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Determination of the Neutron Star Equation of State from Astrophysical Measurement[1]

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Recent observations of cooling neutron stars and of photospheric radius expansions in X-ray bursters are used to simultaneously estimate their masses and radii. Although the observational uncertainties for these sources are large, they nevertheless snugly constrain the mass-radius relation and the underlying equation of state. The results of a Bayesian analysis using a parametrized equation of state are discussed. The results for the low-density equation of state are consistent with those deduced from recent nuclear physics estimates of pure neutron matter. Furthermore, the deduced nuclear incompressibility is surprisingly compatible with nuclear systematics and experiment. The density dependence of the nuclear symmetry energy is predicted to be relatively small, leading to correspondingly small values for the predicted neutron skin thickness of lead and for the radii of 1.4 $M_\odot$ stars. The high-density equation of state is predicted to stiffen, however, and the estimated neutron star maximum mass, to 90% confidence, is greater than 1.85 solar masses. I also will discuss recent observations of the cooling of the neutron star in the Cas A supernova remnant, which provides not only strong evidence for the existence of both neutron superfluidity and proton superconductivity, but also a tight measurement of the $^3P_2$ neutron gap.

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