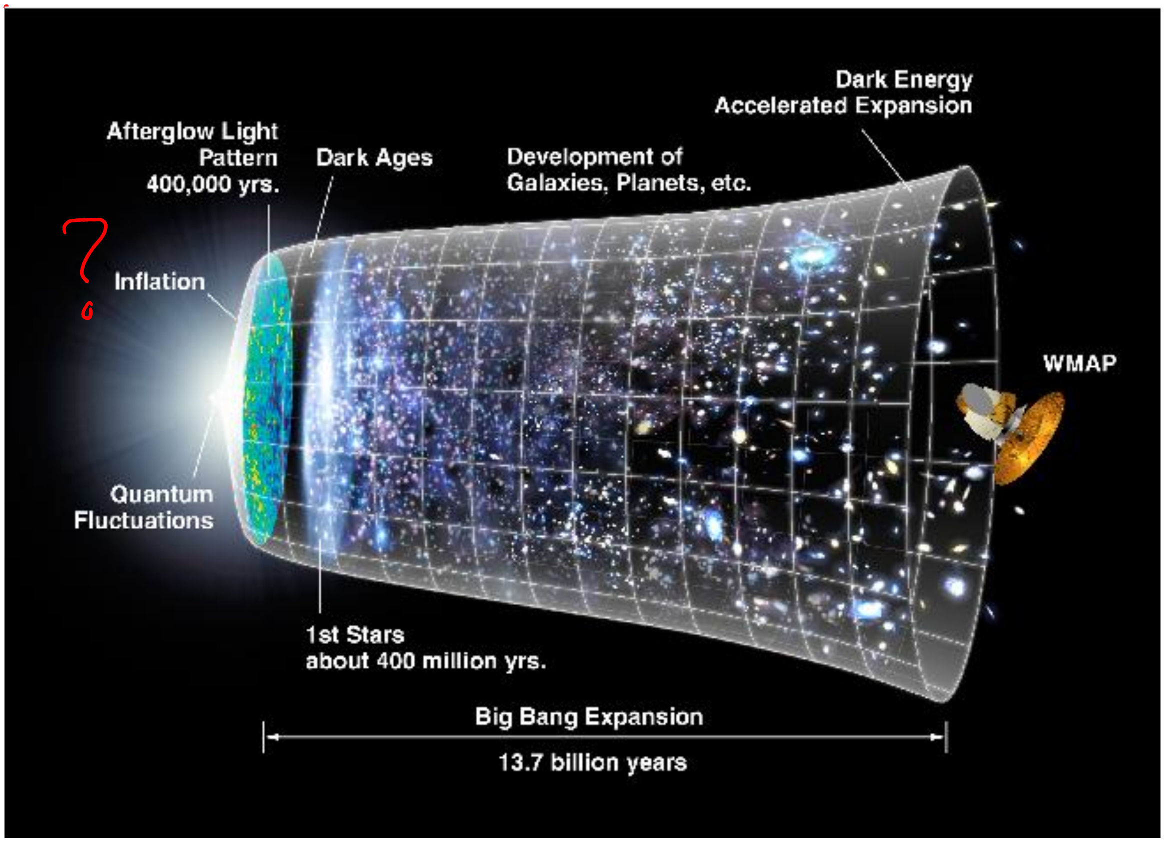
Inflation and Density

Thursday, November 06, 2008
3:11 PM



Age 13.7 ± 0.2 billion yrs (Sean Carroll
100 billion dog years)

100 billion galaxies
100 billion stars/galaxy

Do not Know what happened before t=0.
hot, dense soup of particles
- filled known universe

Know how the early universe expanded - Standard Big Bang Model
- formed light elements
- Stars galaxies

- Stars, galaxies ...

Features not described

1) What caused the expansion
   Not about "Bang" - only about its aftermath
   what banged?
   Not about how, why, before?

2) Where did matter come from?
   All matter is assumed to be present from the beginning.

Introduction - Inflationary Model 80's Guth

Small evolution of universe
+ inflation (exponential expansion) 10^{-32} s
Then 380,000 release of CMBR

Idea from particle physics
at very high temps - high energy
The exist forms of matter that upset gravity. - it makes gravity repulsive
Only need a little bit of repulsive gravity 10^{-9} size of a proton

⇒ Exponential increase size of universe
Doubling Time 10^{-37} s
about 100 doubling times
Density doesn't drop - constant
↳ mass/vol.

Conservation of Matter

needs the energy of gravity to balance the seeming decrease in density

- energy of gravitational field < 0

$$\underset{>0}{\text{matter}} + \underset{<0}{\text{gravity}} \approx 0$$

Successes

① Large Scale Uniformity - seen CMBR

② Overall mass density

Critical Density $\rho_c = 10^{-29}\, g/cm^3$

$\Omega = \rho/\rho_c$ — matter (baryons, dark matter)

radiation (dark matter)

curvature

$$\Omega = \Omega_M + \Omega_\Lambda + \Omega_K$$

③ Small Scale Structure

nonuniformity - galaxies

quantum fluctuations — WMAP

What don't we know?

In the dark about the details

Fits data

22% dark matter

73% dark energy

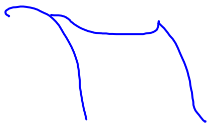
(repulsive gravity)

New Observational Data -

Universe is essentially flat!

