



Contribution ID: 680

Type: Oral presentation

Gravitational Waves Probing Quark Matter Crossover

Wednesday, 6 April 2022 08:40 (20 minutes)

Crossover Scenario

If there were a first-order phase transition, some signatures could be expected, but the most challenging is an experimental confirmation of realistic crossover scenario. It is already known from the NS observations / pQCD calculations that a crossover transition to quark matter is likely to occur around 3-5 times normal nuclear density, where a slope parameter on the energy-pressure plane exhibits a significant change. The difficulty lies in the fact that the relevant density is too high even in cores of heavy NSs.

Gravitational Waves Signal

We will discuss prospects of gravitational waves to distinguish the EoSs with/without not a first-order but a crossover transition to quark matter. To this end, we will emphasize the importance of multiple observations as follows.

[Inspirational Stage]

So far, we still have to wait for the post-merger signals, and it is crucial to make analysis to clarify what we can infer from the inspiral stage (before binary NSs merge). We show the gravitational waves obtained from the numerical relativity to constrain the tidal deformation parameter from which we can make extrapolation of EOS to high density in a scenario with/without crossover.

[Post-merger Stage]

We then demonstrate the effect of crossover in the post-merger stage (after binary NSs start merging). We will report a prominent difference between two scenarios with/without crossover. The life time from the merger till the collapse into a blackhole significantly depends on the softened EOS in the dense region of 4-5 times normal nuclear density. We also quantify theoretical uncertainties from the finite-temperature extension that is parameterized by the thermal index. We point out that it is of tremendous importance to take account of the density dependence of the thermal index.

Conclusion

We can make use of already available gravitational wave signal in the inspiral stage to constrain the EOS of cold and dense matter before crossover. Since the uncertainty in this density region is sufficiently reduced (and the finite-temperature uncertainty is absent!), we can apply it to the post-merger analysis up to an hypothetical (but very likely) crossover density, which enables us to probe the crossover from the life time after the merger, which has been quantified by our simulations of the numerical relativity with the most realistic EOS.

Primary authors: Prof. FUKUSHIMA, Kenji (The University of Tokyo); HOTOKEZAKA, Kenta (The University of Tokyo, RESCEU); KYUTOKU, Koutarou (Kyoto University); FUJIMOTO, Yuki (The University of Tokyo)

Presenter: Prof. FUKUSHIMA, Kenji (The University of Tokyo)

Session Classification: Parallel Session T10: Baryon rich matter, neutron stars, and gravitational waves

Track Classification: Baryon rich matter, neutron stars, and gravitational waves