Constraining the interior of neutron stars with gravitational-wave observations

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Abstract

Born in the aftermath of core-collapse supernovae, neutron stars (NSs) are among the most compact objects in the Universe. With a mass of the order of that of the Sun for a radius of ~ 12 km only, these stars are also remarkably dense (their central density is expected to be $\sim 5 - 10$ times higher than the densities measured in atomic nuclei). The physical conditions prevailing inside NSs are actually so extreme that they cannot be experimentally reproduced. Although the analysis of the electromagnetic radiation of these stars (especially through the pulsar phenomenon) has already brought interesting constraints, the equation of state (EoS) characterizing the interior of NSs remains still poorly known [1].

The recent detection of the gravitational-wave (GW) signal GW170817 from the merger of two NSs [2] and the subsequent observations of electromagnetic counterparts [3, 4] offer new opportunities to probe the EoS of dense matter. Apart from estimates of the masses of the two inspiralling NSs, the analysis of this (so far) unique signal has also provided valuable information on their tidal deformations during the last orbits in the inspiral stage [5, 6]. Implications for the EoS will be briefly discussed in this talk.

Up to now, the community has been mainly focused on GWs from NSs in binary systems. Still, isolated NSs are also likely to emit GWs, through the excitations of sismic waves or the presence of 'mountains' on these stars for instance. Recently, a new project has started at ULB, which aims at computing a whole set of GW spectra associated with the oscillations of a single rotating NS for different realistic EoSs. In this talk, I will mention the first steps made so far towards this direction. The comparison of these models with future GW observations related to these oscillation modes will bring further interesting constraints on the EoS.

References

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