GR 16: Numerical Relativity

Time: Thursday 15:00–18:10 Location: H 2013

GR 16.1 Thu 15:00 H 2013

Perturbing AdS space—turbulence and time-periodic solutions — •Maciej Maliborski — Albert-Einstein-Institut, Potsdam

In this talk I will present recent analytical and numerical analysis of asymptotically anti-de Sitter spacetimes in a spherical symmetry. I will review the turbulent phenomena in AdS gravity (discovered by Bizoń and Rostworowski) and present results supporting the existence of time-periodic solutions—non-generic, stable solutions with AdS asymptotics.

GR 16.2 Thu 15:20 H 2013

Critical behaviour in the Einstein-Yang-Mills system — •Oliver Rinne and Maciej Maliborski — Albert-Einstein-Institut, Potsdam

The Einstein-Yang-Mills system displays a variety of critical phenomena in gravitational collapse. Two new results are reported here. By tuning two parameters in the initial data, the magnetic Reissner-Nordström solution appears as an approximate intermediate attractor separating the critical line of coloured black hole solutions of opposite sign. The second result concerns the influence on critical collapse of a sphaleron contribution in the ansatz for the spherically symmetric Yang-Mills field.

GR 16.3 Thu 15:40 H 2013

Numerical evolution of the axisymmetric vacuum Einstein equations in spherical coordinates: the linear case — •Christian Schell and Oliver Rinne — Max Planck Institute for Gravitational Physics, Golm

We discuss a new approach to solving the axisymmetric vacuum Einstein equations numerically. Spherical polar coordinates are best suited for situations such as gravitational collapse. Also they allow for a spectral approach using spherical harmonics. In this talk we consider the linearization of the equations about flat spacetime. We show why the considered situation requires a new gauge condition and we derive an exact solution for our choice. After regularizing at the origin we present numerical evolutions and discuss their properties.

30 min. break

GR 16.4 Thu 16:30 H 2013

Discontinous Galerkin methods in general relativistic hydrodynamics — •Marcus Bugner[1], Tim Dietrich[1], Sebastiano Bernuzzi[2,3], and Bernd Brügmann[1] — [1]Theoretical Physics Institute, University of Jena, 07743 Jena, Germany — [2]TAPIR, California Institute of Technology, Pasadena, California, USA — [3]DiFeST, University of Parma, and INFN Parma, I-43124 Parma, Italy

We investigate the properties of a Discontinous Galerkin (DG) method applied to solve the equations of special and general relativistic hydrodynamics in 3+1 dimensions. In order to avoid artificial oscillations at discontinuities, this is combined with a weighted essentially non-oscillatory (WENO) limiting procedure. We test the stability, convergence and scaling of our algorithm and compare our results with finite differencing simulations.

GR 16.5 Thu 16:50 H 2013

Axisymmetric constant mean curvature slices in the Kerr space-time — •David Schinkel, Rodrigo Panosso Macedo, and Marcus Ansorg — Theoretisch-Physikalisches Institut, Jena, Germany

Recently, there have been efforts to solve Einstein's equation in the context of a conformal compactification of space-time. Of particular importance in this regard are the so called CMC-foliations, characterized by spatial hyperboloidal hypersurfaces with a constant extrinsic mean curvature K. However, although of interest for general space-times, CMC-slices are known explicitly only for the spherically symmetric Schwarzschild metric. This work is devoted to numerically determining axisymmetric CMC-slices within the Kerr solution. We construct such slices outside the black hole horizon through an appropriate coordinate transformation in which an unknown auxiliary function A is involved. The condition K=const throughout the slice leads to a nonlinear partial differential equation for the function A, which is solved with a pseudo-spectral method. The results exhibit exponential convergence, as is to be expected in a pseudo-spectral scheme for analytic solutions. As a by-product, we identify CMC-slices of the Schwarzschild solution which are not spherically symmetric.

GR 16.6 Thu 17:10 H 2013

Initial data for binary neutron stars with adjustable eccentricity — •Niclas Moldenhauer[1], Charalampos Markakis[2], Nathan Johnson-McDaniel[3], Wolfgang Tichy[4], and Bernd Brügmann[1] — [1]Theoretical Physics Institute, University of Jena — [2]Mathematical Sciences, University of Southampton — [3]ICTS of the Tata Institute of Fundamental Research — [4]Physics Department, Florida Atlantic University,

Binary neutron stars in circular orbits can be modeled as helically symmetric, i.e., stationary in a rotating frame. This symmetry gives rise to a first integral of the Euler equation. For eccentric orbits, however, the lack of helical symmetry has prevented the use of this method, and the numerical relativity community has often resorted to constructing initial data by superimposing boosted spherical stars, which leads to spuriously excited neutron star oscillations during the evolution. We consider eccentric confgurations at apoapsis that are instantaneously stationary in a rotating frame and extend the notion of helical symmetry to eccentric orbits. We use the obtained first integrals as the basis of a self-consistent iteration of the Einstein constraints to construct conformal thin-sandwich initial data for eccentric binaries. We discuss that effect of the improved data on the evolutions, e.g. by looking at the spurious stellar oscillations and the tidally induced oscillations.

GR 16.7 Thu 17:30 H 2013

Dynamical simulations of neutron star spacetimes with conservative mesh refinement — •Tim Dietrich[1], Sebastiano Bernuzzi[2,3], Maximiliano Ujevic[4], and Bernd Brügmann[1] — [1]Theoretical Physics Institute, University of Jena, 07743 Jena, Germany — [2]TAPIR, California Institute of Technology, 1200 E California Blvd,Pasadena, California 91125, USA — [3]DiFeST, University of Parma, and INFN Parma, I-43124 Parma, Italy — [4]Centro de Ciencias Naturais e Humanas, Universidade Federal do ABC, 09210-170, Santo Andre, Sao Paulo, Brazil

The most recent and improved general-relativistic grid-based simulations of neutron star systems produced with our code BAM are presented. We focus in particular on the adaptive mesh refinement (AMR) implementation. AMR is an important tool to reduce computational costs and still to resolve multiple scales: the stars interiors, the orbital strong field region, and the radiation zone. Here, the use of a conservative AMR enforcing mass conservation over refinement boundaries is investigated. We show the usage during (i) a variety of single neutron star test spacetimes, (ii) the gravitational collapse of rotating neutron stars to black holes, and (iii) the ejection of material in a binary neutron star system. According to our results accurate simulations beyond the merger should include a conservative mesh refinement.

GR 16.8 Thu 17:50 H 2013

A new gravitational wave generation algorithm for particle perturbations of the Kerr spacetime — •Enno Harms[1], Sebastiano Bernuzzi[2], Alessandro Nagar[3], and Anil Zenginoglu[4] — [1]TPI Uni Jena — [2]California Institute of Technology - USA — [3]IHES - Bures Sur Yvette - France — [4]IHES - Bures Sur Yvette - France

We present a new approach to solve the 2+1 Teukolsky equation for gravitational perturbations of a Kerr black hole. Our approach relies on a new horizon penetrating, hyperboloidal foliation of Kerr spacetime and spatial compactification. In particular, we present a framework for waveform generation from point-particle perturbations and its application to black-hole binary inspirals in the large-mass-ratio limit.