Constraining the Neutron Star Equation of State Using Observational Data

Plohr, Tate (School: Los Alamos High School)

Neutron stars are remnants of the cores of massive stars after they undergo supernovae at the end of their lives. They were theoretically predicted in the 1930s and first observed in the 1960s. Since then, much research has been done to understand the properties of the neutron stars. In particular, the Equation of State for the neutron star is an active research area. In the last few years, unprecedented observational data from the Neutron star Interior Composition Explorer (NICER) and the Laser Interferometer Gravitational-wave Observatory (LIGO) on neutron stars became available, making it possible to test out numerous theories. In nuclear physics, there are many proposed Equations of State (EOSs) for neutron stars based on theories with various assumptions and approximations. To find the true EOS for neutron stars, we adopted a data-oriented, model-agnostic approach, based on random sampling and Bayesian analysis. Starting with many possible EOSs, we utilized observational data of neutron stars to constrain these candidates. The prediction of the 90th percentile range of the radius of a 1.4-solar-mass neutron star provides a quantitative measure of the constraint and can be compared to other works. One outstanding question in neutron star research is the composition of the core. That is, whether the cores of neutron stars are made of nucleonic matter, like the outer layers, or instead, quarks or exotic states of matter. Using the constrained set of EOSs, I investigated the state of matter at the core. By analyzing the structure of the likely EOS curves, I calculated the probability that the core is made of nucleons relative to the probability of deconfined quark matter. I found that nucleonic matter is strongly favored over deconfined quark matter.

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