The interiors of neutron stars reach densities and temperatures beyond the limits of terrestrial experiments, providing vital laboratories for probing nuclear and particle physics. While the star’s interior is not directly observable, its pressure and density determine the star’s macroscopic structure which, in turn, affects the spectra observed in telescopes. The relationship between the observations and the internal state is complex and partially intractable, presenting difficulties for inference. Previous work has focused on the regression from stellar spectra of parameters describing the internal state. In this study, we demonstrate a calculation of the full likelihood of the internal state parameters given observations, accomplished by replacing intractable elements with machine learning models trained on samples of simulated stars. Our machine-learning-derived likelihood allows us to perform (fit maximum a posteriori) estimation of the parameters of interest, as well as full scans. We demonstrate the technique by inferring stellar mass and radius from an individual stellar spectrum, as well as equation of state parameters from a set of spectra. Our results are more precise than pure regression models, reducing the width of the parameter residuals by 12% in the most realistic scenario. This research is in print with the Journal of Cosmology and Astroparticle Physics (JCAP).


This research is supported by the National Science Foundation grant (PHY-2012152) and the Computational Science Research Center (CSRC) at San Diego State University