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Peer Review

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

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The article talks about the current understanding of the equation of state (EoS) for neutron stars, using microscopic theories. The authors focus on the latest constraints related to the maximum mass of neutron stars and the requirement of causality. They highlight the need to combine both ab initio theories and phenomenological models to better describe neutron star matter. The article discusses the limitations of microscopic theories and suggests new ways to extend the EoS, ensuring that it remains causal while supporting heavier neutron stars. The authors also include cooling simulations for neutron stars, trying to match thermal observations with theoretical models of very dense matter.

Overall, the article offers important insights into how the EoS for neutron stars is being developed. However, there are areas where clarity and detail can be improved, especially when discussing phase transitions and exotic matter, as well as connecting the cooling curves more closely to observational data.

Suggested Comments for Improvement:

1. The paper could provide a clearer explanation of how the current microscopic models can be integrated with future data, particularly in light of upcoming observational missions.
2. It would be helpful to elaborate further on the role of phase transitions (such as the transition from hadronic to quark matter) and how these influence the high-density EoS, including their potential impacts on the cooling curves.

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3. The joining point between the low-density and high-density EoS is not clearly explained. The authors should include a small paragraph to clearly state how these regions are joined and whether this affects the properties of neutron stars.
4. While the authors discuss the cooling mechanism, they should clarify how it is integrated into the EoS. What methods are being used, and how does the EoS incorporate this information? This will help clarify many doubts for new researchers. I suggest providing a brief overview of this process.
5. What are the potential impacts of a softer or stiffer symmetry energy on the neutron star mass-radius relationship and its cooling evolution?
6. How robust are the results presented for different input parameters, such as the choice of EoS and the modeling of pairing gaps in neutron matter?
7. The cooling simulations presented could be enhanced by incorporating more diverse envelope models and including additional constraints from recent neutron star observations.

Questions for Further Consideration:

1. In Figures 1 and 2, the authors should consider adjusting the legends inside the figures, as currently, it looks odd to have to refer to the table for additional information. This is a suggestion, and the authors can decide based on their preference.
2. Could the inclusion of more exotic degrees of freedom, such as strange quarks or hyperons, significantly alter the cooling behavior of neutron stars?

Declarations

Potential competing interests: No potential competing interests to declare.

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