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# Where Do Stars Explode in Galaxies? The Local Environments of Low-Redshift Supernovae

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## SUMMARY

- We characterize the dust and stellar properties at supernova sites in order to constrain the stellar populations that give rise to supernovae and their resulting impact on the surrounding gas and dust.
- This is the largest such study to date, with a sample size of ~1,000 supernovae drawn from the Open Supernova Catalog[2].
- We locate each supernova in ultraviolet and infrared images[3] of galaxies. These images highlight the locations of old stars, young stars, and dust in these galaxies. We search for the correlation between this infrared and ultraviolet emission and different types of supernova to characterize the environments in which supernovae explode.
- Following previous works[4], we use pixel statistics in order to generate cumulative distribution functions (CDFs) of supernova types in relation to the ultraviolet and infrared emission of their host galaxies.
- The resulting CDFs support the idea that there is a correlation between environment and supernova type. Specifically, type Ia supernovae track the total distribution of stars in a galaxy while core-collapse supernovae occur in areas of star formation, which is in line with current theoretical expectations.


## INTRODUCTION

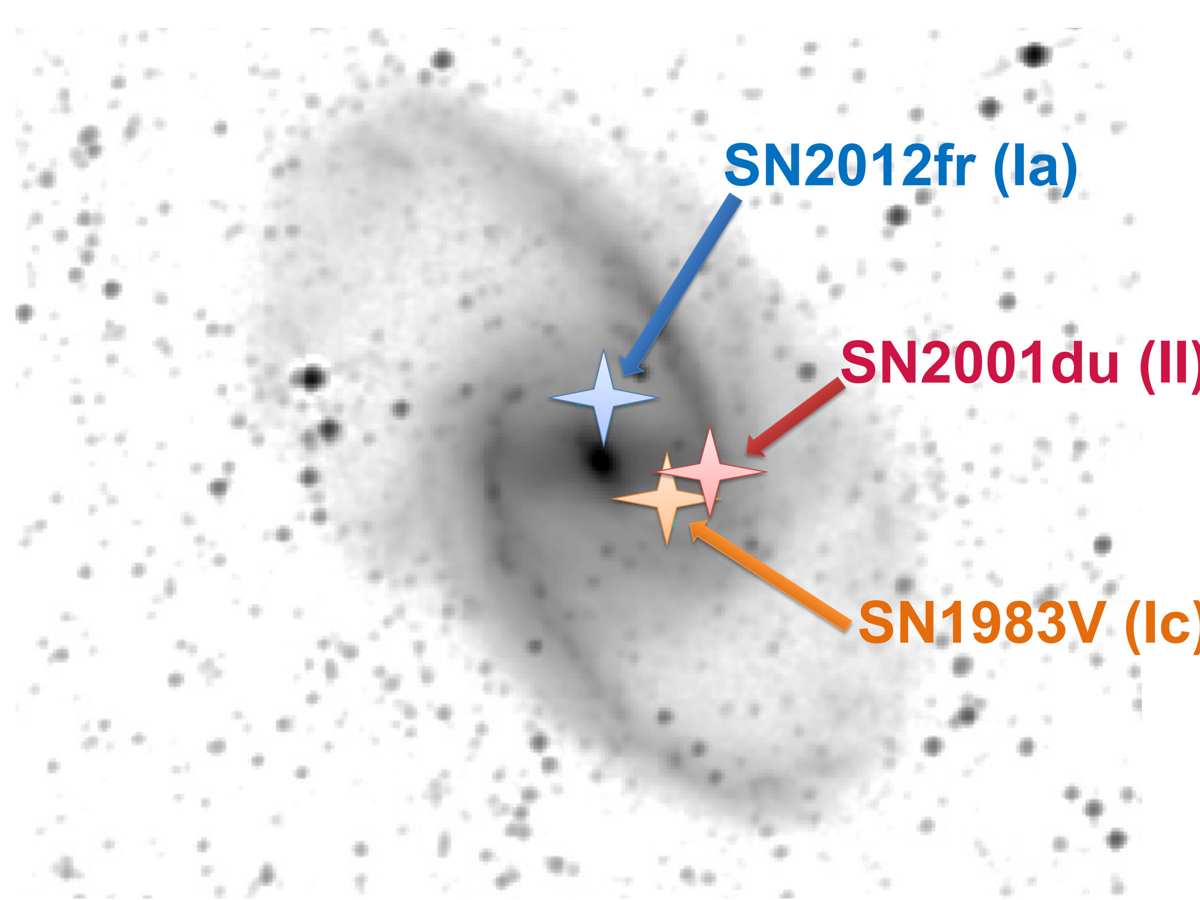
### What is a Supernova?

