Contribution ID: **30** Type: **not specified**

A physics-based deep learning algorithm for solving inverse problems

Thursday 9 November 2023 16:00 (5 minutes)

An accurate description of matter under different conditions is given by the so-called 'Equation of State'(EoS). Currently, the EoS of matter under extremely high temperatures and densities is poorly understood, and remains a major challenge in the field of nuclear astrophysics. Neutron stars (NSs) harbor such extreme conditions and therefore serve as celestial laboratories for constraining the dense matter EoS. The past decade has witnessed great progress in the research of these objects. The structure of a neutron star is governed by the underlying EoS and the theory of gravity. The equations describing this structure are the Tolman–Oppenheimer–Volkoff (TOV) equations which arise from General Relativity. These equations provide a one-to-one mapping from a given theoretical EoS model to the corresponding NS masses and radii. Therefore, observations of NS masses and radii are crucial to extract the underlying EoS. With the recent advancements in measurements of NS properties, it is now possible to expand our knowledge on the dense matter EoS, by solving the inverse-problem. We present a novel physics-based deep learning method that exploits the concept of Automatic Differentiation to reconstruct the NS EoS from mass-radius (M-R) observations. A primary neural network (NN) (EoS Network) is deployed to represent the EoS in a model-independent way. A second NN (TOV-Solver Network) is trained to solve the TOV equations efficiently. The EoS Network is then combined with the pre-trained TOV-Solver Network and a gradient-based approach is implemented to optimize the weights of the EoS Network, in an unsupervised manner. Thus, the designed pipeline is trained to optimize the EoS, so as to yield through TOV equations, an M-R curve that best fits the observations. Importance Sampling (a Bayesian perspective) is adopted to evaluate the uncertainty of the NN reconstruction. The devised scheme can be implemented in a number of fields that face challenges with inverse-problems. Related Articles: [1] JCAP 08 (2022) 071 (arXiv:2201.01756) [2] Phys.Rev.D 107 (2023) 8, 083028 (arXiv:2209.08883)

Presenter: SOMA, Shriya

Session Classification: Session 7