

LTCC Advanced Course

Title: Mathematical Topics of General Relativity

Basic Details:

- Core Audience (1styr or 2nd/3rdyr: pure, app. or stats): 1st -3rd year pure and applied.
- Course Format (**Extended:** 5 x 2hr lectures)

Course Description:

- *Keywords:* Initial value problem in General Relativity, initial data sets, evolution equations, static and stationary solutions, mass in General Relativity.
- *Syllabus:* The main objective of the course is to provide a discussion of General Relativity as an initial value problem. In addition, the course will serve as an introduction to applied methods of Differential Geometry and Partial Differential Equations. It is expected that at the end of the course the student will have a good overview of the main ideas and methods of modern mathematical General Relativity. The topics to be covered are:
 - a. Review of the key ideas of General Relativity and the vacuum field equations.
 - b. Selected topics of Lorentzian and Riemannian Differential Geometry including embeddings and submanifolds, intrinsic metrics, extrinsic curvature, Gauss-Codazzi and Codazzi-Mainardi equations.
 - c. The constraint equations of General Relativity including selected topics of elliptic PDE theory.
 - d. The evolution equations including selected topics of hyperbolic PDE theory.
 - e. Time independent solutions to the Einstein field equations.
 - f. Energy and momentum in General Relativity.
 - g. Time allowing: trapped surfaces and Penrose's singularity theorem.

-Recommended reading:

R.M. Wald. *General Relativity*. Chicago University Press, 1984.

-Additional Optional reading:

Y. Choquet-Bruhat. *General Relativity and Einstein's equations*. Oxford University Press, 2008.

D. Christodoulou. *Mathematical problems of General Relativity. I*. Zürich lectures in Advanced Mathematics. European Mathematical Society, 2008.

A.D. Rendall. *Partial differential equations in General Relativity*. Oxford University Press, 2008.

H. Ringström. *The Cauchy Problem in General Relativity*. European Mathematical Society, 2009.

-Prerequisites: A first course in General Relativity that discusses the Schwarzschild spacetime. Acquaintance with the basic notions of Differential Geometry will also be of advantage.

Format:

- h. No of discussion/problem sheets (typically 4 for with solutions): 4 problem sheets, solutions to be provided.
- i. Electronic lecture notes (these are strongly encouraged, as they will form the core of the individual study of the students): electronic notes will be provided.
- j. Necessary support facilities: beamer and whiteboard.

Lecturer Details:

- k. Lecturer: Prof. Juan A. Valiente Kroon
- l. Lecturer home institution: School of Mathematical Sciences, Queen Mary University of London
- m. Lecturer e-mail: j.a.valiente-kroon@qmul.ac.uk