Qeios

Peer Review

Review of: "General Features of the Stellar Matter Equation of State From Microscopic Theory, New Maximum-Mass Constraints, and Causality"

Ankit Kumar[1]

1. National Institute of Technology Delhi, New Delhi, India

Reviewer Report

Title: General Features of the Stellar Matter Equation of State From Microscopic Theory, New Maximum-Mass Constraints, and Causality

Authors: Francesca Sammarruca, Tomiwa Ajagbonna

Overall Evaluation

The manuscript presents an analysis of the neutron star equation of state (EoS) based on microscopic theories, maximum-mass constraints, and causality. The work includes EoS modeling at various density regimes and incorporates neutron star cooling simulations. The topic is timely and important, given the recent advances in multi-messenger astrophysics.

However, the paper **lacks clarity in several places**, contains **inconsistencies in descriptions**, and **needs a connection with observational constraints**. The **scientific arguments must be refined**, and **some assumptions require better justification**. Below are detailed major and minor comments to improve the manuscript.

Major Comments (Require Substantial Revision)

1. Lack of Justification for Model Assumptions

doi.org/10.32388/8PIXRK

- The authors assume a **piecewise polytropic EoS extension at high densities**, but they do not sufficiently justify why this particular form is preferred over alternative methods (e.g., spectral representations or hybrid EoS with phase transitions).
- The choice of the polytropic indices **Γ1 and Γ2** is somewhat arbitrary. While the authors state they are chosen based on literature, a stronger argument backed by prior constraints (e.g., Bayesian inference studies) would improve credibility.

2. Causality Violations and High-Density Extrapolations

- Figure 5 shows the **speed of sound approaching causality limits** at high densities. However, the manuscript does not discuss **at what density each model violates causality**. A clearer statement on this is required.
- The assumption that **the EoS should soften at extreme densities** (to maintain causality) is reasonable, but what observational evidence supports this claim? Some models suggest **a stiffening due to exotic phases** rather than softening. This needs to be addressed.

3. Weak Connection to Observational Constraints

- The paper does not **quantitatively compare** the predicted **M-R relations (Figure 3 & 4)** with constraints from NICER (e.g., PSR J0740+6620) or gravitational waves (e.g., GW170817, GW190814). A more detailed comparison would strengthen the results.
- The authors mention the **2.35 M⊙M_{\odot} neutron star (PSR J0952-0607)** but do not discuss how their EoS predictions fit within the uncertainty range of this measurement.

4. Cooling Model Limitations Not Addressed

- The neutron star cooling section **does not consider the effect of superfluidity**, which is crucial for neutron star thermal evolution. If superfluidity is neglected, the authors should justify this and discuss its potential impact.
- The **chemical composition of the envelope** significantly affects surface temperature evolution (Figures 6-8). However, no clear argument is given for why different envelope models were chosen.
-

Minor Comments (Require Corrections & Clarity)

1. Clarity & Language Issues

- The **Introduction** contains vague statements, e.g.:

"No theory of hadrons can be considered reliable if extended to those regions."

Correction: Some hadronic models are extended to high densities with effective field theory corrections. Consider **rephrasing this more cautiously**.

2. Figures & Labels

- Figures **lack clear descriptions in captions**. For example, Figure 3 shows different M-R relations, but the **meaning of different curve colors is not fully explained**. Add a **legend or better caption explanation**.

3. Some more relevant Citations & References are missing.

Attachments: available at https://doi.org/10.32388/8PIXRK

Declarations

Potential competing interests: No potential competing interests to declare.