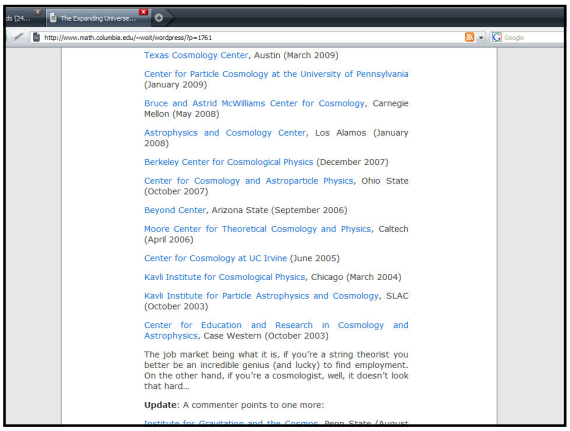
March 26, 2009

Astroparticle Physics & Beyond

Agenda

- Possible Observation Dates:
  - April 16, 21, 23, 28
- Return Test 2
- Discuss Project Part II…Due April 7
  - Email me
  - References
  - Controversy, your position, how you'll support it
- Solar Altitude Lab observations done w/ next sunny day
- Astroparticle Physics
- Particle Physics Detectors
- Grand Unification
- Arguing against the standard cosmology
- Elegant Universe Part II

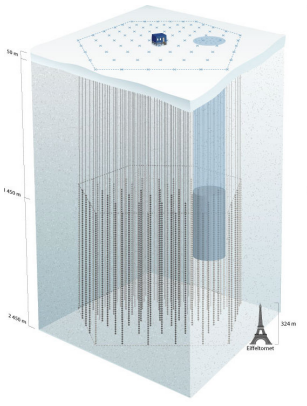


Astroparticle Physics

- Using cosmology and astronomy to understand fundamental particle physics
- And vice-versa
- Universe as lab:
  - Hotter and more energetic: Big Bang, BHs, cosmic rays
- Particle Accelerators as lab:
  - Controlled, repeatable environment

Other Particle Facilities

- Ice Cube Neutrino Observatory
- Neutrinos:
  - Only weakly interacting
  - Fast moving
  - Hard to detect
  - Small, but nonzero, mass
  - Produced in abundance astronomically

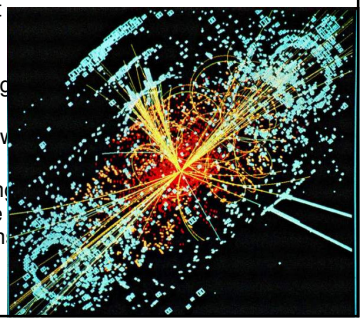


PAMELA

- Satellite which studies cosmic rays
- In particular, looks at antimatter particles, e.g. positrons
- Could be a sign of dark with its own antiparticle

LHC

- World's largetst particle accelerator
- 17 mile long ring near Geneva
- Broken right now
- Very small chance of seeing BHs if there are extra dimensions



Quantum Mechanics

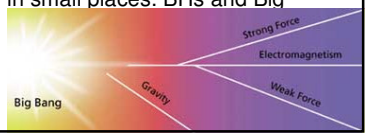
- Waves are particles: e.g. photons
- Particle are waves: e.g. electrons
- Universe described in terms of probabilities:
  - QM predicts very well tested probabilities
  - Limits what we can know about the Universe (allows for free will?)

Four Forces

- Strong
- Weak
- Electromagnetic
- Gravity

Holy Grail: Grand Unification

- Can unify the first three using QM
- Can't incorporate gravity
- Gravity and QM work great except where you need both:
  - High density in small places: BHs and Big Bang



GUTs

- Two main competitors:
  - Loop Quantum Gravity
  - String Theory
- Each says different things about cosmology

Arguing against the Big Bang

- Ad hoc introductions of dark things could explain any and everything
- Big Bang requires very low entropy to be consistent with Second Law of Thermodynamics
- Doesn't explain where Universe came from
- Arguing against Inflation:
  - No evidence for inflaton
  - Very hard to turn off at the right time
  - Requires a very particular state for beginning

Alternative to Dark Matter: MOND

- Modified Newtonian Dynamics
- For "normal" accelerations, just Newton's
- For very small accelerations, gives larger force
- Consistent with galactic rotation curves with *no* dark matter

Alternative to Inflation: Special State

- Inflation explains:
  - Seeds of structure
  - Horizon problem
  - Flatness problem
- But a bit ad hoc
- Instead, just say the Universe started in a near perfect homogenized, flat state with small density variations for structure formation

Alternative to Inflation: Ekpyrotic Universe

- Two "branes" collide
- Branes are 3D and move in another dimension
- Flatness: branes would settle in low energy state which would be flat
- Baryogenesis: brane's kinetic energy would create particles ala the Big Bang
- Structure formation: branes collide at slightly different times in different places

Read articles

- LQG bouncing universe
- Holographic principle
- Fate of Universe w/ expansion

Elegant Universe part II

- Motivation and development of string theory
- Promise of string theory
- Extra dimensions
  - Why don't we see them?
  - Why are they being looked for?