



Einladung zur öffentlichen Defensio

Liam Dylan URBAN

Thema der Dissertation

**On the Big Bang formation for cosmological solutions to
nonvacuum Einstein equations**

Abstract:

Friedman-Lemaître-Robertson-Walker (FLRW) spacetimes arise as natural models for our universe by virtue of the Cosmological Principle. This principle posits that, when viewed at large scales, no point and no direction in our universe has a preferential role. Observations support the Cosmological Principle, i.e., the physical universe is well approximated by FLRW models. However, a full mathematical analysis of these models is necessary to understand to what extent this approximation remains valid in our distant past and future, to which we cannot fully apply observational methods. To this end, this thesis studies the stability of FLRW spacetimes as solutions to the Einstein equations, predominantly towards the Big Bang singularity. This amounts to analysing the blow-up stability of solutions to an elliptichyperbolic system of partial differential equations.

The thesis consists of three works, preceded by a brief introduction to cosmological and mathematical aspects of Big Bang formation. In the first work, initial data for the Einstein scalar-field equations close to that of an FLRW spacetime with negative spatial curvature is considered. In the contracting direction, it is shown that the maximal globally hyperbolic development of said initial data is incomplete, forming a quiescent crushing Big Bang singularity. In the expanding direction, their development is complete and asymptotically approaches the vacuum solution, provided that a certain spectral assumption with respect to the spatial reference geometry holds. These results combine into a global stability result for a large class of FLRW spacetimes with negative spatial curvature.

The two subsequent works are concerned with Big Bang formation for the Einstein scalarfield Vlasov system in four and three spacetime dimensions respectively. FLRW solutions with isotropic matter and arbitrary spatial geometry are shown to be past stable, with the spacetime and scalar field behaviour matching that of the first result. Additionally, the Vlasov distribution is shown to be extendible towards the past when viewed on the co-

mass shell, while the leading asymptotic order of the components of the Vlasov energy-momentum tensor lightly degenerates. Finally, the $(2 + 1)$ -dimensional stability result is leveraged to control the past asymptotics of $(3 + 1)$ -dimensional vacuum solutions in polarized $U(1)$ -symmetry.

Prüfungssenat

Univ.-Prof. Mag. Dr. Andreas Cap
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Zeit und Ort

Dienstag, 18. November 2025, 09:00 Uhr

Online:

<https://univienne.zoom.us/j/62170054219?pwd=Kq3arrUacPBibn81fQnIXURlavlbfvq.1>

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