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Neural-network-based surrogate model for the properties of neutron stars in 4D Einstein-Gauss-Bonnet gravity

Machine learning and artificial neural networks (ANNs) have increasingly become integral to data analysis research in astrophysics due to the growing demand for fast calculations resulting from the abundance of observational data. Simultaneously, neutron stars and black holes have been extensively examined within modified theories of gravity since they enable the exploration of the strong field regime of gravity. In this study, we employ ANNs to develop a surrogate model for a numerical iterative method to solve the structure equations of neutron stars (NSs) within a specific 4D Einstein-Gauss-Bonnet gravity framework. We have trained highly accurate surrogate models, each corresponding to one of twenty realistic EoSs. The resulting ANN models predict the mass and radius of individual NS models between 10 and 100 times faster than the numerical solver. In the case of batch processing, we demonstrated that the speed up is several orders of magnitude higher. We have trained additional models where the radius is predicted for specific masses. Here, the speed up is considerably higher since the original numerical code that constructs the equilibrium models would have to do additional iterations to find a model with a specific mass. Our ANN models can be used to speed up Bayesian inference, where the mass and radius of equilibrium models in this theory of gravity are required.

Focus areas

HEP

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