



The Universe Today

- Homogenous and isotropic on large scales; structure on smaller scales
- Expanding w/ no center
- Nearly flat and density very close to critical
- Accelerating Expansion (Huge & difficult work)
- Filled with CMBR indicative of a 2.7 K temperature
- 13.7 billion years old
- Finite lifetime limits what we can see; cosmic horizon / visible universe
- Mostly hydrogen(75%) and helium(25%), and some other stuff (along with whatever stars produce)
- Composition:
 - 73% dark energy
 - 23% dark matter
 - 4% "regular stuff"

The Universe in the Past

- Big Bang Theory:
 - Universe was hot, dense, and smaller in the past
 - As Universe cooled, it expanded
 - Extremely violent beginnings: matter changes into energy and back again; pair creation/annihilation
 - A bit later, cool enough to leave excess of matter over antimatter
 - Quarks combine into neutrons and protons
 - After 3 minutes, nuclei of helium form
 - After 400,000 yrs, electrons bind to nuclei:
 - Called "recombination"
 - Universe becomes transparent
 - CMBR is a picture of the Universe at this time
 - Galaxies formed where density was higher than other places...these places are "seeds" of structure and not well understood

Evidence for Big Bang

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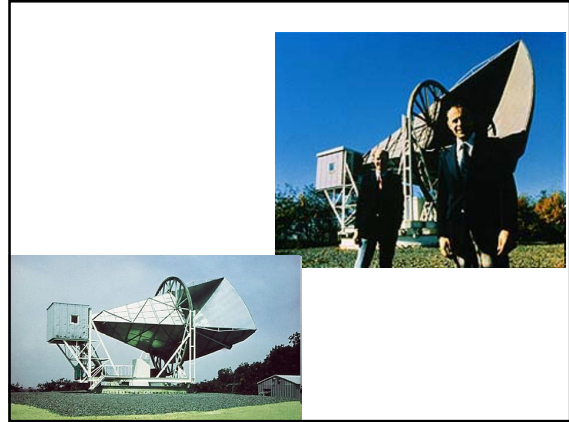
- Hubble's Law

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- Abundances of light elements



Problems w/ Big Bang

- Horizon Problem: How can Universe be so isotropic and homogenized and yet still produce structure?
- Flatness Problem: Why is Universe flat? Any deviations from flat would drive it be less flat.

Problems w/ Big Bang

- Horizon Problem: How can Universe be so isotropic and homogenized and yet still produce structure?
- Inflation starts with a supertiny universe; easy to homogenize, then it blows it up
- Flatness Problem: Why is Universe flat? Any deviations from flat would drive it be less flat.
- Inflation increases size of universe which *drives* the universe to be flat

