EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

Mathematisch-
Naturwissenschaftliche
Fakultät
Fachbereich Mathematik

Seminar Big Bang Theory

In Lorentzian Geometry, one considers smooth manifolds carrying a so-called *Lorentzian metric*. The easiest example for such a *Lorentzian manifold* is the Minkowski spacetime $(\mathbb{R}^4, \eta)$ of Special Relativity, where η is a non-degenerate symmetric bilinear form of signature $(-,+,+,+)$ on $\mathbb{R}^4$. Lorentzian manifolds play a central role in General Relativity, but they are also of purely mathematical interest and possess many surprising geometric features.

We will first discuss the geometry of the Minkowski spacetime and then move on to general Lorentzian manifolds. Here, we will first study some interesting examples (de Sitter and anti de Sitter spacetimes, FLRW spacetimes). Then we will discuss and prove the singularity theorems by Stephen Hawking and Roger Penrose. These are related to the physical "prediction" of the existence of a big bang at the beginning of our universe – a relation we will also discuss in this seminar.

I will be happy to assign Bachelor (BSc, BEd) and Master (MSc, MEd) theses building upon the material studied in this seminar.

References:

- Christian Bär: *Lorentzgeometrie*, `http://geometrie.math.uni-potsdam.de/documents/baer/skripte/skript-LorGeo.pdf`, 2004.
- John M. Lee: *Riemannian Manifolds: an Introduction to Curvature*, Springer, 1997.
- Barrett O'Neill: *Semi-Riemannian Geometry With Applications to Relativity*, Academic Press, 1983.
- Robert M. Wald, *General Relativity*, The University of Chicago Press, 1984.

All interested students are invited to the preliminary meeting on July 7, 1pm, in C4H33.

Instructor: Prof. Dr. Carla Cederbaum, `cederbaum@math.uni-tuebingen.de`

Teaching Assistant: Olivia Vičánek Martínez, `Olivia.vicanek-martinez@math.uni-tuebingen.de`

Time: Fridays, 12.15pm-1.45pm, starting October 21, 2022

SWS / ECTS: 2 / 3

Prerequisites: Real Analysis, Linear Algebra, and basic knowledge in Differential Geometry, such as e.g. *Geometry in Physics*. Knowledge in Special, General, and Mathematical Relativity will be helpful but not necessary.