Parameter Estimation with Physics Informed Neural Networks

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Abstract

Physics informed neural networks (PINNs) are machine learning algorithms with an embedded knowledge of physical laws in the form of nonlinear partial differential equations. PINN's versatility has proven effective in engineering and biology even with limited data where other machine-learning based methods lack robustness. I demonstrate that their capacity to solve inverse problems can be applied to cosmological parameter estimation from astronomical data. As an example, I show that PINNs outperform traditional methods when inferring the mass of ultralight axions from mock galaxy rotation curves. I combine a PINN with a Monte-Carlo Markov Chain sampler and build an unbiased axion mass estimator which avoids the computationally expensive calibration of scaling relations. Notably, the algorithm converges using more than an order of magnitude fewer core-hours than a single ultralight axion simulation. I demonstrate that while neural networks of this type can be integrated into commonly-used statistical analysis pipelines, they do not eliminate the need for fully non-linear simulations. Nevertheless, they extend the range of cosmological models which can be efficiently constrained with existing and upcoming surveys.
Slides: in PDF
Video: https://youtu.be/uAhcxcvV8YI

Keywords: Dark matter, neural networks, parameter estimation, galactic dynamics, axions, fuzzy dark matter

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