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Normalising flows for dense matter equation of state inference from gravitational wave observations of neutron star mergers

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We present a Machine Learning approach to perform fully Bayesian inference of the neutron star equation of state given results from parameter estimation from gravitational wave signals of binary neutron star (BNS) mergers. The detection of gravitational waves from BNS merger GW170817 during the second observing run of the ground based gravitational wave detector network provided a new medium through which to probe the neutron star equation of state. With the increased sensitivity of the current and future observing runs, we expect to detect more of such signals and therefore further constrain the equation of state. Traditionally, equation of state inference is computationally expensive and as such there is a need to improve analysis efficiency for future observing runs. Our analysis facilitates both model-independent and rapid equation of state inference to complement electromagnetic follow-up investigation of gravitational wave events. Using a conditional Normalising Flow, we can return O(1000) neutron star equations of state given mass and tidal deformability samples in O(0.1) seconds. We also discuss strategies for rapid hierarchical inference of the dense matter equation of state from multiple gravitational wave events.

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