

4th Young Astrophysicists of Today's India (YATI4)

Atharva Shinde

Department of Physics, IISER Bhopal
Bhopal-462066, Madhya Pradesh, India
atharva21@iiserb.ac.in

ABSTRACT

Quantum Chromodynamics predicts a hadron-to-quark phase transition (PT) in matter at densities higher than nuclear saturation density. If the phase transition is strong enough, a new branch of hybrid stars can form, separated from neutron stars and giving rise to twin stars (TSs) (i.e stars with same mass but different radii). It is important to study equations of state (EoSs) with a PT that can form TSs, with an emphasis on constraining the onset of PT and its strength. We use an agnostic parameterization to model our EoSs using the transition density, transition pressure, density discontinuity, and constant speed of sound in quark matter as our parameter space. In the $P - \epsilon$ space, we generate a large ensemble of Maxwell-type equations of state that can give rise to TS configurations. We report the conditions on our parameter space imposed by causality and TOV solutions. For fixed transition density and speed of sound in quark matter, we report distinct ranges of transition pressures and strength of discontinuity. The range of discontinuity increases with decreasing transition pressure. We identify loci of the limits on discontinuities varying with transition density and speed of sound in quark matter. Based on the values of parameters, the loci can be complete or punctured. Strong constraints on this pictures are drawn by imposing the CET constraints on hadronic part of EoSs and imposing NICER and GW170817 constraints on their mass-radius sequences. We compute the maximum allowed mass of TSs to be $2.05 M_{\odot}$, the maximum allowed strength in rest mass discontinuity to be $7.76 \rho_{\text{sat}}$ and the maximum transition rest mass density to be $4.03 \rho_{\text{sat}}$. Furthermore, we analyse the impact of the stiffness of quark matter EoS and the confidence level of observational constraints on the TS scenario and the limits on transition parameters.