

Cosmology Course

problems for the oral exam

February 7th 2018

1. (a) Advantages of different parts of the electromagnetic spectrum for cosmological observations. Applications of other emissions for cosmology.
- (b) Astronomical units.
- (c) Observed structures.
- (d) The Cosmological Principle.
- (e) Olber's paradox and its solutions.
- (f) Hubble Law and the evidence for the expansion of the Universe.
- (g) Evidence for the dark matter.

2. (a) The energy-momentum tensor for the perfect fluid.
- (b) "Construction" of the FLRW metric and its application for cosmology.
- (c) The derivation of the Friedmann equations.
- (d) The covariant conservation of the energy-momentum tensor and its consequences.
- (e) The horizons.
- (f) Derivation of

$$\text{emission} \quad \rightarrow \quad \frac{\lambda(t_1)}{R(t_1)} = \frac{\lambda(t_0)}{R(t_0)} \quad \leftarrow \quad \text{detection}$$

- (g) Derivation of

$$1 + z = \frac{R_0}{R}$$

3. (a) The de Sitter model.
- (b) The energy density evolution for $p = w\rho$.
- (c) Solutions of the Friedmann equation for $k = 0$ in the presence of matter which satisfy $p = w\rho$.
- (d) The deceleration parameter and its determination.
- (e) The age of the Universe for RD with $k \neq 0$.
- (f) The age of the Universe for MD with $k \neq 0$.
- (g) The age of the Universe in the presence of matter and cosmological constant for $k = 0$.
- (h) The age of the Universe: the general case.
- (i) Future of the Universe as a function of Ω_i .
- (j) Cosmological distances.
- (k) Discuss the content of the figure 1.
- (l) Distance to the horizon as a function of the redshift.
- (m) The standard candles and the determination of cosmological parameters.
4. (a) Relations between fundamental interactions and cosmology.

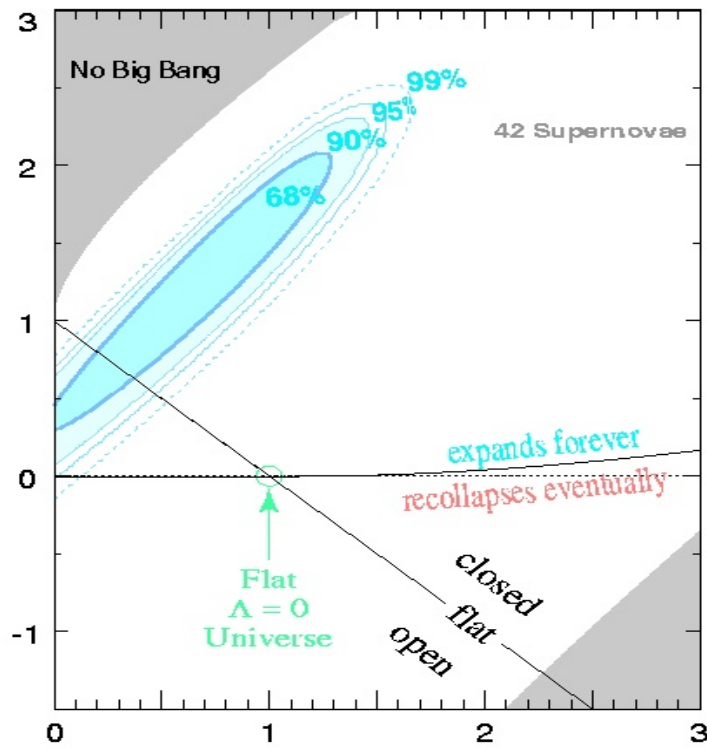


Figure 1: Confidence region for Ω_m vs. Ω_Λ plane, from SCP.

- (b) Number density, energy density and pressure for a gas in equilibrium. Non-relativistic and ultra-relativistic limits.
 - (c) Distribution functions after decoupling, massless and non-relativistic case.
 - (d) Relation between time and temperature.
 - (e) Entropy and its role in cosmology.
 - (f) Decoupling of neutrinos.
- 5.
- (a) The Boltzmann equation.
 - (b) Hot relics.
 - (c) Cold relics e.g. heavy stable neutrino.
 - (d) BBN.
 - (e) BBN constraints on fundamental interactions.
 - (f) Recombination.
- 6.
- (a) The horizon problem.
 - (b) The flatness problem.
 - (c) The basic mechanism of inflation.
 - (d) The horizon problem versus inflation.
 - (e) The inflation from a single real inflaton.
 - (f) Reheating