Tidal deformability of neutrons and hyperon star

Bharat Kumar[1,2*] and S. K. Patra[1,2†]
[1] *Institute of Physics, Sachivalaya Marg, Bhubaneswar - 751005, INDIA and*
[2] *Homi Bhaba National Institute, Anushakti Nagar, Mumbai 400 085, India.*

Introduction

The detection of gravitational waves is a major breakthrough in astrophysics/cosmology which is detected for the first time by advanced Laser Interferometer Gravitational-wave Observatory (aLIGO) detector. Inspiraling and coalescing of binary black-hole results in emission of the gravitational waves. We may expect that in a few years the forthcoming aLIGO, VIRGO and KAGRA detectors will also detect gravitational waves emitted by binary neutron star (NSs). This detection will provide a valuable guidance and a better understanding of highly compressed baryonic system. Flanagan and Hinderer [1–3] have recently pointed out that tidal effects are also potentially measurable during the early part of the evolution when the waveform is relatively clean. It is understood that the late inspiral signal may be influenced by tidal interaction between binary stars (NS-NS), which gives the important information about the equation-of-state (EOS). Some recent studies inferred that the tidal effects could be measured using the recent generation of gravitational wave (GW) detectors.

In the present talk, we will systematically present the tidal deformability for neutron and hyperon stars using relativistic mean field (RMF) equations of state (EOSs) [4]. The tidal effect plays an important role during the early part of the evolution of compact binaries. Although, the deformability associated with the EOSs has a small correction, it gives a clean gravitational wave signature in binary inspiral. These are characterized by various love numbers k_l (l=2, 3, 4), that depend on the EOS of a star for a given mass and radius. The tidal effect of star could be efficiently measured through advanced LIGO detector from the final stages of inspiraling binary neutron star (BNS) merger.

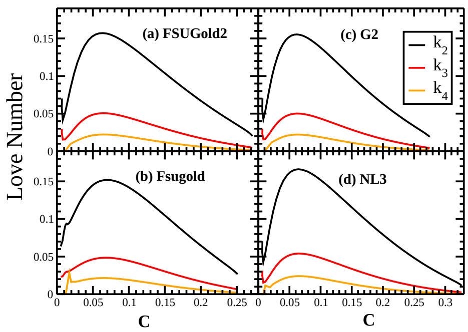

FIG. 1: The tidal love numbers k_2, k_3, k_4 as a function of the mass of the four selected EOSs of the neutron star.

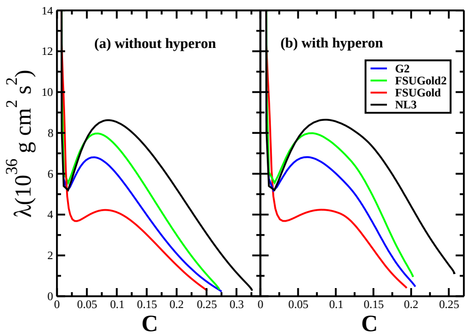

FIG. 2: The tidal deformability λ as a function of the compactness C for the four EOS with and without hyperon.

*Electronic address: bharat@iopb.res.in
†Electronic address: patra@iopb.res.in

Results and Discussions

The results of our calculations for various love numbers which are directly related with the tidal deformations are shown in Fig2. 1 and 2. The dimensionless love number k_l (l=2, 3, 4) is an important quantity to measure the internal structure of the constituent body. These quantities directly enter into the gravitational wave phase of inspiralling binary neutron star (BNS) and extract the information of the EOS. Fig. 1 shows the tidal love numbers k_l (l=2, 3, 4) and Fig. 2 the tidal deformability as a function compactness parameter C for the neutron star with four selected EOSs. Due to the tidal interactions in the neutron star binary, the shape of the star acquires quadrupole, octupole, hexadecapole and other higher order deformations.

Conclusions

We have extended our calculations to various tidal responses both for electric-type (even-parity) and magnetic-type (odd-parity) of neutron and hyperon stars in the influence of an external gravitational tidal field. The love numbers are directly connected with surficial love number h_l associated with the surface properties of the stars. Subsequently, we study the quadrupolar tidal deformability λ of normal neutron star and hyperon star using different set of equations of state. These tidal deformabilities particularly depend on the quadrupole love number k_2 and radius (R) of the isolated star. Although the maximum value of k_2 is not very sensitive to the EOS for neutron and hyperon stars lying in the range $k_2 \approx 0.144-0.170$ and $0.143 - 0.194$ for neutron and hyperon stars, respectively, but it is very much sensitive to the radius of the star.

References

[1] $\acute{E}.\acute{E}.$ Flanagan and T. Hinderer, Phys. Rev. D **77**, 021502 (2008).

[2] T. Hinderer, Astrophys. J. **677**, 1216 (2008); 697964(E) (2009).

[3] T. Hinderer, B. D. Lackey, R. N. Lang, and J. S. Read, Phys. Rev. D **81**, 123016 (2010).

[4] Bharat Kumar, S. K. Biswal and S. K. Patra, Phys. Rev. C **95**, 015801 (2017).