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Impact of the galaxy cluster environment on the stretch distribution of type-Ia supernovae with ZTF

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Understanding the impact of astrophysical environment on type Ia supernovae (SNe Ia) properties is crucial to minimize systematic uncertainties in cosmological analyses aiming at constraining the properties of Dark Energy using this probe. We investigated the dependence of the SN Ia SALT2.4 light-curve stretch on the distance from their nearest galaxy cluster to study a potential effect of the intracluster medium (ICM) environment on SNe Ia intrinsic properties. We used the largest SN Ia sample to date, the ZTF DR2 sample, and cross-matched it with existing X-ray, Sunyaev-Zel'dovich, and optical cluster catalogs in order to study the dependence between stretch and distance to the nearest detected cluster from each SN Ia. In this presentation, I will show how clusters can help understanding SNe Ia astrophysical systematics and how SNe Ia offer a new avenue to studying the evolution of star formation rate in clusters. Our work supports previous evidence that the age of the stellar population is the underlying driver of the bimodial shape of the SN Ia stretch distribution. It also indicates that SNe Ia search at high redshift targeted towards clusters to maximize detection probability should be considered with caution as the stretch distribution of the detected sample would be strongly biased towards the old sub-population of SNe Ia. Furthermore, we show that the effect of the ICM environment on the SNe Ia properties appears to be significant up to the splashback radius of clusters. This is compatible with previous works based on observations and simulations of a galaxy age gradient with respect to cluster-centric distance in massive halos. The next generation of large area surveys will provide an order of magnitude increase in the size of SNe Ia and cluster catalogs. This will enable more detailed analyzes of the impact of halo mass on the intrinsic properties of SNe Ia and of the fraction of quenched galaxies in the outskirts of clusters, where direct measurements are challenging.

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