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Establishing connection between neutron star properties and nuclear matter parameters through a comprehensive multivariate analysis

We have attempted to mitigate the challenge of connecting the neutron star (NS) properties with the nuclear matter parameters that describe equations of state (EOSs). The efforts to correlate various neutron star properties with individual nuclear matter parameters have been inconclusive.
A Principal Component Analysis is employed as a tool to uncover the connection between multiple nuclear matter parameters and the tidal deformability as well as the radius of neutron stars within the mass range of $1.2 - 1.8M_{\odot}$. The essential EOSs for neutron star matter at low densities have been derived using both uncorrelated uniform distributions and minimally constrained joint posterior distributions of nuclear matter parameters. For higher densities ($\rho > 0.32\text{fm}^{-3}$), the EOSs have been established through a suitable parameterization of the speed of sound, which consistently maintains causality and gradually approaches the conformal limit. Our analysis reveals that in order to account for over 90\% of the variability in NS properties, it is crucial to consider two or more principal components, emphasizing the significance of employing multivariate analysis. To explain the variability in tidal deformability needs a greater number of principal components compared to those for the radius at a given NS mass. The contributions from iso-vector nuclear matter parameters to the tidal deformability and radius of NS decrease by $\sim$ 25\% with the increase in mass of NS from $1.2M_{\odot}$ to $1.8M_{\odot}$.

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