GR 10: Numerische Relativitätstheorie II

Zeit: Mittwoch 16:30–18:30 Raum: HS 6

GR 10.1 Mi 16:30 HS 6

Simulations of Binary Neutron Star Mergers — •Wolfgang Kastaun — Albert Einstein Institut Golm

The inspiral and merger of binary neutron star systems is one of the most promising sources for current gravitational wave astronomy and also the most likely explanation for short gamma ray bursts. Such events are sensitive to a unique mix of physics, namely general relativity in the strong field regime, nuclear physics at extreme densities and a large temperature range, neutrino physics, and relativistic (Magneto-)Hydrodynamics. Three-dimensional numerical simulations are the only way to map the theoretical unknowns onto observable predictions. In this talk, we will present simulations of non-magnetized binary neutron star mergers done at the AEI, incorporating nuclear physics descriptions of matter at high densities and a fully general relativistic evolution, with focus on the gravitational wave signal and the temperature evolution.

GR 10.2 Mi 16:45 HS 6

Highly eccentric neutron star binaries as revealed by numerical relativity: Properties of their gravitational waves and merger remnants — •Nathan Johnson-McDaniel, Sebastiano Bernuzzi, Marcus Thierfelder, and Bernd Brügmann — Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität, Jena, Deutschland

We describe the results of our numerical evolutions of highly eccentric neutron star binaries, focusing on the properties of their gravitational wave signal, accretion disk, and ejecta. On the gravitational wave side, we consider the repeated burst structure from the stars' close encounters and the signal from tidally induced oscillations of the neutron stars, and assess prospects for detection. On the matter side, we consider how the properties of the (in some cases fairly massive) accretion disk and ejecta from the merger relate to potential electromagnetic signals (e.g., short gamma-ray bursts or radio afterglow) and r-process nucleosynthesis. We also discuss how all these properties depend upon the binary's initial conditions and the masses and equation of state of the neutron stars. Finally, we describe our efforts to ensure the accuracy of our simulations.

GR 10.3 Mi 17:00 HS 6

Evolution of magnetized hypermassive neutron stars — •Daniel Siegel, Riccardo Ciolfi, and Luciano Rezzolla — Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut), Potsdam-Golm, Germany

Differentially rotating hypermassive neutron stars (HMNSs) are metastable configurations which can be formed in the latest stage of binary neutron star mergers. Their eventual collapse produces a spinning black hole surrounded by a hot and thick accretion disk. The dynamics of such a system is of crucial importance, since it could generate the relativistic jets observed in short gamma-ray bursts. By performing simulations of very high resolution, we discuss the influence of magnetic fields on the evolution of HMNSs. In particular, we provide convincing evidence for the occurrence of the *magneto-rotational instability* (MRI), which is responsible for strong magnetic field amplification. Characteristic features of the MRI are discussed and quantities such as the characteristic growth rate and the wavelength of the fastest growing mode are extracted and compared with analytical predictions. We also show the emergence of coherent channel flows and their eventual rearrangement through reconnection.

GR 10.4 Mi 17:15 HS 6

Tidal effects in binary neutron star coalescence — •Sebastiano Bernuzzi — TPi, Jena, Germany

Gravitational waves from coalescing neutron stars carries unique information about the star's equation of state. An accurate theoretical modeling of these systems is of primary importance to extract robust data in a direct detection of gravitational waves.

I will present results about tidal effects in binary neutron star coalescence and their signature in gravitational radiation emitted. In particular, I will discuss the outcome of state-of-art numerical relativity simulations and their comparison with analytical approaches like post-Newtonian method and the effective-onde-body model.

GR 10.5 Mi 17:30 HS 6

A minimax approach to solving for relativistic stellar equilibria — •Charalampos Markakis[1,2], Bernd Brügmann[1], Richard Price[3], and John Friedman[4] — [1]University of Jena, Germany — [2]University of Southampton, UK — [3]University of Texas - Brownsville, US — [4]University of Wisconsin - Milwaukee, US

Similar methods have been used to construct models of rapidly rotating or binary stars, in Newtonian and relativistic contexts. The choice of method has been based on numerical experiments, which indicate that particular methods converge quickly to a solution, while others diverge. The theory underlying these differences, however, has not been understood. In an attempt to provide a better theoretical understanding, we analytically examine the behavior of different iterative schemes near an exact static solution. We find the spectrum of the linearized iteration operator and show for self-consistent field methods that iterative instability corresponds to unstable modes of this operator. We show that minimizing the maximum eigenvalue accelerates convergence and allows computation of highly compact configurations that were previously inaccessible via self-consistent field methods.

GR 10.6 Mi 17:45 HS 6

Numerical long-term integration of compact binary systems — •Jonathan Seyrich — Numerical Analysis Group, Universitaet Tuebingen, Auf der Morgenstelle 10, 72076 Tuebingen

The two most common descriptions of relativistic binary systems - the Geodesic approximation and the post-Newtonian approach- give rise to equations of motion which have to be integrated numerically. In the investigation for chaos, integrations over very long time ranges are necessary. For this purpose, highly accurate and efficient numerical integration schemes are presented. The best integrators will turn out to be based on Gauss collocation methods.

GR 10.7 Mi 18:00 HS 6

Initial data for perturbed Kerr black holes on hyperboloidal slices — •David Schinkel, Marcus Ansorg, and Rodrigo Panosso Macedo — Theoretisch-Physikalisches Institut, Jena, Germany

We construct initial data corresponding to a single perturbed Kerr black hole in vacuum. These data are defined on specific hyperboloidal slices on which the mean extrinsic curvature K approaches a constant asymptotically. More precisely, we require that K obeys the Taylor expansion $K = K_0 + O(\sigma^4)$ where K_0 is a constant and σ describes a compactified spatial coordinate such that future null infinity (scri+) is represented by $\sigma = 0$. We excise the singular interior of the black hole and assume an apparent horizon as inner boundary of the computational domain. Momentum and Hamiltonian constraints are solved by means of pseudo-spectral methods. We find exponential rates of convergence of our numerical solutions which are planned to be dynamically evolved in a future project.

GR 10.8 Mi 18:15 HS 6

Spinning Q-balls and Boson Stars in Anti-de Sitter Spacetime — Jutta Kunz, Eugen Radu, and •Bintoro Subagyo — Institut für Physik, Universität Oldenburg, Postfach 2503, D-26111 Oldenburg, Germany

We construct spinning Q-balls and boson stars in d dimensional anti-de Sitter spacetime. These are smooth, horizonless solutions for gravity coupled to a complex scalar field with a harmonic dependence on time and an azimuthal angle. We find that a class of solutions with a self-interaction potential has a limit corresponding to static solitons with axial symmetry only. We also discuss an exact solution describing spherically symmetric Q-balls in a fixed AdS background.