

## COSMOLOGY AND GENERAL RELATIVITY

- Short review of the undergraduate level course. Metric, Christoffel connection, Riemann tensor, Einstein's equations, Lagrangian formulation (Einstein-Hilbert action principle).
- Symmetries of geometrical objects, Infinitesimal form – Killing vector fields, Spacetime symmetries and their application in Einstein's field equations.
- Mathematical cosmology: Spatially homogeneous spacetimes (Bianchi Types), automorphisms of the corresponding 3D symmetry groups and their use for solving the cosmological Einstein's equations.
- Classical singular systems: Irreversibility of the Legendre transformation, the Hessian matrix, the Dirac-Bergmann algorithm, Primary-Secondary constraints, termination of the algorithm and the reduced phase space, weak and strong equality, Second class constraints and the Dirac brackets, First class constraints and gauge symmetries.
- Hamiltonian formulation of gravitational field: Einstein-Hilbert action, (3+1) canonical decomposition of the metric, Primary constraints and lapse and shift function, Secondary constraints and invariance of the canonical equations of motion, the linear constraints and spatial diffeomorphisms, the quadratic constraint and hypersurface deformations, Canonical quantization.
- Big Bang theory
- Dark matter and energy
- Universe evolution: Cosmological inflation - Nucleosynthesis - decoupling of radiation from matter - CMB - Structures formation