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Constraining the Equation of State of Hybrid Stars Using Recent Information from Multidisciplinary Physics

Abstract: At the ultrahigh densities existing in the core of neutron stars (NSs), it is expected that a phase transition from baryonic to deconfined quark matter may occur. Such a phase transition would affect the underlying equation of state (EoS) as well as the observable astrophysical properties of NSs. Comparison of EoS model predictions with astronomical data from multimessenger signals then provides us an opportunity to probe the behavior of dense matter. In this work, we restrict the allowed parameter space of EoS models in NSs for both nucleonic (relativistic mean field model) and quark matter (MIT bag model) sectors by imposing state-of-the-art constraints from nuclear calculations, multimessenger astrophysical data, and perturbative quantum chromodynamics (pQCD). We systematically investigate the effect of each constraint on the parameter space of uncertainties using a cutoff filter scheme, as well as the correlations among the parameters and with NS astrophysical observables. Using the constraints, we obtain limits for maximum NS mass, maximum central density, as well as for NS radii and tidal deformability. Although pQCD constraints are only effective at very high densities, they significantly reduce the parameter space of the quark model. We also conclude that astrophysical data supports high values of the bag parameter B and disfavors the existence of a pure quark matter core in hybrid stars.

Author: SHIRKE, Swarnim (Inter-University Centre for Astronomy and Astrophysics)

Co-authors: Prof. CHATTERJEE, Debarati (Inter-University Centre for Astronomy and Astrophysics); Mr GHOSH, Suprovo (Inter-University Centre for Astronomy and Astrophysics)

Presenter: SHIRKE, Swarnim (Inter-University Centre for Astronomy and Astrophysics)

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