Friedmann -

$$H^2 = \frac{8\pi G}{3}\underset{\text{gravity}}{\rho} - \frac{Kc^2}{R^2} + \underset{\text{pressure}}{\frac{\Lambda}{3}}$$

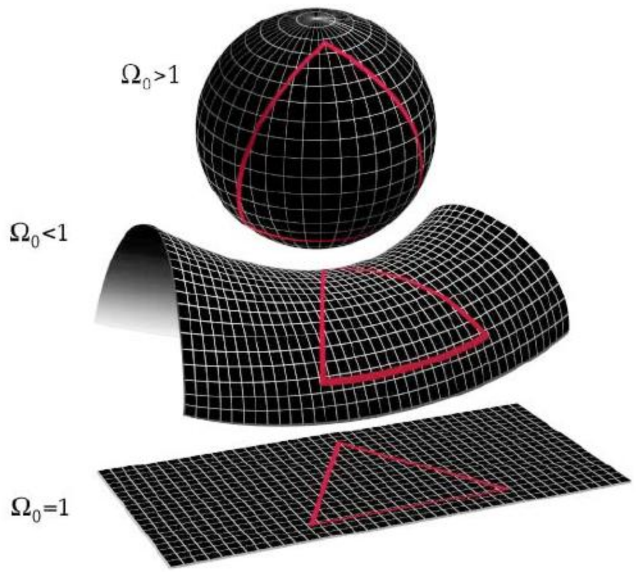


K<0

K=0

K>0

$$\Omega_m + \Omega_\Lambda + \overset{0}{\cancel{\Omega_k}} = 1$$



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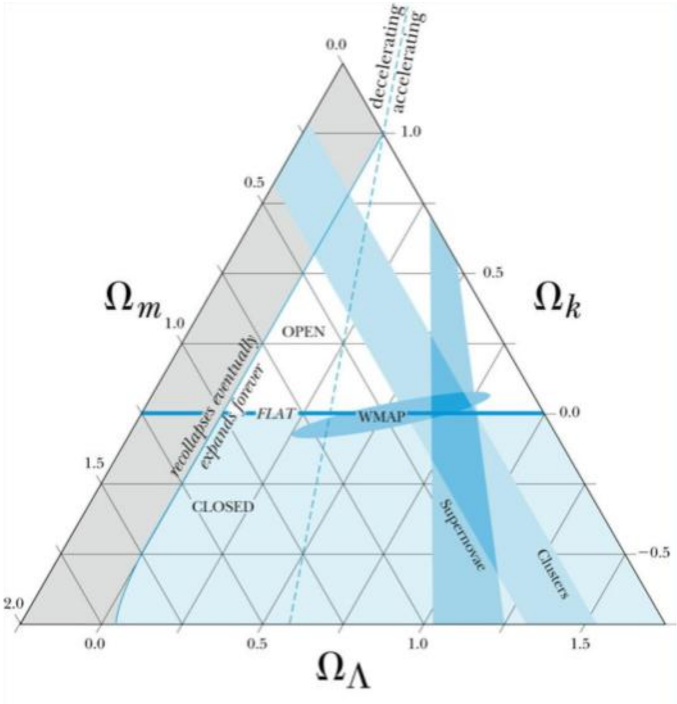
It is now thought that Omega (Ω), the ratio of the density of matter in the universe to the density of matter required for a flat universe, is equal to one. That is, the universe is flat so it will expand forever but more and more slowly, so that after an infinite time it will coast to a stop.

The Cosmic Triangle - http://arxiv.org/abs/astro-ph/9906463



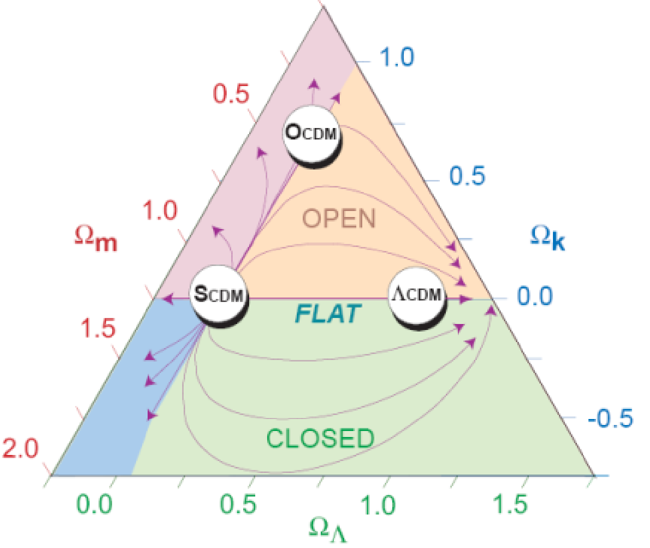


Figure 8: **The past and future of the universe** are represented by various trajectories in the cosmic triangle plot. The trajectories, which originate from near $\Omega_m = 1$ (an unstable equilibrium point matching the approximate condition of the universe during early structure formation), indicate the path traversed in the triangle plot as the universe evolves. For the current best-fit ΛCDM model, the future represents a flat, accelerating universe that expands forever, ultimately reaching $\Omega_m \to 0$ and $\Omega_\Lambda \to 1$.