NewCompStar STSM scientific report

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STSM topic: Neutron star twins at high mass as an indication for a critical point in the QCD diagram

Host: David Blaschke

The goal of this STSM was to implement hybrid neutron star equations of state (EoS) appropriate for the description of a third family of compact stars (mass twins) at high mass of about $2M_\odot$ by means of a microscopic approach both at the quark and hadronic level. Neutron star twins are relevant since they indicate a strong first-order transition in the QCD phase diagram and prove the existance of a critical point. Therefore exploration of the twin phenomenon serves as a tool to study matter under extreme conditions.

For their description we have introduced the $SU(2)$ hNJL model for quark matter where, besides the traditional 4-quark interactions, also 8-quark interactions were included as described in [1]. On the hadronic side we implementated the excluded volume approximation that takes into account quark substructure effects in baryonic matter at suprasaturation densities. This model provides the necessary stiffness to the EoS to support heavy mass twins when hadronic matter undergoes a phase transition to quark matter.

First investigations in [2, 3] showed that a rather stiff quark matter equation of state was necessary to explain the twins phenomenon. We have improved the model presented in [2] by including microphysical approaches in both quark and hadron matter while using a more realistic Maxwell construction for phase transition rather than the previously introduced interpolation procedure [3]. Within our approach we have found that neutron star twins can present radius differences of about 1.5 km or less, therefore becoming a potential candidate for future astronomical observations. In this respect we have started a series of Bayesian analysis studies [4, 5] aiming at providing the relevant probabilities for radius measurements of high mass twins. Upcoming missions such as LOFT and NICER have the potential to yield sufficiently precise radius measurements to identify neutron star twins.

During this STSM we were able to finish the aforementioned study and summarize the result in a manuscript [6] that has been submitted for publication. Continuation of this work goes into the direction of the extension to finite temperature of the equation of state for supernova simulations [7].

References

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[6] S. Benic, D. Blaschke, D. E. Alvarez-Castillo, T. Fischer and S. Typel, "A new quark-hadron hybrid equation of state for astrophysics - I. High-mass twin compact stars," arXiv:1411.2856 [astro-ph.HE].

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