EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

Mathematisch-
Naturwissenschaftliche
Fakultät
Fachbereich Mathematik
AB Geometrische Analysis und
Mathematische Relativitätstheorie

Wintersemester 2026/27

Null Geometry in General Relativity

Lecturer: Johannes Schirbort
Start: Wednesday, October 14
Time: Wednesday, 14:15–16:00, C4H33 and virtually via zoom/recordings
Platform: Please join the ILIAS group Null Geometry 2026, all information will be shared there
Modul number: MAT-60-08, 3 ECTS

Description

Most information from far-away stars and galaxies reaches us as signals travelling at the speed of light. Null Geometry provides a framework in the context of General Relativity for studying lightrays and, in particular, the surfaces ruled by them from a mathematical perspective. We will begin with a brief introduction to *semi-Riemannian submanifold theory* discussing concepts such as the second fundamental form and the mean curvature of submanifolds of arbitrary codimension. We will then turn our attention to the main object of the course: *Null hypersurfaces* embedded in an ambient Lorentzian manifold. We will first study the geometry of such null hypersurfaces in general and then focus on the extrinsic geometry of *spacelike codimension-2 surfaces* embedded in a given null hypersurface, where we will be particularly interested in the study of *foliations* of null hypersurfaces by spacelike codimension-2 surfaces. In the end, we will discuss applications of this null geometric framework in General Relativity such as the *small sphere limit* of quasi-local energies.

Requirements

Geometry in Physics or Differential Geometry

Useful, but not required: Mathematical Relativity

Literature

B. O'Neill, *Semi-Riemannian Geometry with Applications to Relativity*, Academic Press, Math. 103 (1983)

J. Sauter, *Foliations of Null hypersurfaces and the Penrose Inequality*, PhD Thesis, ETH Zürich, 2008

M. Wolff, *On the Spacetime Mean Curvature of Surfaces in General Relativity*, PhD Thesis, University of Tübingen, 2023

J. Schirbort, *A New Perspective on the Small Sphere Limit of the Hawking Energy*, Master's Thesis, University of Tübingen, 2026

Exam

There will be an oral exam in the lecture-free period conducted by Prof. Carla Cederbaum.

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