

Tuesday 3/31/09

Agenda

- Announce:
 - Observation when? 8pm
- String Theory Cosmology
- LQG Cosmology
- Holographic Universe
- Last Installment of Elegant Universe
- 4pm Solar Observation
 - Graph
 - Uncertainty
 - What questions to answer?

String Theory

- Everything can be broken down to strings
- Strings are fundamental...can't be broken
- Small....about 10^{-33} m
- Strings of what?
- Different particles arise from different "notes" on strings
- String theory has a spin-2 particle...ended up being gravity
 - Turned string theory from a theory of the strong force to a theory of everything
 - Reconciles gravity with quantum mechanics
- Requires "extra" dimensions which are somehow hidden
- The "shape" of the extra dimensions determines the physical constants of our Universe...ties into cosmology

String Theory...The controversy

- Predictions of course match what we have observed (low energies)
- Predictions at high energies can't be tested!
- Is it science?
- Contributed to various ideas somewhat independent of string theory...extra dimensions, AdS/CFT/holography

String Theory Cosmology

- Theorists had hoped to find one shape for the extra dimensions to match our Universe
- Instead they found 10^{500} !
- The fix:
 - Combine string theory with eternal inflation
 - And use anthropic argument

Multiple Universes

- These come up when thinking about our Universe:
 - Is it unique?
 - Could it have been different?
- To understand, follow these questions:
 - How do we define our Universe?
 - What does it mean not to be in our Universe?

Could our Universe be Different?

- Think about the whole realm of possible Universes...
- In how many could an intelligent lifeform develop to question its existence?
- If we were to increase the mass of the electron, galaxies may not form, and universe wouldn't live long enough for life to form
- Anthropic Principle: The Universe is the way it is because otherwise entities such as ourselves couldn't exist.
- Universes that don't support life wouldn't be observed
- Does it predict anything? Just explain it? Is it science?

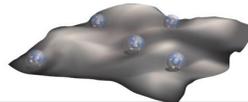
Eternal Inflation

- An inflaton field exists (the field which causes inflation)
- Inflaton "field" takes different values everywhere
- In some places/times, inflation takes place giving birth to a universe
- Across the "multiverse" many universes all with different properties

String Cosmology

- Eternal Inflation+String Theory: Huge multiverse which explores every possible shape of extra dimensions
- +Anthropic Universe: We just happen to find ourselves in one of the universes that is compatible with life!

- No predictive power



LQG

LQG

- Universe constructed from loops: "analogues of electric and magnetic field lines"
- Loops are the "atoms" of space
- Quantum mechanics applied to the loops → Quantum theory of space
- Space subdivided...can only hold limited amount of energy
 - avoids singularities
 - Gravity becomes repulsive at high energies → get inflation free!
- For very simple models, can extend universe back through the big bang...bounce model
- Quantum turmoil erases "memory" of past Universe
- Predicts frequency dependent effects on light (which must fit on space lattice)

Holographic Principle

- Hologram—2D "picture" of 3D object

- AdS/CFT Correspondence:

- Quantum gravity theory for AdS equivalent to an ordinary quantum theory on the boundary



Holographic Universe

- Perhaps Universe can be described by a lower dimensional theory
- Implications for BH support holographic principle in theory
- RHIC results...collisions of gold ions resembles fluids with low viscosity...may provide experimental support