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A Bayesian investigation of the neutron star equation-of-state vs. gravity degeneracy

Despite its elegance, the theory of General Relativity is subject to experimental, observational, and theoretical scrutiny to arrive at tighter constraints or an alternative, more preferred theory.
In alternative gravity theories, the macroscopic properties of neutron stars, such as mass, radius, tidal deformability, etc. are modified. This creates a degeneracy between the uncertainties in the equation of state (EoS) and gravity since assuming a different EoS can be mimicked by changing to a different theory of gravity. We formulate a hierarchical Bayesian framework to simultaneously infer the EoS and gravity parameters by combining multiple astrophysical observations. We test this framework for a particular 4D Horndeski scalar-tensor theory originating from higher-dimensional Einstein-Gauss-Bonnet gravity and a set of 20 realistic EoS and place improved constraints on the coupling constant of the theory with current observations. Assuming a large number of observations with upgraded or third-generation detectors, we find that the $A+$ upgrade could place interesting bounds on the coupling constant of the theory, whereas with the LIGO Voyager upgrade or the third-generation detectors (Einstein Telescope and Cosmic Explorer), the degeneracy between EoS and gravity could be resolved with high confidence, even for small deviations from GR.

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