GR 8: GW III

Time: Wednesday 13:30–14:50 Location: ZHG007

GR 8.1 Wed 13:30 ZHG007

Systematic Errors In Gravitational Waveform Models — •Max Melching[1], Frank Ohme[1], and Sumit Kumar[1,2] — [1]Max Planck Institute for Gravitational Physics, Callinstraße 38, 30167 Hannover, Germany — [2]Utrecht University, Heidelberglaan 8, Utrecht 3584 CS, Netherlands

Measurements of gravitational wave source properties rely on waveform models in order to compare the detector data with theoretical signal predictions and find the best-fitting parameters. However, the waveform models used today are not entirely faithful representations of numerical relativity due to the high computational cost of generating accurate simulations. Instead, several approximate models are used, which can lead to differences in the inferred results. Therefore, it is crucial to be able to describe and understand model-induced uncertainties, so-called systematic errors.

To date, however, there is no universal way to do so. In this talk, I will introduce geometric ideas from the Fisher-matrix formalism that allow interpreting signal differences as measurement uncertainties in the associated parameter space. This includes a discussion of the estimates derived in this formalism, e.g. about their accuracy. Additionally, I will talk about the interplay between systematic errors and the calibration uncertainty of gravitational wave detectors, addressing questions like: How to build up a reliable framework to account for them in parameter estimation? Can the two types of errors be distinguished? Which of them is dominant?

GR 8.2 Wed 13:50 ZHG007

Systematic Biases in Estimating the Properties of Black Holes Due to Inaccurate Gravitational-Wave Models: Part I — Arnab Dhani[1], •Sebastian H. Völkel[1], Alessandra Buonanno[1,2], Hector Estelles[1], Jonathan Gair[1], Harald P. Pfeiffer[1], Lorenzo Pompili[1], and Alexandre Toubiana[1] — [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, MD 20742, USA

Gravitational-wave observations of binary black-hole coalescences are expected to address outstanding questions in astrophysics, cosmology, and fundamental physics. Realizing the full discovery potential of upcoming LIGO-Virgo-KAGRA observing runs and new ground-based facilities hinges on accurate waveform models. We present a comprehensive state-of-the-art analysis of binary black hole waveform systematics. Using linear-signal approximation methods and Bayesian analysis, we start to assess our readiness for what lies ahead using two state-of-the-art quasi-circular, spin-precessing models: `SEOBNRv5PHM` and `IMRPhenomXPHM`. Future progress in analytical calculations and numerical-relativity simulations, crucial for calibrating the models, must target regions of the parameter space with significant biases to develop more accurate models. Only then can precision gravitational wave astronomy fulfill the promise it holds. In this talk, part 1 of 2, we outline the importance of such studies, introduce waveform modeling and statistical methods. Review and discussion of our results will be provided in another talk as part 2. [arXiv:2404.05811]

GR 8.3 Wed 14:10 ZHG007

Systematic Biases in Estimating the Properties of Black Holes Due to Inaccurate Gravitational-Wave Models: Part II — Arnab Dhani[1], Sebastian H. Völkel[1], Alessandra Buonanno[1,2], Hector Estelles[1], Jonathan Gair[1], •Harald P. Pfeiffer[1], Lorenzo Pompili[1], and Alexandre Toubiana[1] — [1]Max-Planck-Institute for Gravitational Physics, Am Mühlenberg 1, 14476 Potsdam — [2]Dept. of Physics, University of Maryland, College Park, MD 20742, USA

Gravitational-wave observations of binary black-hole coalescences are expected to address outstanding questions in astrophysics, cosmology, and fundamental physics. Realizing the full discovery potential of upcoming LIGO-Virgo-KAGRA observing runs and new ground-based facilities hinges on accurate waveform models.

This talk is part 2 of two talks presenting an in-depth study of the impact of parameter estimation biases due to imperfect waveform models. Using the techniques presented in part 1, we analyse in depth three prototypical binaries expected to occur in future GW detectors, and find potentially large errors in the estimated parameters (among them component masses and distance) if today's waveform models are utilised. We furthermore highlight were in BBH parameter space significant parameter estimation errors are most likely, and how widespread and how severe they are.

GR 8.4 Wed 14:30 ZHG007

Fighting Gravity Gradient Noise with Gradient-Based Optimization at the Einstein Telescope — •Patrick Schillings and Johannes Erdmann — III. Physikalisches Institut A, RWTH Aachen University

The Einstein Telescope is a third-generation, underground gravitational wave detector that will allow us to measure gravitational waves with significantly improved precision. Its 'xylophone' arrangement is designed to extend the frequency range down to a few Hertz. To improve the sensitivity of the low-frequency interferometer, one needs to mitigate the gravitational effect of density fluctuations in the surrounding rock caused by seismic activity, which result in so-called Newtonian noise in the detector. To achieve that, an array of seismometers will be installed around the mirrors. Expensive boreholes will have to be drilled in order to place these seismometers, which will limit the total number of seismometers that can be placed for a given budget. Therefore, the available resources should be used optimally in terms of predicting the Newtonian noise from the seismometer data. This talk will focus on a differential approach to this optimization problem, which leads to an improvement in terms of noise reduction and runtime compared to methods that were used before.