School of Mathematics

MA4448 — General Relativity 2011-12
(SS Theoretical Physics
SS Mathematics)

Lecturer: Prof. Peter Taylor

Requirements/prerequisites:

Duration: Hilary Term, 11 weeks

Number of lectures per week:

Assessment:

ECTS credits: 5

End-of-year Examination: This module will be examined jointly with MA3429 in a 3-hour examination in Trinity term, except that those taking just one of the two modules will have a 2 hour examination. However there will be separate grades for MA3429 and MA4448.

Description:

Learning Outcomes: On successful completion of this module, students will be able to:

- Define the Einstein-Hilbert action and derive Einstein's equations from an action principle.
- Define the stress-energy-momentum tensor, obtain its components in an orthonormal tetrad, and obtain explicit expressions for the stress-energy-momentum tensor describing a perfect fluid matter distribution.
- Derive the canonical form of the Schwarzschild solution to the vacuum field equations under the sole assumption of spherical symmetry, and hence state Birkhoff's Theorem.
- Derive expressions for the gravitational redshift, perihelion advance of the planets, and light deflection in the Schwarzschild space-time and hence discuss solar system tests of General Relativity.
- Obtain the geodesic equations in arbitrary space-times and hence describe various trajectories such as radially in-falling particles or circular geodesics etc.
- Obtain the maximal extension of the Schwarzschild solution in Kruskal coordinates and hence discuss the Schwarzschild black hole.
- Define spatial isotropy with respect to a universe filled with a congruence of time-like world-lines, discuss the consequences of global isotropy on the shear, vorticity and expansion of the congruence and hence construct the Friedmann-Robertson-Walker metric.

- Obtain the Friedmann and Raychaudhuri equations from the Einstein field equations, solve these equations for the scale factor and discuss the cosmogonical and eschatological consequences of the solutions.
- Derive the Einstein equations in the linear approximation and discuss the Newtonian limit in the weak-field, slow-moving approximation.
- Use the gauge freedom to show that, in the Einstein-deDonder gauge, the perturbations satisfy an inhomogeneous wave-equation, to solve in terms of plane-waves, and to use the residual gauge freedom to show that for waves propagating in the positive z-direction there are only two linearly independent non-zero components.
- Derive the Reissner-Nordstrom solution of the Einstein-Maxwell field equations, obtain its maximal extension and discuss the Reissner-Nordstrom black hole solution.

February 15, 2012