Neutron star equation of state and uncertainty on the radius determination

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Contrary to the core of neutron stars (NS), the crust is non-uniform and composed of nuclear clusters. Consequently, calculating the crust equation of state (EOS) is much less straightforward than for the core, which explains the smaller number of crust EOS available compared to those for the core. Thus non-unified EOS, i.e. based on different nuclear models for the crust and core, are often used. However, as shown in [1], for masses $M \geq 1\,M_\odot$ the use of non-unified EOS can introduce an uncertainty on the radius determination on the order of 5%, which is as large as the precision expected from the next generation of X-ray telescopes: NICER, Athena, and potential LOFT-like missions.

I will present two solutions to this problem. On the one hand, 50 unified EOS (for a purely nucleonic core or a hyperonic one) have been calculated and made are available to the NS community in [1]. On the other hand, in [2] we developed an approximate approach to the NS crust, whether it is catalyzed or accreted. Then, for a given core EOS, the NS radius can be determined independent of the crust model with an error smaller than 0.1%. I will conclude by discussing correlations obtained for large sets of nuclear models in [1, 3] between the NS radius and some nuclear parameters, which are properties of nuclear matter that can be indirectly measured in laboratory. This opens the possibility of potentially constraining the NS radius with experiments on Earth.

References

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