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Redshift evolution of the underlying type Ia supernova stretch distribution

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The detailed nature of type Ia supernovae (SNe Ia) remains uncertain, and as survey statistics increase, the question of astrophysical systematic uncertainties arises, notably that of the evolution of SN Ia populations. We study the dependence on redshift of the SN Ia light-curve stretch, which is a purely intrinsic SN property, to probe its potential redshift drift. The SN stretch has been shown to be strongly correlated with the SN environment, notably with stellar age tracers. We modeled the underlying stretch distribution as a function of redshift, using the evolution of the fraction of young and old SNe Ia as predicted using the SNfactory dataset, and assuming a constant underlying stretch distribution for each age population consisting of Gaussian mixtures. We tested our prediction against published samples that were cut to have marginal magnitude selection effects so that any observed change is indeed astrophysical and not observational. In this first study, there are indications that the underlying SN Ia stretch distribution evolves as a function of redshift, and that the age drifting model is a better description of the data than any time-constant model, including the sample-based asymmetric distributions that are often used to correct Malmquist bias at a significance higher than 5 σ. The favored underlying stretch model is a bimodal one, composed of a high-stretch mode shared by both young and old environments, and a low-stretch mode that is exclusive to old environments. The precise effect of the redshift evolution of the intrinsic properties of a SN Ia population on cosmology remains to be studied. The astrophysical drift of the SN stretch distribution does affect current Malmquist bias corrections and thereby the distances that are derived based on SN that are affected by observational selection effects. This bias will increase with surveys covering increasingly larger redshift ranges.

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