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Qeios

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 authors discuss the constraints imposed by causality and maximum neutron star mass when the EoS below 0.277 fm^-3 is described by a chiral effective field theory approach. Above this density, the authors consider either two polytropes or one polytrope as a speed-of-sound function that ensures causality. For their chEFT calculation, they have considered a cutoff equal to 450 MeV. The theoretical approach is highly summarized, and details can be found in ref 14. They give results obtained with both N2LO and N3LO chEFT calculations. Maximum masses, corresponding central densities and radii, and the radius of 1.4M_Sun are given for the proposed EOS. Photon luminosity and effective temperature profiles as a function of time are provided for some neutron star masses. The authors discuss some issues related to proton and neutron pairing in neutron stars but leave the inclusion of pairing in their calculations to future work. There are several aspects that remain unclear and would strengthen the conclusions if clarified. It would be nice if the authors would discuss the following points:

- Given the uncertainties associated with the N3LO and N2LO shown in Figure 1, how does the chosen EOS reflect these uncertainties below rho_1? Can a confidence level be assigned to these uncertainties? This information is important for constraining the low-density EOS using phenomenological approaches.
- Could the authors explain how they construct the inner crust EOS for the chEFT results?
- Stars with central densities below about twice the saturation density are essentially described by ab-initio calculations in the present approach. It would be nice to identify NS masses with this central density.

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- Are the maximum masses in Fig. 2 reached before causality is violated? Could the maximum mass configurations be identified by a cross?

- Is there any reason to define rho_2-rho_1 as twice the saturation density?

- Is the high-density EOS proposed by the authors consistent with the predictions of perturbative QCD at high densities? Causality and thermodynamic conditions impose some restrictions at densities inside neutron stars, as shown in Komoltsev and Kurkela (PRL128, 202701).

- The data colors in Figures 6, 7, and 8 are ambiguous. In reference 36, the authors only distinguish between TINS, PSR, and XINS. What do the colors mean?

- With respect to the profiles shown in Figs. 6, 7, and 8, it is not clear which EOS was used: Gamma=3.3 or 3.8? How is the composition above rho=0.277fm^-3 included if the polytrope plus sound velocity EOS is used?

- Could the authors summarize what their conclusions are regarding the strong limits set by how microscopic theory, along with causality and maximum mass constraints? Since it is not clear what conditions underlie the choice of the high-density EOS, it is not clear how strong the authors' conclusions are.

Other aspects:

- Lambda _b is stated to be of the order of 700 MeV on pg 3 and 600 MeV on pg 9.

- Do the authors really consider rho_1=0.202 fm^{-1} as written on top of pg 9?

- Could the authors clarify the difference between Lambda_b and Lambda?

- Were the curves in Figures 2 and 3 and the results in Table 1 obtained with the N3LO EoS? This should be stated in the captions. Could Table 1 be supplemented with the radius of maximum mass configurations and central densities?

- Could you also show the speed of sound for Gamma=3.3 in Fig. 5, since this value was used in Fig. 4?

Declarations

Potential competing interests: No potential competing interests to declare.

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