SYPS 1: Extreme matter meets extreme gravity

Zeit: Mittwoch 15:00–17:00 Raum: HS 5

Hauptvortrag SYPS 1.1 Mi 15:00 HS 5

Black-hole superradiance: Probing ultralight bosons with compact objects and gravitational waves — •Paolo Pani — Sapienza University of Rome, Italy

Ultralight bosonic fields (e.g. stringy axions, axion-like particles, dark photons, light spin-2 fields) are compelling dark-matter candidates and provide a serious alternative to the WIMP paradigm. These fields have eluded particle detectors so far, but can dramatically affect the strong-gravity dynamics of compact objects (black holes and compact stars) in various detectable ways. Light bosonic fields can trigger superradiant instabilities which have peculiar signatures, e.g. they produce "gaps" in the mass-spin diagram of astrophysical black holes and predict a measurable spin-down rate of pulsars. These effects can be used to constrain axion-like particles, to derive bounds on dark photons and on the mass of the graviton, as well as to constrain the fraction of primordial black holes in dark matter. Because of their tiny mass and coupling to the Standard Model, detecting axions and other light bosons in the lab is extremely challenging. However, boson condensates formed through superradiance would emit a periodic gravitational-wave signal (whose frequency is related to the boson mass) which can be detected with present and future gravitational-wave interferometers, either as stochastic background or as continuous resolvable sources. The theoretical potential of these phenomena as almost-model-independent smoking guns for physics beyond the Standard Model are presented.

Hauptvortrag SYPS 1.2 Mi 15:40 HS 5

Modelling and analyzing a binary neutron-star merger: Interpreting a multi-messenger picture — •Tim Dietrich — Nikhef, Amsterdam, Netherlands

With the detection of the binary neutron-star merger GW170817 a new era of multi-messenger astronomy started. GW170817 proved that neutron-star mergers are ideal laboratories to constrain the equation of state of cold supranuclear matter, to study the central engines of short GRBs, to understand the origin and production of heavy elements, to measure the expansion of the universe, and to determine the speed of gravitational waves. In the talk, we give an overview about some of the interesting insights we learned from GW170817 and present work crucial for this recent scientific success. In particular, we discuss the development of accurate gravitational waveform models, employed data analysis tools, and the progress made in the field of numerical relativity and in the modelling of electromagnetic signals arising from binary neutron-star mergers.

Hauptvortrag SYPS 1.3 Mi 16:10 HS 5

What can neutron-star mergers reveal about the equation of state of dense matter? — •Ingo Tews — Theoretical Division, Los Alamos National Laboratory, Los Alamos, NM 87545, USA

Neutron stars (NS) are astrophysical objects of extremes. They contain the largest reservoirs of degenerate fermions, reaching the highest densities we can observe in the cosmos, and are, thus, ideal laboratories for fundamental physics. Of particular interest for nuclear physics is the equation of state (EOS) of dense matter, probed in the NS cores. In August 2017, the first NS merger, GW170817, has been observed and provided compelling evidence that these events are an important site for the production of neutron-rich heavy elements within the r-process. In addition, GW170817 provides constraints on the NS tidal polarizability. The tidal polarizability describes how a star deforms under an external gravitational field and strongly depends on the star's compactness. Therefore, GW170817 has been used to constrain the mass-radius relationship and, hence, the EOS.

In this talk, I will use state-of-the-art calculations of the EOS, using Chiral effective field theory and advanced Quantum Monte Carlo many-body methods, and two different high-density extrapolations to address the question how GW170817 and future NS-merger observations can improve our understanding of the high-density nuclear physics probed in the cores of neutron stars.

Final 20min: Panel discussion