Contribution ID: **122** Type: **not specified**

Spanning the full range of neutron star properties within a microscopic description

Wednesday 25 January 2023 16:45 (30 minutes)

The high density behavior of nuclear matter is analyzed within a relativistic mean field description with non-linear meson interactions. To assess the model parameters and their output, a Bayesian inference technique is used. The Bayesian setup is limited only by a few nuclear saturation properties, the neutron star maximum mass larger than 2 $M_\odot$, and the low-density pure neutron matter equation of state (EOS) produced by an accurate N^3LO calculation in chiral effective field theory. Depending on the strength of the non-linear scalar vector field contribution, we have found three distinct classes of EOSs, each one correlated to different star properties distributions. If the non-linear vector field contribution is absent, the gravitational maximum mass and the sound velocity at high densities are the greatest. However, it also gives the smallest speed of sound at densities below three times saturation density. On the other hand, models with the strongest non-linear vector field contribution, predict the largest radii and tidal deformabilities for 1.4 $M_\odot$ stars, together with the smallest mass for the onset of the nucleonic direct Urca processes and the smallest central baryonic densities for the maximum mass configuration. {These models have the largest speed of sound below three times saturation density, but the smallest at high densities, in particular, above four times saturation density the speed of sound decreases approaching approximately $\sqrt{0.4}c$ at the center of the maximum mass star. On the contrary, a weak non-linear vector contribution gives a monotonically increasing speed of sound.} {A 2.75 $M_\odot$ NS maximum mass was obtained in the tail of the posterior with a weak non-linear vector field interaction. This indicates that the secondary object in GW190814 could also be an NS.}

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