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A Markov Chain Monte Carlo approach to the relativistic inverse stellar problem

The lack of information on the nature of the neutron star (NS) core at supra-nuclear densities, has so far prevented a unique description of its equation of state (EoS). Future gravitational wave (GW) detections by second and third-generation of ground-based interferometers will shed new light on this open problem. The income of new and detailed experimental data will help to reconstruct the fundamental properties of the NS EoS by measurements of its macroscopic observables, within the so called *inverse stellar problem* [1,2].

In this work we propose a method to determine the EoS features using GW signals produced by coalescing binary systems. This approach can be combined with experimental data obtained through astrophysical observations or nuclear physics experiments, leading to a genuine multi-messenger framework.

We parametrize the EoS using phenomenological piecewise polytropic models [3], which accurately fit a large class of realistic EoS, representing an effective way to discriminate among them. Adopting a Bayesian scheme of inference, we determine the posterior probability distribution of the EoS parameters, for a given set of NS masses and tidal deformabilities, within their experimental uncertainties measured by GW detections.

We apply this approach to two realistic EoS, APR4 and MS1, which represent extreme examples of soft and stiff NS matter, respectively. Our results suggest that a network of second-generation interferometers will be already able to rule out such extreme cases by means of a relatively small number of binary NS detections. Moreover, future instruments, like the Einstein Telescope, will further increase our ability to infer the properties of nuclear matter at high densities, and will ultimately lead to a complete identification of the NS EoS at 3σ level.

References

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Authors: ABDELSALHIN, Tiziano (Sapienza University of Rome); Dr MASELLI, Andrea (University of Tuebingen); Prof. FERRARI, Valeria (Sapienza University of Rome)

Presenter: ABDELSALHIN, Tiziano (Sapienza University of Rome)

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