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EDITORIAL
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Editorial: Neutron Star Physics in the Multi-Messenger Discourse

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Editorial on the Research Topic

Neutron Star Physics in the Multi-Messenger Discourse

In 2017, Multi-messenger astronomy/astrophysics finally arrived when gravitational waves were directly observed by the LIGO and VIRGO detectors. This event, known as GW170817, triggered a worldwide effort involving 70 observatories on seven continents and in space to gather data across a wide band of electromagnetic radiation (in particular, a short gamma ray burst and kilonova). With little doubt, GW170817 was produced by the inspiral and final merger of two neutron stars (the collapsed cores of regular stars which have exhausted their nuclear fuel). In fact, analysis of the GW170817 remnant contained the tell-tale signs of gold, as well as platinum, confirming nuclear physics predictions that the energetics of neutron star collisions is likely required for natural production of the two elements. This research topic is devoted to the theoretical and computational tools required to model crucial elements of events like that of GW170817.

"Neutron stars (NSs) are extraordinary not only because they are the densest form of matter in the visible Universe but also because they can generate magnetic fields 10 orders of magnitude larger than those currently constructed on earth." This is a quote taken from this article by Ruiz et al.. They discuss results of a broad physical and computational framework that combines extreme gravity with enormous electromagnetic fields in order to model events like the gravitational wave signal, short γ-ray burst, and kilonova captured by the detections of GW170817, and the electromagnetic signals GRB 170817 and AT 2017gfo.

In his article Andersson reviews the relativistic multifluid system and how it can cover a wide range of scenarios relevant for different astronomical observation channels: radio and x-ray pulsar timing, gravitational-wave searches, neutron star cooling and associated x-ray observations, long-term evolution of a neutron star's magnetic field, and explosive phenomena like gamma-ray bursts.

In their article Gavassino and Antonelli review recent progress on understanding the mathematical origin of instabilities which occur when non-equilibrium thermodynamics fluid phenomena are considered in relativity.

In their article Krüger et al. review the main results from their recent research on the oscillations of fast rotating neutron stars. They present universal relations (e.g., independent of the equation of state of dense nuclear matter) which combine bulk properties of isolated neutron stars as well as of binary systems before and after merger. Combining these with data on the frequencies of non-axisymmetric modes of compact objects, they have developed what could become a valuable tool for gravitational wave asteroseismology.

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