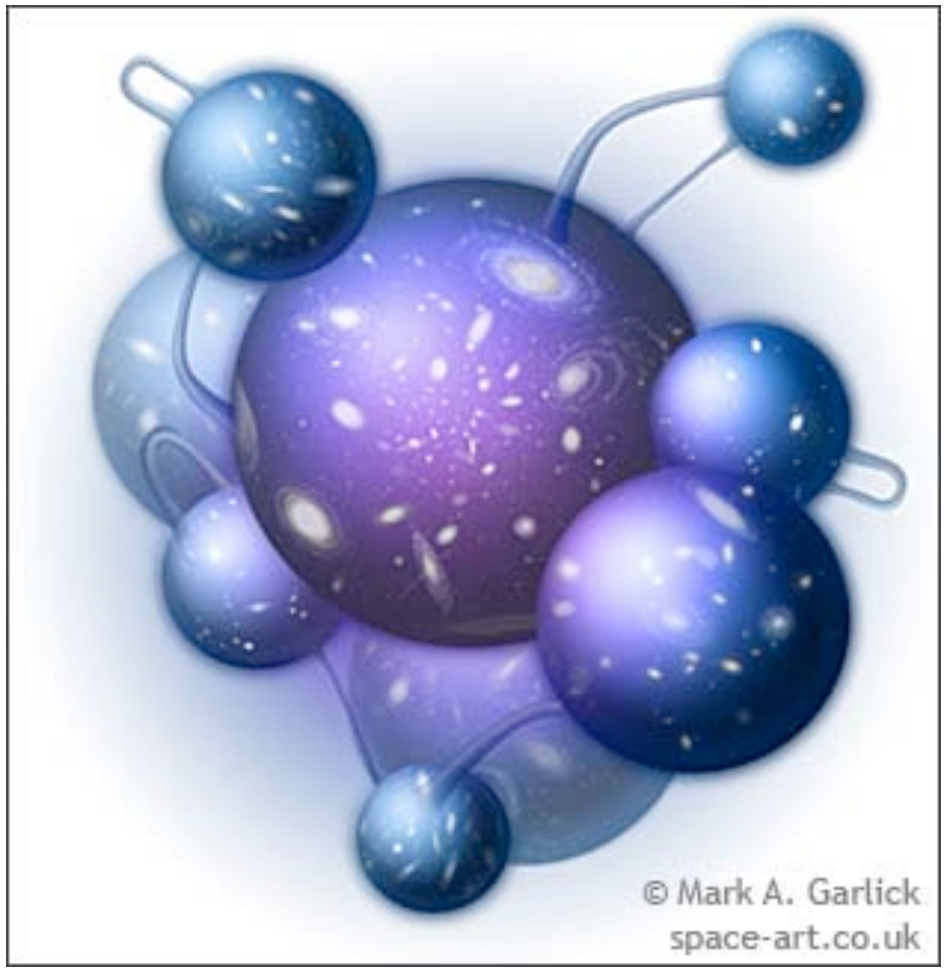


The String Landscape - current estimates are that string theory might provide 10^{500} different solutions, "universes," each with a different set of values of the physical constants, speed of light, the gravitational constant, Planck's constant that determines the size of quantum uncertainty, Einstein's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



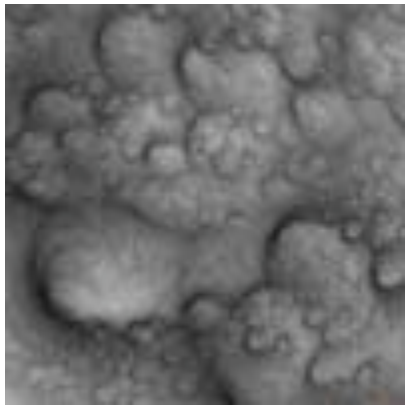
Bubble Universes - the individual universes created from the parameters of the String Landscape that populate the Multiverse.

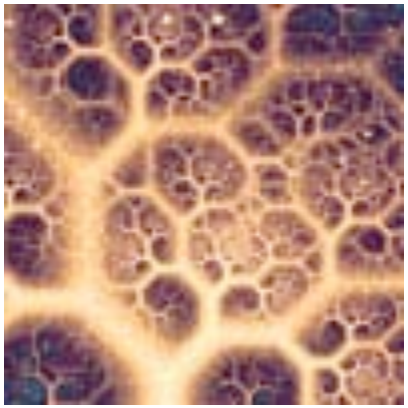
One idea: when a black hole forms a singularity in one universe, a new universe is born "elsewhere" in hyperspace.



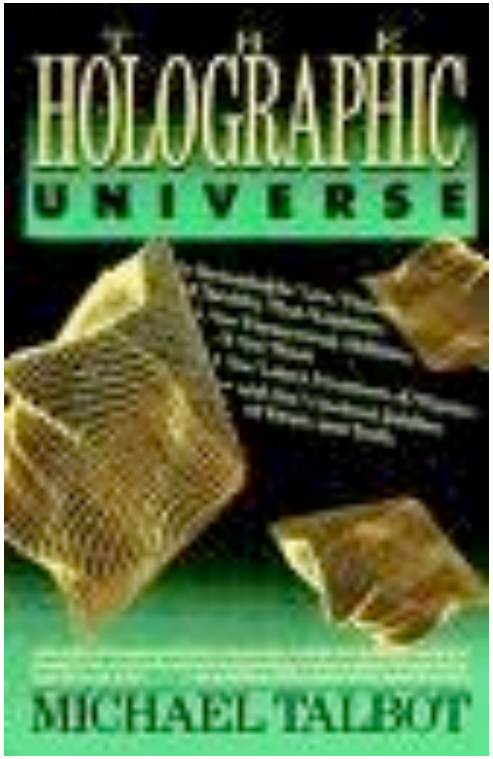
Eternal Inflation - the notion that new bubble universes are constantly being born, "inflated" from the quantum foam or stringy space-time.

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





The Holographic Universe - the notion that the real information content is imprinted in quantum bits on the surface of the observable universe (we are just 3D hologram projections from the 2D surface, or that our 3D physics is the projection of quantum gravity, string theory, from the 4D bulk (we are the hologram on the credit card).



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) under construction at CERN, near Geneva, will begin to operate in 2008. Strong expectation that evidence for new physics, confirming or denying string theory ideas, will be seen.

Take Away Message:

Hyperspace might be real…

Stay tuned!

(and remember to keep an eye on Betelgeuse!)