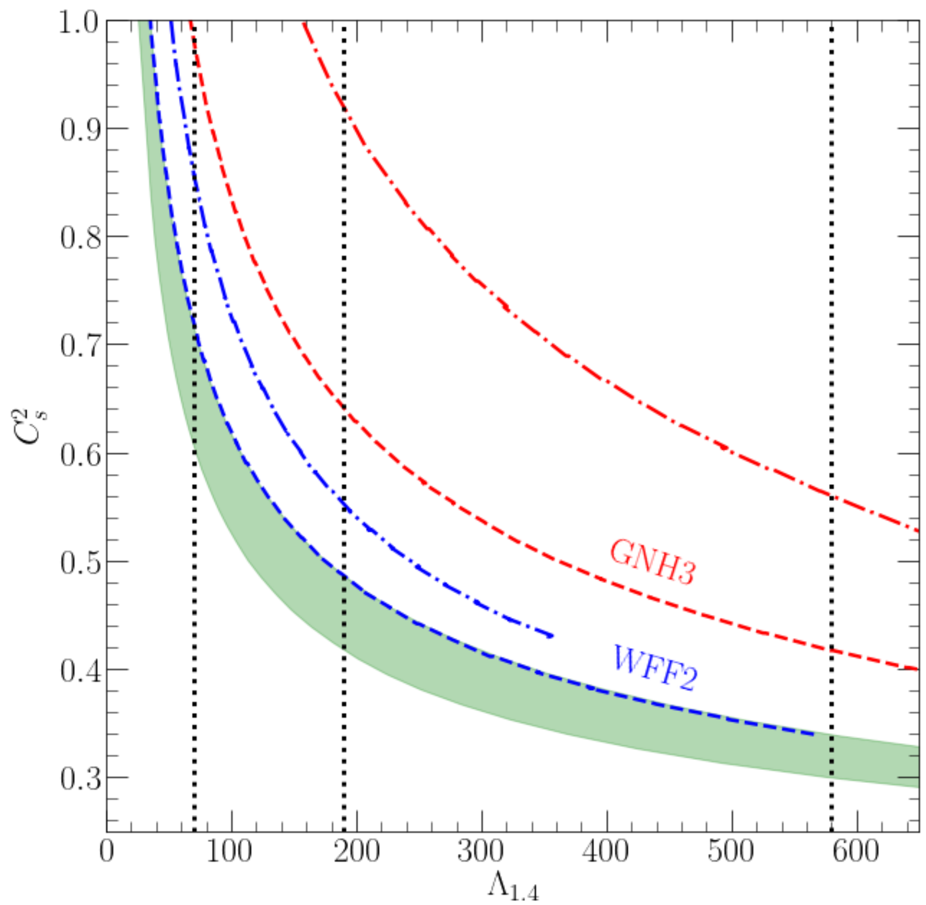
Large Sound Speed in Dense Matter and the Deformability of Neutron Stars

Objectives

- Infer a fundamental property of dense matter from astrophysical observations.
- Reproduce both gravitational wave observations by LIGO of merging neutron stars and radio observations of very massive pulsars.



The maximum speed of sound (over the speed of light) squared in a neutron star must be above the green band as a function of the deformability Λ of a neutron star (x-axis). The LIGO observation $\Lambda=190^{+390}_{-120}$ is shown as vertical dotted lines.

Impact

- We modify a range of equation of state models at high densities to reproduce both the deformability of a neutron star (how the star is polarized by a nearby star), as observed by LIGO, and the maximum mass of a neutron star.
- We find that the pressure of dense matter must increase rapidly at high densities. This implies that the maximum speed of sound in a neutron star is a significant fraction of the speed of light.
- The high sound speed implies that there are strong interactions between the nucleon or quark and gluon constituents of dense matter.
- This rules out matter in the core of a neutron star being a nearly asymptotically free quark gluon plasma.
- Our result, that cold dense matter in a neutron star is strongly interacting, is consistent with hot dense matter in relativistic heavy ion collisions at RHIC being a strongly interacting quark gluon plasma with a low shear viscosity.

Accomplishments

Brendan Reed and C. J. Horowitz,

Phys. Rev. C **101**, 045803 (2020)