ICTP DIPLOMA PROGRAMME IN HIGH ENERGY PHYSICS 2012-13

SYLLABUS

General Relativity - {25 Lectures = 37.5 hours} P. Creminelli

Part I: Towards the Einstein equations

1. **Review of special relativity**
   Vectors and tensors in Minkowski. The energy-momentum tensor.

2. **The equivalence principle**
   Statement and motivation for a geometrical perspective. Gravitational redshift.

3. **Differentiable manifolds**
   Definition. Vectors and tensors on manifolds. The metric.

4. **Covariant derivative**
   Covariant derivative and Christoffel's symbols. Metric compatibility. Geodesic equation.

5. **Curvature**
   Riemann tensor and its properties. Bianchi identities.

6. **Einstein equations**
   Principle of general covariance. Newtonian limit. Einstein equations.

Part II: Selected Applications of General Relativity

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

8. **Isometries**
   Isometries, Killing fields. Geodesic deviation equation.

9. **Gravitational waves**
   Wave equation: spin 2. Production of GWs. Energy and momentum tensor in GR.

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

11. **GR as field theory**
    Einstein-Hilbert action. Matter stress-energy tensor. Weinberg's theorem on massless spin 2-particles.