Phenomenological Model of Hyper-Massive Neutron Star Phase Gravitational Wave of Binary Neutron Star

Peter T.H. Pang[1], Tjonnie G.F. Li[1]

[1]*Department of Physics, The Chinese University of Hong Kong, Shatin, N.T., Hong Kong*

E-mail: thpang@phy.cuhk.edu.hk, tgfli@phy.cuhk.edu.hk

(Received June 18, 2017)

Recent discoveries of binary black holes by gravitational-wave detection hint at the opportunity of observing binaries containing neutron stars. The presence of a neutron star can help us constrain the equation of state of ultradense matter. The feasibility of constraining the equation of state through gravitational-wave detections have typically been studied using the inspiral and post-merger stages separately. We present a phenomenological gravitational-wave signal model of the hyper-massive neutron star stage. The purpose of the model is to investigate the possible improvement of combining inspiral and post-merger information and the feasibility of classifying the post-merger behaviour.

KEYWORDS: Gravitational Wave, Neutron Star, Equation of State

1. Introduction

The coalescence of binary neutron star undergoes 3 stages, namely, inspiral, merger and post-merger. Information on the neutron stars' matter is encoded throughout the gravitational-wave signal through the tidal deformability of individual neutron stars. Therefore, we can probe the equation of state by measuring the tidal deformability using gravitational-wave detections.

The feasibility of constraining the nuclear equation of state with the inspiral or the post-merger stage has only been demonstrated separately. The discovery of universal relationships of the post-merger stage by Hotokezaka *et al.* [1] and Bernuzzi *et al.* [2] provides us a way to connect the information of these two stages.

We present a phenomenological gravitational-wave model of the hyper-massive neutron star (HMNS) stage that can be attached to an inspiral model. This model can be used to study the possible improvement in constraining the equations of state by combining inspiral and post-merger information and the feasibility of classifying the post-merger stage behaviour of binary neutron stars.

2. A Phenomenological Model of the Hyper-Massive Neutron Star Stage

Hotokezaka *et al.* [1] shows the presence of a distinct peak at the high frequency portion of the hyper-massive neutron star stage gravitational-wave spectrum among different binary-neutron-star configurations. Moreover, Bernuzzi *et al.* [2] shows a universal relation of the peak frequency $f_{\rm peak}$ and the frequency at which the neutron stars merge $f_{\rm merg}$ as a function of κ_2^T given by

$$f_{\rm merg} = \frac{0.057232}{M} \frac{1 + 0.024382\kappa_2^T - 1.7167 \times 10^{-5}(\kappa_2^T)^2}{1 + 0.068865\kappa_2^T} \tag{1}$$

$$f_{\rm peak} = \frac{0.053850}{M} \frac{1 + 0.00087434\kappa_2^T}{1 + 0.00455\kappa_2^T}, \tag{2}$$