GR 11: Numerical Relativity II

Time: Thursday 11:00–12:00 Location: KH 01.016

Invited Talk GR 11.1 Thu 11:00 KH 01.016

Numerical Relativity for LISA and the Einstein Telescope — •Nils Vu — California Institute of Technology, Pasadena, USA

The upcoming European gravitational-wave detectors LISA and the Einstein Telescope are bound to revolutionize our understanding of black holes across the Universe, but to make sense of their data we will require extremely accurate numerical simulations of merging black holes and their gravitational waves. This is the realm of numerical relativity and requires solving Einstein's equations of general relativity to extreme precision on large supercomputers. In this talk, I will give an overview of the state-of-the-art in numerical relativity, recent advances in simulating merging binary black holes with highly efficient spectral finite-element methods, and the challenges that lie ahead to reach the requirements for the era of next-generation gravitational-wave astronomy.

GR 11.2 Thu 11:30 KH 01.016

A novel approach for the systematic study of long-lived merger remnants with neutrino radiation — •Marie Cassing[1], Luciano Rezzolla[1,2,3], Carlo Musolino[1], Konrad Topolski[1], Harry Ho-Yin Ng[1], and Keneth Miler[1] — [1]Goethe University Frankfurt, Frankfurt am Main, Germany — [2]CERN, Theoretical Physics Department, Geneva, Switzerland — [3]School of Mathematics, Trinity College, Dublin, Ireland

We introduce a novel hybrid framework for simulating binary neutron star mergers (BNS) with neutrino radiation, developed to explore the long-term evolution of postmerger remnants. The approach combines the strengths of the general-relativistic magnetohydrodynamics (GRMHD) code FIL for modeling the inspiral and merger phase with the advanced code BHAC+, which takes over in the postmerger phase. In BHAC+, we implement an M1 two-moment neutrino transport scheme and solve the stiff source terms with an implicit-explicit (IMEX) time integration strategy. This enables robust simulations of neutrino matter coupling over long timescales. Our primary aim is to study neutrino-driven winds, changes in remnant structure, and their potential to influence jet launching in scenarios involving long-lived neutron stars or delayed collapse to a black hole. We present results of M1 test problems and physical setups validating our implementation and outline the potential of this hybrid approach to systematically explore ejecta properties and electromagnetic counterparts in BNS mergers.

GR 11.3 Thu 11:45 KH 01.016

Gravitational Scattering of two Neutron Stars — •Joan Fontbuté — Friedrich-Schiller Universität, Jena, Germany

In this talk I'm going to present the first numerical relativity simulations of gravitational scattering between neutron stars and the first comparison of such simulations with analytical predictions as well as the black hole case. Constraint-satisfying initial data for two equal-mass non-spinning sequences are constructed at fixed energy and various initial angular momenta for two Equations of State. Our results probe extreme strong-field regimes up to the threshold of dynamical capture, revealing both agreement and significant tidal discrepancies with effective-one-body and post-Minkowskian predictions to the scattering angle. Together with these results obtained with the BAM code, I'm also going to present an extension to more realistic scenarios containing magnetic fields, M1 neutrino transport and a better atmosphere treatment with the GR-Athena++ code, where we also study in detail other properties of such events like the final spins, magnetic field properties and mass ejecta. The matter ejected is found to be crucial to explain the decrease in the binding energy that eventually makes the system become bound.