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Constraining the properties of strongly interacting matter with the multi-messenger observations of compact stars

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Compact stars are the most exotic and dense laboratories in the Universe to test the properties of strongly interacting matter. Understanding the complex phenomena observed in neutron and hybrid stars requires profound knowledge in a wide range of scientific disciplines. In addition to the experimental data on nuclear and hadron matter, the realistic equation of state (EoS) should be consistent with the astrophysical, and gravitational wave observations. While details of the phase transitions and properties of quark matter are traditionally investigated in the accelerator experiments on heavy-ion collisions, compact astrophysical objects recently gained a big interest since observational data on their radii, masses, rotational frequencies, etc. significantly constrain the properties of strongly interacting matter. Another source of information comes from the binary neutron star mergers. Thus, the LIGO-Virgo interferometers detection of gravitational waves emitted during the binary neutron stars merger, GW170817, set the major limit on the tidal deformabilities of the stars involved in the collision and, therefore, on the EoS at the super-high baryonic densities.
I will present the astrophysical and gravitational wave constraints on the EoS of strongly interacting matter as well as the smoking gun signals of the deconfinement phase transition in compact stars and their mergers. As regards observations of gravitational waves, it has been recently reported that phase transition from hadron to quark matter is expected to have a dramatic impact on the frequency of gravitational waves emitted during neutron star mergers, which provides a fresh and continuously updating ground for testing the formulated equation of state. Finally, I will briefly mention how the next generation of gravitational wave telescopes will probe the existence of the deconfinement phase transition in compact stars.

Using an example of the recently announced lightest compact star HESS J1731-347 I will demonstrate how the multi-messenger observations could shed light on the interior composition of the star.

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