GR 9: Gravitational Waves

Time: Wednesday 16:15–18:35 Location: GR-H2

GR 9.1 Wed 16:15 GR-H2

Machine Learning Gravitational-Wave Search Mock Data Challenge — •Marlin Benedikt Schäfer — Albert-Einstein-Institut, D-30167 Hannover, Germany — Leibniz Universität Hannover, D-30167 Hannover, Germany

Gravitational wave astronomy is a rapidly growing field and the number of detections is rising faster with each observational period. With this come new challenges when extracting the signals from noise. A new approach to handle large quantities of data and possibly search regions of parameter space that are computationally prohibitive to search with state-of-the-art classical algorithms is the utilization of machine learning techniques. This projects aims to clarify the capabilities of current deep learning algorithms and how they compare to traditional methods. The challenge provides mock data of gradually increasing realism to aid the adoption of machine learning based algorithms in detection pipelines and wants to help establishing the wide adoption of astrophysically motivated evaluation metrics.

GR 9.2 Wed 16:35 GR-H2

New generation effective-one-body waveforms for binary black holes with non-precessing spins — Serguei Ossokine[1], Deyan Mihaylov[1], •Lorenzo Pompili[1], Alessandra Buonanno[1,2], Michael Pürrer[1], and Mohammed Khalil[1,2] — [1]Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Am Mühlenberg 1, Potsdam 14476, Germany — [2]Department of Physics, University of Maryland, College Park, Maryland 20742, USA

We present an improved inspiral-merger-ringdown gravitational waveform model for quasi-circular, spinning, non-precessing binary black holes within the effective-one-body (EOB) formalism. Compared to its predecessor SEOBNRv4HM the waveform model i) incorporates recent high-order post-Newtonian results in the inspiral, with improved factorizations ii) includes the gravitational modes $(\ell, |m|) = (3, 2), (4, 3)$, in addition to the $(\ell, |m|) = (2, 2), (3, 3), (2, 1)(4, 4), (5, 5)$ modes already implemented in SEOBNRv4HM iii) has been recalibrated to larger mass ratios and spins using a catalog of 441 numerical-relativity (NR) simulations, and to 13 additional waveforms from black-hole perturbation theory. The accuracy of the waveform model is quantified by computing the unfaithfulness against the NR catalog used for its construction. The waveform model has been implemented in a new Python framework, that makes it easily extensible to include spin-precession and eccentricity effects, thus making it the starting point for a new generation of EOB waveform models (SEOBNRv5) to be employed for upcoming observing runs of the LIGO-Virgo-KAGRA detectors.

GR 9.3 Wed 16:55 GR-H2

TEOBResumS: an advanced waveform model for O4 — •Rossella Gamba — Friedrich-Schiller-Universität Jena, Jena, Germany

The detection of Gravitational Waves by LIGO and Virgo opened a new, exceptional avenue for studying the physics of binary systems of compact objects, such as black holes and neutron stars. Source properties can be extracted from the LIGO/Virgo data via matched filtering techniques that employ waveform templates, i.e. theoretical models of the gravitational waves (GWs) emitted by the two coalescing bodies. To be able to obtain the largest amount of information from the data, such models must incorporate a large amount of physics while retaining high faithfulness to waveforms from numerical relativity simulations. In this talk I will present TEOBResumS, an efficient state-of-the-art waveform model for GWs from generic binary systems. I will detail the physics included, highlight its computational efficiency and faithfulness and show applications to real and simulated data in view of the fourth observing run O4, planned for late 2022.

GR 9.4 Wed 17:15 GR-H2

TEOBResumS for black-hole-neutron star merger waveforms — •Alejandra Gonzalez[1], Rossella Gamba[1], Matteo Breschi[1], Francesco Zappa[1], Sebastiano Bernuzzi[1], and Alessandro Nagar[2] — [1]Theoretisch-Physikalisches Institut, Friedrich-Schiller-Universität Jena, 07743, Jena, Germany — [2]INFN Sezione di Torino, Via P. Giuria 1, 10125 Torino, Italy

We present a new effective-one-body (EOB) model for black-hole-neutron-star merger waveforms based on a numerical-relativity (NR) informed model of the remnant BH state and a ringdown that deforms the EOB ringdown for binary black holes. The new model reproduces the (2,2) mode waveform of NR simulations with typical phase agreement within 0.5 rad to merger and within 1 rad including ringdown. Comparing to other available BHNS waveform models, the NR phasing is captured with a comparable accuracy. The model also includes higher modes (2,1), (2,2), (3,2), (3,3), (4,4) and (5,5). We present a full Bayesian analysis of the gravitational-wave events GW190814, GW200105, and GW200115, and find consistent results with previous studies.

