

ICTP DIPLOMA PROGRAMME IN HIGH ENERGY, COSMOLOGY AND ASTROPARTICLE PHYSICS 2017-2018

SYLLABUS

General Relativity - {27 Lectures = 40.5 hours}
M. Mehrdad and P. Creminelli

Part I: Towards the Einstein equations (Mirbabayi)

1. Special Relativity

Poincaré Symmetry . Relativistic Kinematics . Electromagnetism, Gauge Symmetry.
Variational Principle: Point Particles, Maxwell Theory. Noether Theorem, Currents,
and Stress-Energy Tensor. Spin, Representation Theory of Poincaré Group

2. Relativistic Theory of Gravitation

Scalar Gravity. Experimental Failure of Scalar Gravity . Spin-2 Gravity.
Gravitational Waves . Emission of Gravitational Waves, Quadrupole Formula

3. General Covariance

Particles in Nonlinear Gravitational Field. Tensor Analysis . Curvature. Energy
Momentum Tensor. Einstein Theory of Gravity. ADM Mass

Part II: Selected Applications of General Relativity and Cosmology (Creminelli)

4. The Schwarzschild Metric

Derivation. Study of singular places. Geodesics in Schwarzschild: gravitational
redshift, precession of orbits and light deflection. Physics inside the horizon: Kruskal-
Szekeres coordinates.

5. Isometries

Isometries, Killing fields. Geodesic deviation equation.

6. FRW metric

Isotropic and homogeneous cosmology. Friedmann equations. Various phases of the
Universe and cosmological constant. Hubble law. Luminosity distance.

7. Equilibrium thermodynamics

Fermi and Bose statistics. Thermodynamical quantities. Entropy conservation.
Neutrino decoupling.

8. Beyond equilibrium

Boltzmann equations. Dark Matter decoupling and WIMP miracle. Nucleosynthesis.
Recombination