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Exploring massive neutron stars towards mass gap: Constraining the high-density nuclear equation of state

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Due to the high-density nuclear matter equation of state (EOS) being as yet unknown, neutron stars (NSs) do not have a confirmed limiting "Chandrasekhar" type maximum mass. However,observations of NSs (PSR J1614-2230, PSR J0348+0432, PSR J0740+6620, PSR J0952−0607) indicate that NS's limiting mass, if there is any, could be well over $2M$. On the other hand, there exists an observational mass gap between $2.5M$ and $5M$, and the "massive NSs" are prime candidates to fill that gap. Several NS EOSs have been proposed using both microscopic and phenomenological approaches. In this project, we look at a class of phenomenological nuclear matter EOSs – relativistic mean field models – and see what kind of NS is formed from them. We compute the maximum mass supported by each model EOS to observe if the mass of the NS is indeed in the "massive" NS ($> 2M$) regime. Using tidal deformability constraints from gravitational wave observations, we place a further check on how physical the EOS used is. We also observe the effects of including exotic particles (hyperons, deltas) in the NS EOS and how that affects the NS mass. Finally, we look at how the NS's magnetic field affects its mass.

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