GR 9.5 Wed 17:35 GR-H2

Realistic observing scenarios for the next decade of early warning detection of binary neutron stars — Ryan Magee[1] and •Ssohrab Borhanian[2] — [1]California Institute of Technology, Pasadena, USA — [2]Friedrich-Schiller-Universität Jena, Jena, Germany

We describe realistic observing scenarios for early warning detection of binary neutron star mergers with the current generation of ground-based gravitational-wave detectors as these approach design sensitivity. Using Fisher analysis, we compute both the number of detections and the sky localizations to expect from future detector network configurations. We estimate that the Advanced LIGO and Advanced Virgo facilities will detect two signals before merger in their fourth observing run, while the addition of the Kagra and LIGO-India detectors, at design sensitivites, should increase these numbers to the order of 10 early warning detections per year in the fifth observing run. More than 70% of these events will be localized to less than $100\,\mathrm{deg}^2$, with one achieving a localization of $\sim 20\,\mathrm{deg}^2$. Given uncertainties in sensitivities, participating detectors, and duty cycles, we include a data release that allows for full generalizability of future detector networks so electromagnetic observers can tailor preparations towards their preferred models.

GR 9.6 Wed 17:55 GR-H2

Quantifying modelling uncertainties when combining multiple gravitational-wave detections from binary neutron star sources — •Nina Kunert[1], Peter Tsun Ho Pang[2,3], Ingo Tews[4], Michael William Coughlin[5], and Tim Dietrich[1,6] — [1]Institute for Physics and Astronomy, University of Potsdam, D-14476 Potsdam, Germany — [2]Nikhef, Science Park 105, 1098 XG Amsterdam, The Netherlands — [3]Institute for Gravitational and Subatomic Physics (GRASP), Utrecht University, Princetonplein 1, 3584 CC Utrecht, The Netherlands — [4]Theoretical Division, Los Alamos National Laboratory, Los Alamos, NM 87545, USA — [5]School of Physics and Astronomy, University of Minnesota, Minneapolis, Minnesota 55455, USA — [6]Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Am Muehlenberg 1, Potsdam 14476, Germany

The combined analysis of multiple gravitational-wave signals from binary neutron star sources enables to constrain the neutron-star radius with unprecedented accuracy in the near future. However, it is crucial to ensure that uncertainties inherent in the gravitational-wave models will not lead to systematic biases when multiple detections are combined. To quantify waveform systematics, we perform an extensive simulation campaign of binary neutron-star sources and analyse them with a set of four different waveform models. We find that statistical uncertainties in the neutron-star radius decrease to ± 250m (2% at 90% credible interval), while systematic differences among currently employed waveform models can be twice as large emphasizing the need for waveform models with increased accuracy.

GR 9.7 Wed 18:15 GR-H2

Neutrino and viscosity effects on binary neutron star dynamics, gravitational waves and emitted material — •Francesco Zappa — Friedrich-Schiller-Universität Jena Theoretisch-Physikalisches Institut

We present a multi-resolution and multi-physics comparison of simulations performed with the `WhiskyTHC` code of a single binary*neutron star merger with component neutron star mass of 1.3 $M_\odot$ using the finite-temperature equation of state SLy4. Our simulations set consists of pure General Relativistic Hydrodynamic evolution; simulations with a leakage scheme for neutrino production; runs which include M0 treatment for the propagation of free-streaming neutrinos; simulations which include an effective treatment for magnetic-driven turbulent viscosity; simulations which make use of the `THC_M1` scheme recently implemented in the code for neutrino treatment. We find that the effect of resolution is dominant with respect to the different physics simulated regarding the gravitational wave production and the merger dynamics, as well as on the onset of black hole collapse. The post-merger disk mass, the disk composition and its thermodynamic properties are instead affected by the production of neutrinos or the presence of turbulent viscosity. The ejected mass and its proton fraction has a very strong dependence on the neutrino treatment employed. Our higher resolution runs confirm that the proton-richest matter is produced when employing M1, at small angles from the orbital plane.