GR 11: Relativistic Astrophysics

Time: Thursday 11:00–12:40 Location: GR-H2

GR 11.1 Thu 11:00 GR-H2

Constraining supranuclear-dense matter with nuclear physics and multi-messenger astrophysics — •Tim Dietrich — Institute of Physics and Astronomy, University of Potsdam, Potsdam, Germany — Max Planck Institute for Gravitational Physics (Albert Einstein Institute), Potsdam, Germany

Our knowledge about dense matter explored in the cores of neutron stars remains limited. Fortunately, the detection of gravitational waves emitted from the merger of neutron stars and the corresponding electromagnetic signals allows us to place constraints on the properties of matter at supranuclear densities. Furthermore, such densities are not only probed in astrophysical observations, but also in terrestrial experiments. In this work, we use Bayesian inference to combine a large set of data from astrophysical multi-messenger observations of neutron stars and from heavy-ion collisions of gold nuclei at relativistic energies with microscopic nuclear theory calculations. Our findings show that constraints from heavy-ion collision experiments show a remarkable consistency with multi-messenger observations and provide complementary information on nuclear matter at intermediate densities. This work combines nuclear theory, nuclear experiments, and astrophysical observations from multiple messengers. Such joint analyses will be the key to shed light on the properties of neutron-rich supranuclear matter over the density range probed in neutron stars.

GR 11.2 Thu 11:20 GR-H2

Tidally-driven crustal failure in coalescing binaries of neutron stars as triggers for precursor flares of short gamma-ray burst — •Hao-Jui Kuan[1,2], Arthur Suvorov[3], and Kostas Kokkotas[1] — [1]Theoretical Astrophysics, IAAT, University of Tübingen, Tübingen, D-72076, Germany — [2]National Tsing Hua University, Hsinchu 300, Taiwan — [3]Manly Astrophysics, 15/41-42 East Esplanade, Manly, NSW 2095, Australia

In some short gamma-ray bursts, precursor flares occurring $\sim$ seconds prior to the main episode have been observed. These flares may then be associated with the last few cycles of the inspiral when the orbital frequency is a few hundred Hz. During these final cycles, tidal forces can resonantly excite quasi-normal modes in the inspiralling stars, leading to a rapid increase in their amplitude. It has been shown that these modes can exert sufficiently strong strains onto the neutron star crust to instigate yieldings. Among other possible modes, the typical frequencies of g-modes being $\sim$ 100 Hz warrant further investigation since their resonances with the orbital frequency match the precursor timings. Adopting realistic equations of state (EOS) and solving the general-relativistic pulsation equations, we study g-mode resonances in coalescing quasi-circular binaries, where we consider various stellar rotation rates, degrees of stratification, and magnetic field structures. We show that for some combination of stellar parameters, the resonantly excited g_1- and g_2-modes may lead to crustal failure and trigger precursor flares, and also some EOS are more likely to cause the crustal cracks.

GR 11.3 Thu 11:40 GR-H2

Non-thermal electromagnetic counterparts to binary neutron star mergers and supernovae — •Vsevolod Nedora — Max-Planck-Institut für Gravitationsphysik, Potsdam, Germany — Universität Potsdam, Potsdam, Germany

In 2017 the merger of two neutron stars was observed in gravitational waves and across the electromagnetic spectrum. The event was associated with the short gamma-ray burst (GRB) GRB170817A, the afterglow from which peaked 160 days after the burst, before starting to decay in agreement with short GRB models. Much later, 1234 days after the burst, a change in the GRB170718A light curve behavior was observed, inconsistent with most GRB models.

We design a new numerical tool to model the synchrotron radiation arising from interactions between the ejected matter and the interstellar medium, employing the recent theoretical advancements in our understanding of relativistic jetted and oblate mildly relativistic outflows.

Assuming that the change of the afterglow is due to an emerging new component (e.g., kilonova ejecta), we investigate the properties of this component by modeling kilonova and GRB afterglows simultaneously. This allows us to take advantage of all the gathered data and obtain new constraints on the dynamics of the ejected matter and NS EOS.

GR 11.4 Thu 12:00 GR-H2

Fast Rotating Relativistic Stars: Spectra and Stability without Approximation — •Christian Krueger and Kostas Kokkotas — Universitaet Tuebingen, Auf der Morgenstelle 10, 72076 Tuebingen

The oscillations and instabilities of relativistic stars are studied by taking into account, for the first time, the contribution of a dynamic spacetime. The study is based on the linearised version of Einstein's equations and via this approach the oscillation frequencies, the damping and growth times as well as the critical values for the onset of the secular (CFS) instability are presented. The ultimate universal relations for asteroseismology are derived which can lead to relations involving the moment of inertia and Love numbers in an effort to uniquely constrain the equation of state via all possible observables. The results are important for all stages of neutron star's life but especially to nascent or post-merger cases.

GR 11.5 Thu 12:20 GR-H2

Exploring black holes as particle accelerators: hoop-radius and escaping conditions — Stefano Liberati[2], •Christian Pfeifer[1], and Javier Relancio[3] — [1]University of Bremen, Bremen, Germany — [2]SISSA and INFN, Trieste, Italy — [3]Università di Napoli Federico II, Napoli, Italy

The possibility that rotating black holes could be natural particle accelerators has been subject of intense debate. While it appears that for extremal Kerr black holes arbitrarily high center of mass energies could be achieved, several works pointed out that both theoretical as well as astrophysical arguments would severely dampen the attainable energies. In this talk I study particle collisions near Kerr black holes, in particular collision between an infalling particle from infinity and a target particle that is already in the near vicinity of the black hole horizon. Most importantly, I will show how to implement the hoop conjecture and discuss the astrophysical relevance of these target particle collisional Penrose processes. The outcome is that the center of mass energy in such collisions can be ultra high. Moreover, I discuss that for nearly extremal black holes, the energy of the particles escaping the black hole region can be similarly large. Thus, these target particle collisional Penrose processes could contribute to the observed spectrum of ultra high-energy cosmic rays, even if the hoop conjecture is taken into account.