Axial quasi-normal modes of neutron stars in massive scalar-tensor theory

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Various theoretical and experimental observations indicate that General Relativity (GR) should be modified in strong regime. Neutron stars represent valuable astrophysical laboratories to investigate various aspects of gravity. In this study, we focus on the axial Quasi-Normal Modes (QNMs) of scalarized neutron stars with and without massive self interacting scalar field. We investigate the effect of scalarization on static and/or slowly rotating neutron stars for a large variety of realistic equations of state, including nuclear, hyperonic and hybrid matter. We extend and confirm several universal relations which are considered to be independent of the employed equation of state (EOS) for the neutron star's matter composition.

The merger of compact binaries emits gravitational wave which its complete waveform has a typical sequence of phases, consisting of inspiral, merger and ringdown. The ringdown of the resulting compact object after the merger is dominated by its quasi-normal modes. In this research project, we compute the axial QNMs of static neutron stars in scalar tensor theory (STT). Although the effect of spontaneous scalarization of neutron stars can be very large, binary pulsar observations and gravitational wave detections significantly constrain the massless STT. This restriction on massless STT motivates us to extend our studies in the case of massive scalar field which cannot be restricted by the observations, resulting in a large deviation of massive scalarized solutions from pure GR.

With the fixed coupling constant and massive scalar field, we compute the physical properties of our neutron stars model for different magnitude of self interacting term. As the self interaction additionally suppresses the massive scalar field, the effect of scalarization decreases by increasing the value of self interaction parameter. We illustrate our models in several plots showing the fundamental curvature modes for the scalarized neutron star solutions comparing with the GR models. Interestingly, the same universal relations are also confirmed for the massive scalarized neutron stars with clearly distinguishable deviations from GR solutions for each of the values of the self interaction parameter.