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The dangers of learning structured data with Normalising Flows: the dense matter equation of state

We discuss data compression methods and evidence of learned structure in using Normalising Flows to perform the conditional mapping of nuclear equation of state data given observed parameters from gravitational wave signals of binary neutron star mergers. We use a convolutional autoencoder to compress unified high density equations of state - including data from the neutron star crust - to a lower dimensional latent representation, preserving unique features of the individual equations of state. We find that the Normalising Flow shows evidence of learning underlying structure of high density phenomenological equations of state but struggles to interpolate between training samples regardless of Flow architecture. To address this issue, we present an additional Normalising Flow method to augment data during training, mitigating inherent grid-like structure and alleviating cost associated with traditionally expensive equation of state data generation. This work promotes the rapid inference of the neutron star equation of state from multiple gravitational wave events. This is especially important for next generation ground based detectors where neutron star merger events are expected to be frequent and the assumption of a unique fixed crust is no longer valid.

AI keywords

simulation-based inference; normalising flows; data interpretation

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Track Classification: Patterns & Anomalies