INPC 2025
May 25-30, 2025
DCC, Daejeon, Korea

Contribution ID: **286**

Type: **Contributed Oral Presentation**

Hadrons vs quarks: A Bayesian model comparison through neutron star observables in light of nuclear and astrophysics data

Thursday, 29 May 2025 11:55 (15 minutes)

The equation of state of matter (EOS) inside neutron stars (NSs) is far from being exactly known. An extremely dense neutron star core is believed to contain exotic matter such as hyperons, quark-gluon plasma and so on, in addition to nucleons. Results from terrestrial nuclear physics experiments and astrophysical observations are routinely incorporated during EOS modelling to simulate cold NSs. As far as astrophysical observations are concerned, mass-radius inferences with gravitational wave (GW) data from binary NS mergers and X-ray observation data of pulsars have provided excellent constraints on the EOS of cold NS matter in the recent past.

We examine whether recent observational data from NICER and LIGO-Virgo (LV) collaborations in combination with nuclear physics constraints favour NS EOSs with hadron-quark phase transitions (PTs) over purely hadronic EOSs through Bayesian inference.

Our set of NS matter EOSs with hadron-quark PTs (hybrid EOS model) combines two models - a relativistic mean-field (RMF) model for nucleonic regime and a mean-field theory of quantum chromodynamics (MFTQCD) for quark regime.

Observational data for pulsars PSR J0030+0451 and PSR J0470+6620 show a slight preference for EOSs with smooth phase transitions, unlike gravitational wave (GW) data, which remain practically indecisive.

Our analysis also highlights tensions between older NICER data and recent measurements for PSR J0437−4715. We observe a clear distinction between the 90% credible interval for NS observables like mass, radius, tidal deformability, f-mode oscillation frequency and GW damping time for hadronic and hybrid EOSs. The hybrid model allows stiffer EOSs that align with NICER data but result in higher tidal deformabilities, at odds with GW observations. Our results indicate the need for more flexible EOS models to resolve the disagreement between astrophysical observations.

Primary author: Mr GUHA ROY, Debanjan (Department of Physics, Birla Institute of Technology and Science, Pilani, Hyderabad Campus, Secunderabad, Telangana 500078, India)

Co-authors: VENNETI, Anagh (BITS Pilani, Hyderabad); MALIK, Tuhin (CFisUC, Department of Physics, University of Coimbra, Coimbra, 3004-516, Portugal); BHATTACHARYA, Swastik (Birla Institute of Technology and Science, Pilani, Hyderabad Campus, Secunderabad, Telangana 500078, India); BANIK, Sarmistha (BITS Pilani, Hyderabad)

Presenter: Mr GUHA ROY, Debanjan (Department of Physics, Birla Institute of Technology and Science, Pilani, Hyderabad Campus, Secunderabad, Telangana 500078, India)

Session Classification: Parallel Session

Track Classification: Nuclear Astrophysics