# GR 19: Numerical Relativity III

Time: Friday 11:00–12:00 Location: KH 02.012

GR 19.1 Fri 11:00 KH 02.012

**Improved Moving-Puncture Techniques for Binary Black-Hole Simulations** — •Linsheng Li — Institut für Theoretische Physik, Goethe Universität, Frankfurt am Main, Germany

To fully exploit current and upcoming gravitational-wave observations, accurate numerical-relativity simulations of compact binaries require tight control of constraint violations in moving-puncture evolutions. We present a moving-puncture scheme in the CCZ4 formulation within the Einstein Toolkit that incorporates both a slow-start lapse (SSL) condition and a curvature-adjusted Hamiltonian-constraint damping (CAHD) prescription, aimed at reducing constraint violations and improving the quality of the extracted waveforms. By exploiting the constraint-propagation and damping properties of CCZ4, we re-tune the Z4 damping and gauge parameters to improve constraint control through inspiral, merger, and ringdown. For equal-mass, nonspinning binary black-hole simulations, the SSL+CAHD+CCZ4 scheme significantly reduces Hamiltonian and momentum-constraint violations in both the strong-field region and the wave-extraction zone.

GR 19.2 Fri 11:15 KH 02.012

**Black hole spectroscopy of collapsing and merging neutron stars** — •Oliver Steppohn[1], Sebastian H. Völkel[2], and Tim Dietrich[1] — [1]Institut für Physik und Astronomie, Universität Potsdam, Haus 28, Karl-Liebknecht-Str. 24-25, 14476 Potsdam, Germany — [2]Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Am Mühlenberg 1, 14476 Potsdam, Germany

Black hole spectroscopy is an important pillar when studying gravitational waves from black holes and enables tests of general relativity. Most of the gravitational wave signals observed over the last decade originate from binary black hole systems. Binary neutron star or black hole-neutron star systems are rarer but of particular interest for the next-generation ground-based gravitational wave detectors. These events offer the exciting possibility of studying matter effects on the ringdown of "dirty black holes". In this work, we ask the question: Does matter matter? Using numerical relativity, we simulate a wide range of collapsing neutron stars producing matter environments, both in isolated scenarios and in binary mergers. Qualitatively, the resulting ringdown signals can be classified into "clean", "modified", and "distorted" cases, depending on the amount of matter that is present. We apply standard strategies for extracting quasinormal modes of clean signals, using both theory-agnostic and theory-specific assumptions. Even in the presence of matter, possible modifications of quasinormal modes seem to be typically dominated by ringdown modeling systematics.

GR 19.3 Fri 11:30 KH 02.012

**Numerical relativity with NRPy+ and deal.ii** — •Göran Ratz[1,2] and Frank Ohme[1,2] — [1]Max Planck Institute for Gravitational Physics, Hannover, Germany — [2]Leibniz University Hannover, Hannover, Germany

Numerical Relativity has been an insightful and irreplaceable part of understanding the nonlinear dynamics of spacetime. It is also known for being a little inaccessible mainly due to its magnificent computational costs and specialisation. In my talk, I want to give a brief introduction to NRPy+ (https://nrpyplus.net/), a well documented and beginner-friendly NR python library which makes, by some smart coordinate choices, certain black-hole merger simulations accessible for the "everyday user". I will also discuss the application of the C++ FEM-library deal.ii (https://dealii.org/) for generating Bowen-York-Brandt-Brügmann initial data slices for numerical relativity.

GR 19.4 Fri 11:45 KH 02.012

**Machine Learning-Accelerated HLLD Riemann Solver for GRMHD** — •Keneth Miler — Institut für Theoretische Physik, Goethe Universität, Max-von-Laue-Str. 1, D-60438

We present a machine-learning-enhanced HLLD Riemann solver for GRMHD simulations that significantly reduces computational cost. The primary bottleneck in HLLD schemes is the iterative pressure recovery from conserved variables. We replace this expensive root-finding procedure with a trained neural network that directly predicts primitive pressure.