MAGIC

Science of the Cosmos

Contribution ID: **92** Type: **not specified**

Non-Constant Speed of Sound approach to model quark cores in Hybrid Stars

The current astrophysical constraints for neutron stars (NSs) are very diverse and challenging. The simultaneous consideration of gravitational waves produced during binary NS mergers, X-ray emission of isolated NSs, and binary pulsar observations generates a tense scenario difficult to satisfy by modern NSs models. In particular, their internal composition and the equation of state (EoS) of dense matter is one of the main unsolved issues regarding NSs. The hadron-quark hybrid stars (HSs) scenario, with the assumption of an abrupt first-order hadron-quark phase transition with slow conversion speed between phases, allows to obtain a branch of stable stars beyond the maximum mass configuration, the so-called slow stable HSs (SSHSs). It has been shown that this proposal could be a possible solution to the constraints puzzle. In this work, we construct a novel hybrid EoSs using a generalized piecewise polytropic scheme for the hadronic sector and developing a parametrized non-constant speed of sound (non-CSS) model for the quark phase. The implementation of the non-CSS model allows exploration of a wide range of speed of sound values while satisfying the conformal limit for the speed of sound at extremely high densities given by perturbative-QCD. We explore the possibility of simultaneously meeting all the current constraints using non-CSS SSHSs and compare our results with other modern proposals.

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