The Effect of Local Environment on Type Ia Supernovae in the Dark Energy Survey

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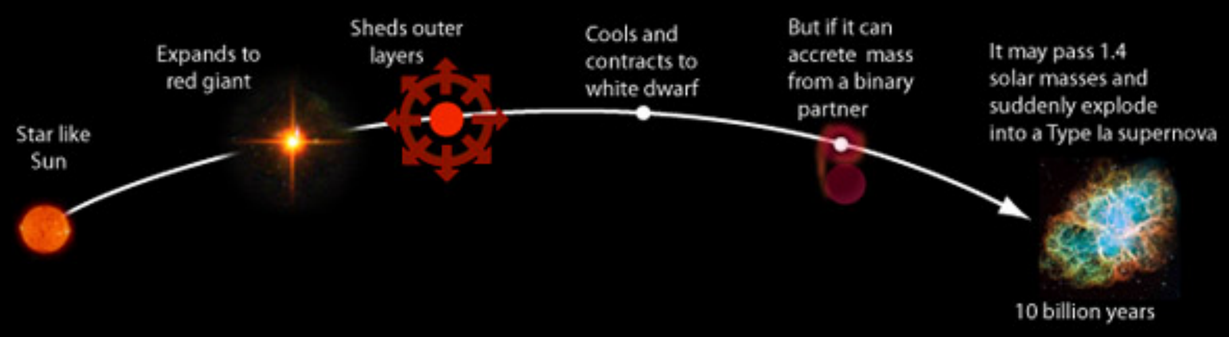
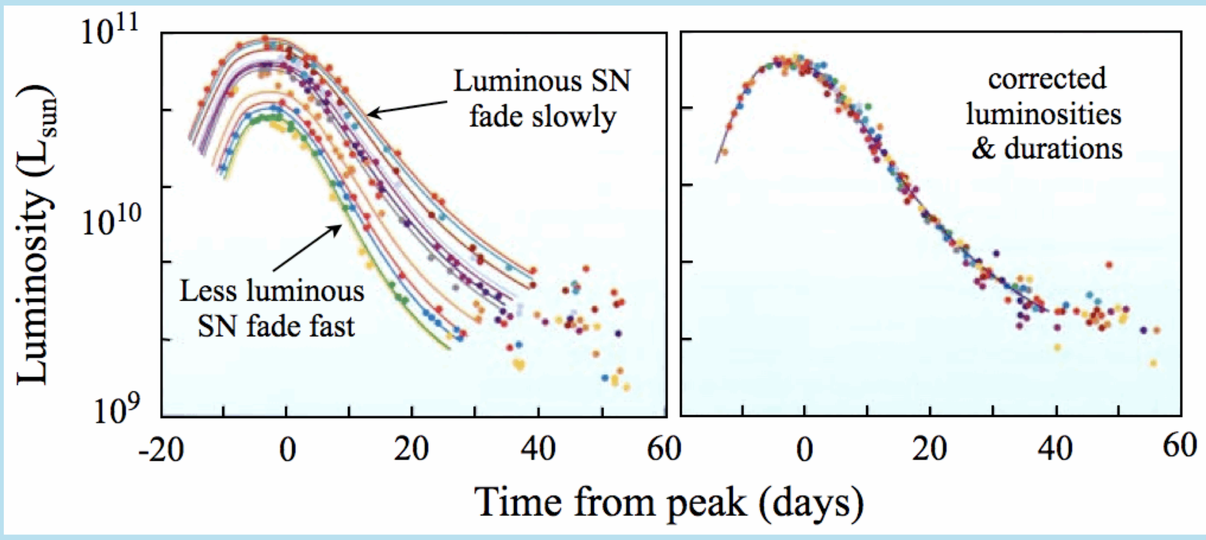
Background

- Type Ia Supernovae (SNe Ia) result from the explosion of a White Dwarf star in a binary system.



- They are used in cosmology as "standard candle" distance measures, due to their well-defined peak brightness after simple corrections. They have also been used to reveal the accelerating expansion of the universe.



- However, recent studies have found that SNe Ia in high-mass galaxies are brighter than those in lower-mass galaxies after the above corrections, questioning their validity as standard candles.
- Masses of galaxies correlate with the ages and chemical composition of the stars within, indicating that the difference in brightness could be due to differences in the progenitor (pre-explosion) stars.
- We correct for host galaxy properties when using SNe Ia in cosmology, but these properties are "light-weighted" - they are most representative of the galactic core, not the actual location of the supernova.
- Using the local environment instead may reduce the SNe Ia brightness variations, improving their standardisation and accuracy in cosmological analysis.

Three colour composite image of one DES CCD. The cluster of bright galaxies near the centre right is Abell 3151.

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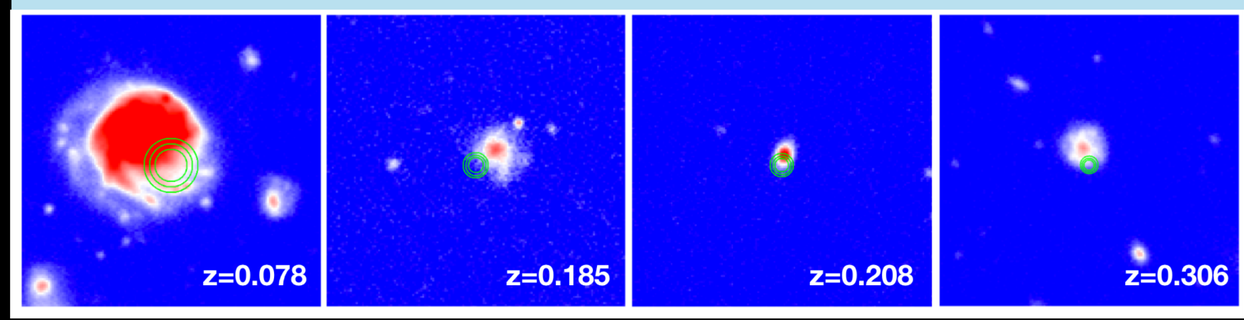
Method

- The Dark Energy Survey (DES) is a 5-year imaging survey covering 5000 square degrees of the southern hemisphere.
- We create stacked images for each SN Ia in the survey, excluding the year in which the supernova in the CCD exploded to avoid light contamination.
- We then take photometry (measure the brightness) of the stacked images, for both the whole host galaxy, and the local region within a radius of 4kpc around each SNIa.



g-band image examples of DES SNIa host galaxies. The concentric green circles represent the local region within a 3kpc, 4kpc and 5kpc aperture radius centred on the supernova location.

- From the photometry, we can estimate the physical parameters of each region: age, stellar mass, star formation rate and rest-frame colours (e.g. U-R), and relate these to the SNIa brightness.

Results

- Greater differences found in SNIa brightness for local environment properties than global galaxy properties
- Stronger effect for environment colour than mass – may be linked to environmental age?

Conclusions

SNe Ia are not perfect standardisable candles due to an unexplained dispersion in their luminosities.
The current method of correcting for their host galaxy mass does not fully explain this difference, but looking at local properties instead provides further information to help improve their standardisation for use in cosmology.

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