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Reconstructing the Hubble function with physics-informed neural networks

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The Hubble function entirely characterizes a given Friedmann-Robertson-Walker spacetime as a consequence of homogeneity and isotropy on cosmological scales. In conjunction with the gravitational field equation, it can be related to the densities of the cosmological fluids and their respective equation of state. The type Ia supernovae allow to constrain the evolution of the luminosity distance which is related to the Hubble function through a differential equation. Physics-informed neural networks can emulate this dynamical system, allowing fast predictions of luminosity distances for a given set of densities and equations of state. PINNs open the possibility of a parameter-free reconstruction of the Hubble function based on supernova Ia observations. This estimation of the Hubble function is then used to reconstruct the dark energy equation of state. Cosmic inference and reconstruction of the Hubble function with associated errors require uncertainty estimates on the network output, we investigate the impact of a heteroscedastic loss on the PINN setup.

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