GR 6: Numerical Relativity

Zeit: Mittwoch 11:00–13:00 Raum: HS 4

Hauptvortrag GR 6.1 Mi 11:00 HS 4

Modeling the strong-field dynamics of binary neutron star merger — •Sebastiano Bernuzzi — FSU Jena, Germany

The observation of gravitational and electromagnetic waves from a binary neutron star merger in August 2017 delivered key information on the nature of matter at supranuclear densities, on the origin of short-gamma ray burst, on the production site of of heavy elements via r-process nucleosynthesis, and on cosmography. Thus, multimessenger observations of compact binary mergers hold the promise to unprecedent insights on some of the most fundamental physics questions. A crucial and necessary ingredient to interpret such observations is the precise knowledge of the dynamics of the source. I will talk about recent developments on the modeling of neutron star mergers using numerical simulations in general relativity. I will focus on the numerical exploration of the the merger remnant and mass ejecta and their dependence on the binary parameters. I will discuss detailed models of the gravitational waves and kilonova light curves, highlighting the prospect of using them in joint analysis of multimessenger data.

GR 6.2 Mi 11:45 HS 4

Electromagnetic Counterpart of Neutron Star Mergers — •Vsevolod Nedora and Sebastiano Bernuzzi — Theoretisch-Physikalisches Institut, Jena, Germany

Neutron star merger is a unique cosmic laboratory to investigate general relativity in a strong field regime and fundamental physics, including dense matter and heavy-elements-nucleosynthesis.

Our work focuses on the kilonovae counterpart of the gravitational wave source GW170817. We study the merger dynamics and light curves employing state of the art numerical general relativistic simulations. We provide further insights into the properties of the equation of state of neutron stars and nucleosynthetic yields.

GR 6.3 Mi 12:00 HS 4

Numerical relativity simulations of highly spinning binary neutron star mergers — •reetika dudi[1], tim dietrich[2], wolfgang tichy[3], and alireza Rashti[3] — [1]Theoretical Physics Institute, University of Jena, 07743 Jena, Germany — [2]Nikhef, Amsterdam, The Netherlands — [3]Florida Atlantic University, Boca Raton, USA

Neutron stars in a binary are spinning objects. Therefore, it is very important to include spin in numerical simulations of binary neutron stars(BNS). Our colleagues have developed a formalism to construct BNS initial data with in principle arbitrary masses, spins and eccentricities. Here we present results of evolution of highly spinning BNS (up to dimensionless spin of approx. 0.5) with full (3+1)D numerical relativity simulations using consistent initial conditions. These are among the highest spinning numerical evolutions of BNSs to date. These waveforms with high resolution can be used as a testbed to extract the spin effects in the GW phase evolution and to test other semi-analytical waveform models.

GR 6.4 Mi 12:15 HS 4

Improvements on Initial Data for Spinning Neutron Star Binaries — •Hannes Rüter — Max-Planck-Institut für Gravitationsphysik, Potsdam/Golm

The current formalism to construct numerical relativity initial data for neutron star binaries with spin makes some assumptions that are not compatible with the constraints given by energy-momentum conservation. This talk will discuss issues of the current formalism and propose possible solutions and improvements, which will be important for future high accuracy binary neutron star simulations.

GR 6.5 Mi 12:30 HS 4

Eccentric Binary Neutron Stars in Numerical Relativity — •Swami Vivekanandji Chaurasia[1], Tim Dietrich[2], Nathan K. Johnson-McDaniel[3], Maximiliano Ujevic[4], Wolfgang Tichy[5], and Bernd Bruegmann[1] — [1]Theoretical Physics Institute, FSU-Jena, Germany — [2]Nikhef, Amsterdam, The Netherlands — [3]DAMTP, Centre for Mathematical Sciences, Cambridge, U.K — [4]Centre for Natural Sciences and Humanities, Fedral University of ABC, Brazil — [5]Department of Physics, Florida Atlantic University, U.S.A

This talk summarizes the recent efforts of the BAM collaboration in pursuing the goal of simulating generic binary neutron star mergers. In particular, I will highlight the recent progress from new simulations of eccentric systems in full general relativity which, for the first time, are based on consistent initial data setting new quality-standard for these simulations. We extract from the simulated waveforms the frequency of the *f*-mode oscillations induced during close encounters before the merger of the two stars. We find the extracted frequency to be in good agreement with *f*- mode oscillations of individual stars, which allows an independent measure of the supranuclear equation of state not accessible for binaries on quasi-circular orbits. Furthermore, the energy stored in these *f*-mode oscillations can be as large as 10^{-3} $M_\odot \sim 10^{51}$ erg (energy in a supernova!), even with a soft EOS. While in general (eccentric) neutron star mergers produce bright EM counterparts, we find that for the considered cases the luminosity decreases when the eccentricity becomes too large, due to a decrease in the ejecta.

GR 6.6 Mi 12:45 HS 4

A discontinuous Galerkin elliptic solver with task-based parallelism for the SpECTRE code — •Nils Fischer — Max-Planck-Institut für Gravitationsphysik (AEI) Potsdam, Deutschland

I report on progress on the next-generation pseudo-spectral numerical relativity code SpECTRE, currently in development by the SXS collaboration. It combines nodal discontinuous Galerkin methods and task-based parallelism to achieve more accurate solutions for challenging relativistic astrophysics problems such as core-collapse supernovae and binary neutron star mergers. In particular, I present the numerical scheme to solve elliptic partial differential equations in SpECTRE. Since equations of this type appear in general relativistic initial data problems, they serve as the starting point for time evolutions. I demonstrate the code's ability to scale to the capacity of the Minerva supercomputer at AEI Potsdam.