SYLLABUS

Note: Two lectures will be taken up with student presentations of independent research topics.

Lecture 1: Introduction to the Universe, conventions, units

GENERAL RELATIVITY

Lecture 2: Tensor analysis: coordinates; metrics; transformations of contravariant vectors, covariant vectors and mixed-rank tensors; operations on tensors

Lecture 3: Covariant differentiation; affine connection (Christoffel symbols); parallel transport of vectors; Riemannian geometry

Lecture 4: Space-time curvature; non-commutivity of covariant derivatives and the Riemann curvature tensor; consequences of Riemmanian geometry; Ricci tensor, Ricci scalar, Einstein tensor

Lecture 5: Bianchi identities; geodesics

Lecture 6: Physics in a curved space-time; principle of equivalence; action principle and the stress-energy tensor; examples of calculating T^{ik}

Lecture 7: Einstein field equations of GR; Newtonian approximation

APPLICATIONS OF GENERAL RELATIVITY

Lecture 8: Schwarzschild solution; Birkhoff's theorem; other black-hole solutions; geodesics in a Schwarzschild metric

Lecture 9: Gravitational redshift; experimental tests of GR

STANDARD COSMOLOGY AFTER $z \sim 10^3$

Lecture 10: Cosmological Principle; Weyl's Postulate; Robertson-Walker metric; R-W metric and observational astronomy

Lecture 11: T^{ik} for matter-dominated and radiation-dominated Universe; the Friedmann equations

Lecture 12: Solutions and consequences for a matter-dominated Universe

Lecture 13: Cosmological models with the "Λ" term; discussion of latest observational tests of Standard Cosmology

THE EARLY UNIVERSE

Lecture 14: Solutions for a radiation-dominated Universe; Intro to High-Energy Particle physics

Lecture 15: Thermodynamics of the early Universe; T(t), S(t)

Lecture 16: Epoch of neutrino decoupling ($t < 10^{-4}s$); the e^+e^- annihilation era; neutron to proton ratio; formation of light nuclei

Lecture 17: Epoch of last scattering and the cosmic microwave background

THE VERY EARLY UNIVERSE

Lecture 18: Grand Unified Theories and baryogenisis; problems with the Friedmann cosmology and the hot Big-Bang

Lecture 19: Inflationary models of the Universe

Lecture 20: Survey of current experiments of relevance to the very early universe

OTHER TOPICS

Lecture 21: Formation of large scale structures; Jean's mass and its evolution

Lecture 22: The role of dark matter in the evolution of the Universe and the formation of structures; status of experiments looking for dark matter

Lecture 23: Stellar formation and evolution