

Typical oral exam questions

Chapter 2

- Types homogeneous and isotropic spaces
- FLRW metric and its properties. Conformally flat metric.
- Geodesic equation. Comoving frame.
- Conformal and physical times/wavelengths. Redshift.
- Gas of free particles: momentum distributions for massless and massive particles and effective temperatures

Chapter 3

- To derive Friedmann equation from Einstein equations.
- Equation of state and covariant conservation of energy-momentum tensor
- Entropy conservation in comoving volume. Temperature today.
- Expansion rate, energy density and horizon: "Dust", "Radiation", "Vacuum" and barotropic e.o.s.

Chapter 4

- Composition of the present Universe. Abundances. LCDM model.
- Deceleration to acceleration: redshift and age at transition
- "Radiation" to "matter": temperature and age at transition
- Present age and horizon size
- Brightness-Redshift relation for Standard Candles. Dark Energy.
- Degeneracy of cosmological parameters
- Quintessence: only cursory

Chapter 5

- Thermal equilibrium. "Freeze out". Chemical potentials.
- Bose and Fermi, relativistic and non-relativistic gases: number densities, energy densities, entropy and pressure
- Baryon asymmetry. Baryon-to-photon ratio.
- Entropy generation: two possibilities

Chapter 6

- Recombination temperature in equilibrium approximation. Saha equation.
- Age at recombination.
- Photon Last Scattering: temperature, horizon and age. Horizon Problem.

Chapter 7

- Neutrino freeze-out temperature. Neutrino temperature today.
- Cosmological bounds on neutrino mass.
- Why neutrino cannot be Dark Matter candidate?

Chapter 8

- Neutron freeze out temperature. Neutron-to-proton ratio at neutron freeze out.
- Effective deuterium production temperature.
- Primordial He-4 abundance.

Chapter 9

- Cold, Warm and Hot Dark Matter models
- Cosmological perturbations and "free streaming" of the DM
- DM freeze out temperature and mass
- DM annihilation and relic DM abundance calculation
- DM detection methods.

Chapter 10

- Example of phase transitions. First- and second-order transitions.
- Bubbles of new phase.
- Bubble size and free energy. Effective bubbles nucleation at the electroweak phase transition.

Chapter 11

- Sakharov conditions for baryogenesis
- Boltzmann equation for anti-baryon number density
- Baryon freeze out temperature
- Electroweak baryogenesis. Sphaleron energy.

Inflation

- Chaotic inflation. Motivation.
- Inflationary and post-inflationary stages.
- Scalar perturbations. Harrison-Zeldovich spectrum.

Cosmic rays

- Primary and secondary CRs. UHECRs.
- Compositions and energy of CRs. GRBs.
- Sources of high-energy CRs and GRBs. Detection instruments. Physics issues.