GR 13: Numerical Relativity

Time: Thursday 14:00–15:40 Location: GR-H2

GR 13.1 Thu 14:00 GR-H2

GRHD simulations with GR-Athena++ — •William Cook — Theoretisch-Physikalisches Institut, Friedrich-Schiller Universitat Jena, 07743, Jena, Germany

For the first time we demonstrate the performance of the code GR-Athena++ in evolving general relativistic hydrodynamics (GRHD) in a dynamically evolving spacetime. GR-Athena++ utilises the task-based parallelism and block based adaptive mesh refinement of the Athena++ code, as well as its approach to solving GRHD problems in stationary spacetimes; combined with new functionality to solve the Einstein equations in the Z4c formulation. We demonstrate the performance of this new code by simulating the evolution of Neutron Stars in GR-Athena++, removing the Cowling approximation assumed in previous work, presenting a fully dynamical spacetime evolution.

GR 13.2 Thu 14:20 GR-H2

Evolution of mixed binaries initial data produced with Elliptica — •Francesco Maria Fabbri[1], Alireza Rashti[2], Bernd Brügmann[1], Swami Vivekanandji Chaurasia[3], Tim Dietrich[4,5], Maximiliano Ujevic[6], and Wolfgang Tichy[2] — [1]Theoretical Physics Institute, University of Jena, 07743 Jena, Germany — [2]Department of Physics, Florida Atlantic University, Boca Raton, FL 33431, USA — [3]The Oskar Klein Centre, Department of Astronomy, Stockholm University, AlbaNova, SE-10691 Stockholm, Sweden — [4]Institut für Physik und Astronomie, Universität Potsdam, Haus 28, Karl-Liebknecht-Strasse 24/25, 14476, Potsdam, Germany — [5]Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Am Mühlenberg 1, Potsdam 14476, Germany — [6]Centro de Ciências Naturais e Humanas, Universidade Federal do ABC, 09210-170, Santo André, São Paulo, Brazilx

In this work, we present the evolution of black hole - neutron star initial data produced with the new pseudo spectral code Elliptica. The code makes use of Schur complement domain decomposition method with a direct solver using cubed sphere coordinate maps and the fields are expanded using Chebyshev polynomials of the first kind. To stress the capability of the code we designed different configurations of mass ratios and spin orientations and we made use of the BAM code to evolve such initial data. Arbitrary spin magnitudes and orientations are evolved, with a maximum adimensional spin of 0.8 for the black hole and an arbitrary high spin for the neutron star.

GR 13.3 Thu 14:40 GR-H2

Comparison of eccentric numerical relativity simulations to small mass-ratio perturbation theory — •antoni ramos-buades, maarten van de meent, and harald pfeiffer — Max Planck Institute for Gravitational Physics, Potsdam, Germany

During the third observing run of the LIGO and Virgo detectors a few gravitational wave (GW) signals from binary black hole (BBH) mergers with unequal masses have been detected. As detectors' sensitivity continues to increase, more systems with more asymmetric masses are expected to be detected, and therefore modelling of BBHs at all mass ratios is of preeminent relevance. In this work we compare two approaches to modeling binary black holes (BBHs): 1) small mass-ratio (SMR) perturbation theory, and 2) numerical relativity (NR). We extend recent work on combining information from quasicircular nonspinning NR simulations of BBHs with results from SMR perturbation theory to nonspinning eccentric BBHs. We produce a dataset of long and accurate eccentric nonspinning NR simulations with the Spectral Einstein Code (SpEC) from mass ratios 1 to 10, and eccentricities up to 0.7. We analyze these NR simulations, compute gauge invariant quantities from the gravitational radiation, and develop tools to map points in parameter space between eccentric NR and SMR waveforms. Finally, we discuss discrepancies between SMR and NR predictions for the energy and angular momentum fluxes due to eccentricity, and limitations of such comparisons due to the limited parameter space in mass ratio covered by the NR simulations.

GR 13.4 Thu 15:00 GR-H2

Critical Collapse with bamps. — Daniela Cors Agulló[1], •Sarah Renkhoff[1], Isabel Suárez Fernández[2], Hannes Rütter[3], David Hilditch[2], and Bernd Brügmann[1] — [1]Theoretisch-Physikalisch Institut, Friedrich-Schiller-Universität, Jena, Germany — [2]CENTRA, Instituto Superior Tecnico, Lisbon, Portugal — [3]Max-Planck-Institut für Gravitationphysik, Potsdam, Germany

Our pseudo-spectral code bamps, with its new adaptive mesh refinement, allows us to tune closer to the critical point between gravitational collapse and dispersed fields. We study, on the one hand critical phenomena in spherical symmetry by evolving scalar fields using generalised harmonic gauge and compare among several gauge source functions. On the other hand, we can assess critical phenomena in an axisymmetric setting by evolving gravitational waves in vacuum. We evolve six one-parameter families of Brill wave initial data: three prolate and three oblate, including two centred and four off-centred. Time permitting, we will discuss the relevance of our results in the context of critical collapse beyond spherical symmetry.

GR 13.5 Thu 15:20 GR-H2

A new approach to helical Killing vectors — •Hannes Rüter — Potsdam, Germany

Helical Killing Vectors are an important ingredient for the description of binary systems in quasi-equilibrium, which makes them one of the central quantities in the construction of numerical-relativity initial data of compact binaries. Current approaches to helical Killing vectors and their generalisations to eccentric orbits are defined in a foliation-dependent manner. In this presentation I will a discuss a new approach that attempts to break this foliation dependence.