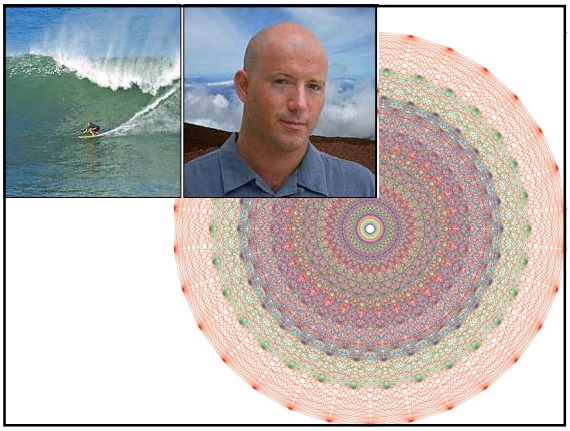
Monday, November 19, 2007

Vilenkin Chs: 4-6

Agenda

- Announce:
  - No Class this Wed (11/21)—Happy Thanksgiving
  - Read Part II (Chs 7-11)
- Surfer Physicist
- Project Reports
- Chs. 4-6



Project Reports

- Due Wednesday after Tgiving
- Bibliography
- Outline or Slides
  - with specific references for important points
  - Comment on
    - validity of any shaky references
    - Or authority of particularly good ones
- Looking for:
  - Understanding of topic…more than just a rephrasing of stuff in wikipedia…some sort of synthesis
  - Interest...either to you or us

The Big Bang

- Very dense
- Very hot…why/how do we know?
- What kind of particles in it? Why?
- Friedmann's solution gives temperature as a function of time
- As one goes back in time, energies become so hot theories start to fail
- Slight imbalance of antimatter/matter towards the matter side

Primordial Nucleosynthesis

- As Universe cooled, atoms could exist
- Proton + electron = hydrogen
- Proton+neutron+electron=deuterium
- Mostly hydrogen, some helium
- No stable 5 nucleon atom
- Various codes compute expected abundances of H, He, Lithium, etc
- Observations (of?) confirm expectations/predictions
- Heavy elements (heavier than He) produced in stellar explosions

CMBR

- Should have been expected from work of Gamow, Alpher, and Herman
- Experimentally found 15 years later by Penzias & Wilson (Nobel Prize) though they thought it just noise
- Dicke at nearby Princeton knew right away
- Blackbody radiation of Big Bang…same spectrum shape as that of Planck's formula
- 2.73 Kelvin

Structure Formation

- If perfectly homogenous, then it would remain so
- Where did "imperfections" come from?
- These "seeded" structure (galaxies, stars, etc)
- Gravitational instabilities from small inhomogenities
- First galaxies after 1 billion years
- Old galaxies small and irregular

Look for inhomogeneities in CMBR

- Can look back to surface of last scattering (300,000 years after big bang)
- Though spectrum looks like perfect 2.73 K spectrum…
- Actually if one looks carefully enough, one sees differences of 1 part in 10,000
- COBE, WMAP, Planck (future)

Why is the Universe so Homogenous?

- It would seem somehow all places in the Universe have been in communication even though they are widely separated
- How does one part of the universe "know" to be 2.73 K at the same time that the side does?
- (why are ice cubes not perfectly transparent…with facets?)
- Horizon Problem
- Do we just assume Big Bang perfectly homogenous?

Big Bang Issues

- Where did seeds of structure come from?
- How is the Universe so nearly homogenous?
- Why is the Universe so very well tuned between recollapse and terrific expansion with no galaxies forming?

Inflation/Guth to the rescue

- Need some repulsive stuff…false vacuum
- True vacuum…lowest energy state of a system (in this case the Universe)
- Not necessarily zero energy
- False vacuum
  - higher energy state
  - More symmetric (electroweak, GUT, etc)
  - unstable

Inflation Solves Problems

- Flatness…expanding Universe means "radius of curvature" goes to infinity…the surface of the Earth appears flat
- Horizon…before inflation, regions of universe could be in contact and homogenize
- Structure…quantum "wiggles" blown up can seed structure (scale invariant…same size no matter on what scale you look)

Ending Inflation…

- Graceful exit problem
- Use scalar field…a single number defined at every spacetime point…e.g. temperature
- Minima represent vacuu:
  - If maximum in between, can quantum tunnel but not end because true vacuum bubbles up between expanding space
  - If no maximum, then field can "roll" to true vacuum
  - Must be slow roll to get the right expansion

Happy Thanksgiving!