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Nuclear physics as a tool to understand neutron stars and QCD phase transitions

Neutron stars are the most mysterious objects in the universe, with a radius of the order of 10 km and masses that can reach two solar masses. In 2017, a gravitational wave was detected (GW170817) and its source was identified as the merger of two neutron stars. Later on, a mass-gap object (either a neutron star or a black hole) was identified in the GW190814 event. To understand neutron stars, an appropriate equation of state that satisfies bulk nuclear matter properties has to be used and gravitational wave detections have provided some extra constraints to determine it. Moreover, the NICER telescope, launched in 2017, has also started (in 2021) to send information that helps us determine the radius of these compact objects.

On the other hand, the analysis of the QCD phase diagram points to a deconfined quark phase standing exactly at the region related to neutron stars, i.e., high densities and low temperatures, which opens the possibility that neutron stars can be different classes of compact objects: hadronic stars, hybrid stars with hadrons and quarks and even strange stars satisfying the Bodmer-Witten conjecture.

I will show that, using different models that describe hadronic and quark matter that massive hybrid stars can be obtained and, for certain model choices, quark cores corresponding to more than 80% of both, its total mass and radius, are possible. Moreover, all classes of compact objects mentioned above can explain the mass-gap object in the GW190814 event.

Attendance Type

Remote

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