GR 11: Relativistic Astrophysics II

Time: Wednesday 15:45–17:05 Location: HBR 14: HS 2

GR 11.1 Wed 15:45 HBR 14: HS 2

Constraining the nuclear equation of state from rotating neutron stars — •Sebastian H. Völkel[1] and Christian J. Krüger[2] — [1]Max Planck Institute for Gravitational Physics (Albert Einstein Institute), D-14476 Potsdam, Germany — [2]Theoretical Astrophysics, IAAT, University of Tübingen, D-72076 Tübingen, Germany

Inferring the nuclear equation of state from neutron stars is a fascinating research objective that calls for accurate and efficient modeling. Due to computational and technical difficulties, most existing works that focus on equation of state inference neglect rotational effects. In this talk, I will review a Bayesian parameter estimation framework that was first introduced in [1] for slowly rotating neutron stars, and more recently extended to fast rotation in [2]. The framework allows to convert measurements of bulk properties of rotating neutron stars, e.g., their masses, radii, but also moments of inertia, and some f-mode frequencies, to bounds on the popular piecewise polytropic equation of state. The key for efficient parameter estimation is the use of novel universal relations and the construction of a template bank. While slow rotation can be well justified in the presence of large measurement uncertainties and slowly rotating stars, it can lead to significant bias for moderately rotating neutron stars and future, high accuracy measurements.

[1] Völkel and Krüger, PRD 105 124071 (2022), arXiv:2203.05555
[2] Krüger and Völkel, accepted in PRD, arXiv:2309.05643

GR 11.2 Wed 16:05 HBR 14: HS 2

Universal relations for bulk quantities of rapidly rotating neutron stars — •Christian J. Krüger[1] and Sebastian H. Völkel[2] — [1]Theoretical Astrophysics, IAAT, University of Tübingen, D-72076 Tübingen, Germany — [2]Max Planck Institute for Gravitational Physics (Albert Einstein Institute), D-14476 Potsdam, Germany

Neutron stars are compact objects whose interior composition is largely unknown and various rather different potential compositions are being debated. Furthermore, astrophysical neutron stars rotate, causing them to be oblate and their fluid bulk quantities to differ significantly from their nonrotating counterparts. Calculating these bulk quantities requires the computationally rather expensive solution of elliptic PDEs while neglecting rotational effects will inevitably result in bias when performing parameter estimation. Despite their complex physical nature, the impact of rotation on neutron stars exhibits quite universal patterns. In this talk, I will present universal relations that allow to estimate fluid bulk quantities of rapidly rotating neutron stars based on mass M, radius R and moment of inertia I of an associated nonrotating neutron star [1], which considerably reduces the computational expense. In extension of the cited work, I will present estimates for additional fluid bulk quantities which will be based on a newly generated set of neutron star models, thereby reducing potential bias in the relations.

[1] Krüger and Völkel, accepted in PRD, arXiv:2309.05643

GR 11.3 Wed 16:25 HBR 14: HS 2

An overview of nuclear and astrophysical constraints on the equation of state for neutron-rich dense matter — •Hauke Koehn — Institut für Physik und Astronomie, Universität Potsdam, Haus 28, Karl-Liebknecht-Str. 24/25, 14476, Potsdam, Germany

At present, a multitude of different observations, experiments and theoretical considerations exist to address the nature of matter at extreme densities. We present a detailed overview across these distinct sources of information and explain why and how they impose constraints on the cold equation of state of neutron-rich dense matter (EOS). By performing Bayesian inference on a large set of candidate EOS for each input, we are able to combine the distinct constraints, which delivers stringent constraints on the radii and maximum mass of neutron stars, and further restrictions on empirical nuclear parameters or the speed of sound.

GR 11.4 Wed 16:45 HBR 14: HS 2

Effects of Quantum Gravity on the Nuclear Astrophysics of Quark Stars: The GUP-Modified MIT Bag Model — •Marcelo Netz-Marzola[1,2], César A. Zen Vasconcellos[3,4], and Dimiter Hadjimichef[3] — [1]FIAS, Frankfurt, Germany — [2]Goethe-Uni, Frankfurt, Germany — [3]UFRGS, Porto Alegre, Brazil — [4]ICRANet, Pescara, Italy

The Generalized Uncertainty Principle (GUP) is motivated by the premise that spacetime distortions near the Planck scale impose a lower bound on the achievable resolution of distances, leading to a minimum length. Inspired by a semiclassical method that integrates the GUP into the partition function by deforming its phase space, we induce a modification on the thermodynamic quantities of the MIT bag model that we propose serves as an effective semiclassical description of deconfined quark matter in a space with minimal length. We investigate the consequences of this deformation on the zero-temperature limit, revealing a saturation limit for the energy density, pressure and baryon number density and an overall decrease of the thermodynamic quantities, alongside a slight increase in the mass-radius relation of compact objects, providing enhanced stability against gravitational collapse. These findings extend existing research on GUP-deformed Fermi gases. Finally, we briefly outline the path towards a more generalized GUP framework capable of integrating a variety of particles and interactions. Theoretical implications of our work can be tested in the future at the HADES experiment at GSI and at the CBM experiment at FAIR.