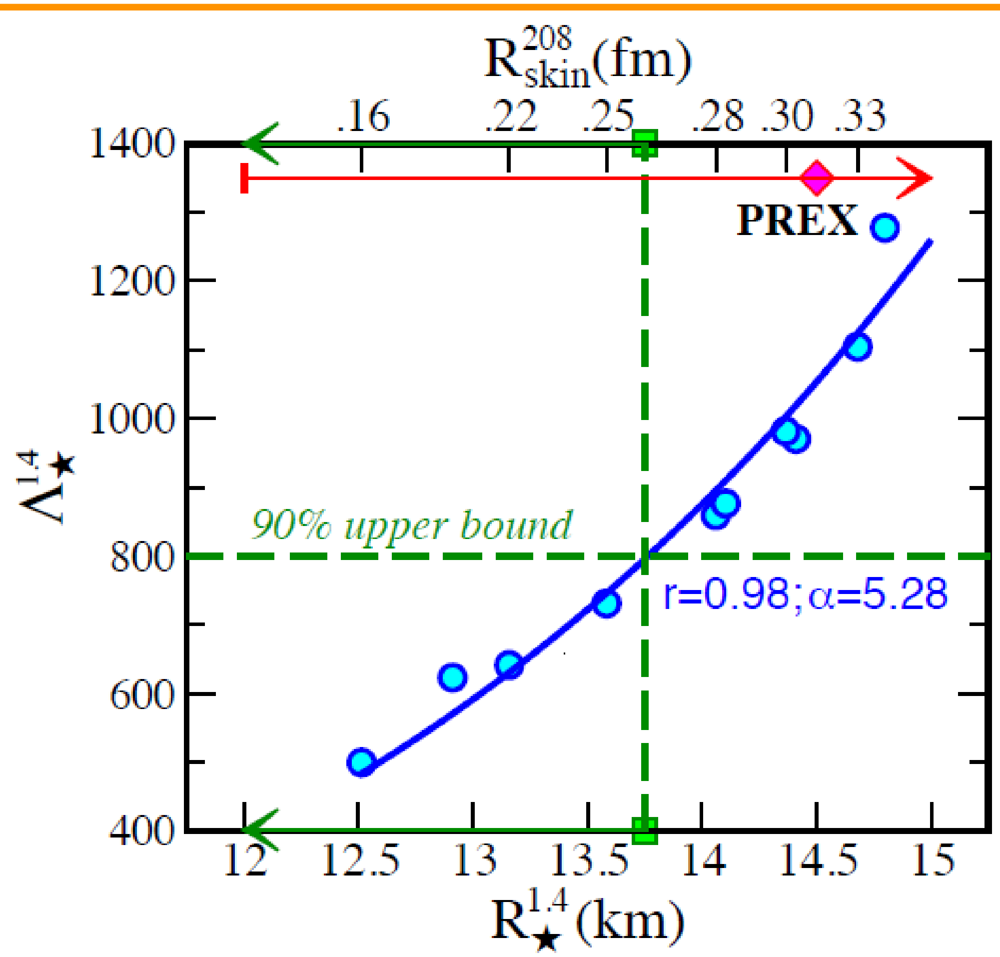
Connecting Neutron Skins to Gravitational Waves

U.S. DEPARTMENT OF ENERGY | Office of Science

NUCLEI Nuclear Computational Low-Energy Initiative

Objectives

- Use a set of realistic equation-of-state (EOS) models to confront their predictions against tidal deformabilities extracted from the gravitational-wave (GW) data of binary neutron star merger GW170817.
- Given the sensitivity of GW data to the EOS, find constraints on the neutron star radius.
- Explore density dependence of the nuclear symmetry energy and analyze the impact of this measurement on the neutron skin thickness of ^{208}Pb.



Model predictions for tidal deformability as a function of the neutron star radius and the neutron skin thickness of ^{208}Pb.

Impact

- Based on the GW data we deduced an upper limit on the neutron star radius of a 1.4 solar-mass neutron star: $R \lesssim 13.76$ km.
- We inferred a corresponding upper limit on the neutron skin thickness of ^{208}Pb: $R_{skin} \lesssim 0.25$ fm.
- Relying on experimental lower bound of $R_{skin}(^{208}Pb)$ as measured by the PREX Collaboration, we were able to provide the lower limit on the tidal deformability $\gtrsim 490$.
- If the upcoming experiment measures a thicker skin, this may be evidence of a softening of the symmetry energy at high densities, or indicative of a phase transition in the interior of neutron stars.

Accomplishments

- Publication: F. J Fattoyev, J. Piekarewicz, and C. J. Horowitz, [Phys. Rev. Lett. 120, 172702 (2018).]
- Highlighted as Editors' Suggestion.
- Featured in Physics (phys.aps.org) as Synopsis: [Gravitational Waves Shed Light on Dense Nuclear Matter].
- Featured by [Inside Science] , [Physics World], [Sky & Telescope,] and several international news outlets.