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Early Inference of Supernova Light Curve Parameters with Physics-Informed Neural Networks

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The early light curves of supernovae provide critical insights into the properties of their progenitor systems and, in some cases, play an essential role in our understanding of the evolution of the Universe. With the advent of wide-field surveys such as the Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST), large samples of early supernova light curves will become available, offering unprecedented opportunities to study massive star evolution and explosion physics. LSST, in particular, will dramatically increase the discovery rate of supernovae during the earliest phases of their explosions. Given the vast number of nightly alerts, rapid and accurate characterization of early light curves from photometric follow-up observations is essential. Here we present a Physics-Informed Neural Network framework to model supernova light curves, combining shock-cooling models for Type II supernovae with color-based models for Type Ia. Using the Type II-P supernova SN 2022acko as a test case, we demonstrate that our method can constrain progenitor star radii from limited data, achieving reliable results within just a few days of observations. This approach provides a scalable path toward extracting physical parameters from the influx of early-time data expected in the LSST era.

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