- Supernovae are the explosive deaths of stars.
- They have catastrophic impacts on the surrounding gas and dust that make up the interstellar medium. They are also vital to creating the heavy elements in the Universe.
- Type Ia supernovae are thermonuclear explosions of white dwarfs.
- Core-collapse supernovae (more specifically, type II and type Ibc supernovae) occur when the cores of high-mass stars collapse due to gravity.
- Despite more than 100 years of study, there are still mysteries yet to solve about supernovae: their exact progenitor properties, their rates of explosion, and the environments in which they explode.

### Data

- We look up the locations of historic supernovae from the Open Supernova Catalog.
- The ultraviolet and infrared images of massive, luminous, nearby galaxies (see: Figure 1) were taken by NASA's WISE and GALEX missions.
- Ultraviolet (UV) and infrared (IR) emission highlight the locations of old stars, young stars, and dust in galaxies. We use UV and IR emission to measure the correlations between supernova type and the properties of the environments in which they explode.

**Figure 1: NGC 1365 and its supernovae in near-infrared**




## METHOD

1. Build CDFs of the total IR and UV emission within the supernova's host galaxy, as sorted by radius from the galactic center (Figure 2).
2. Locate the supernova's radius from the galactic center on the x-axis of its host galaxy's CDF.
3. Record the amount of host galaxy emission that falls within this radius.
4. Repeat this process for every supernova of each type.
5. Compare the distribution of supernovae radii to the distribution of light from their host galaxies as a function of radius in order to test the hypothesis that supernovae are distributed in the same way as the light of their host galaxies (resulting in Figures 3 & 4).

**Figure 2: NGC 1365 CDF of total near-infrared emission**

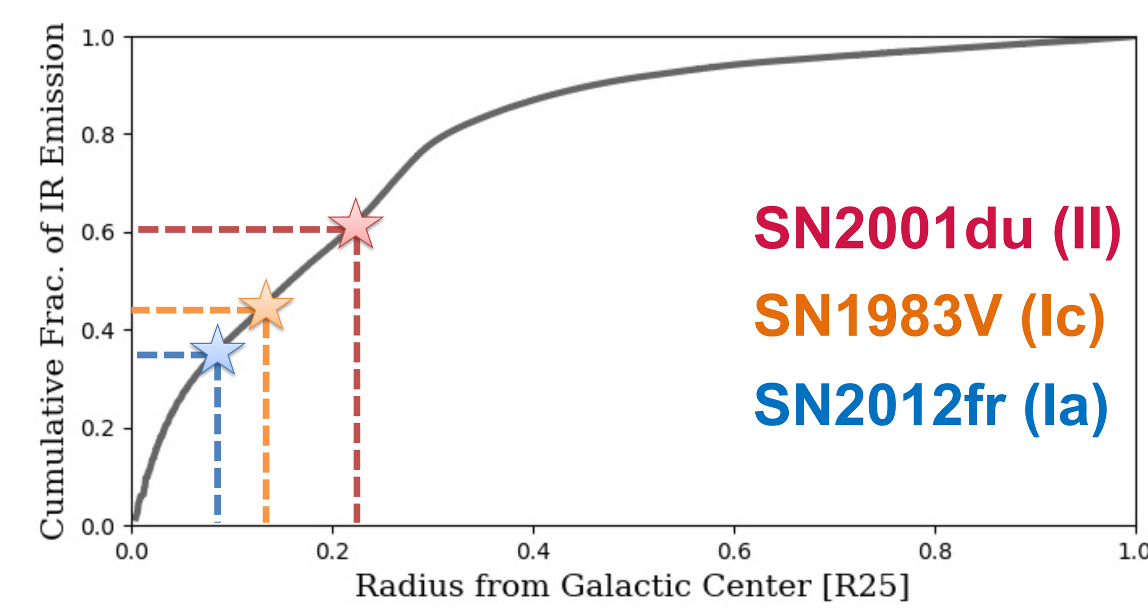
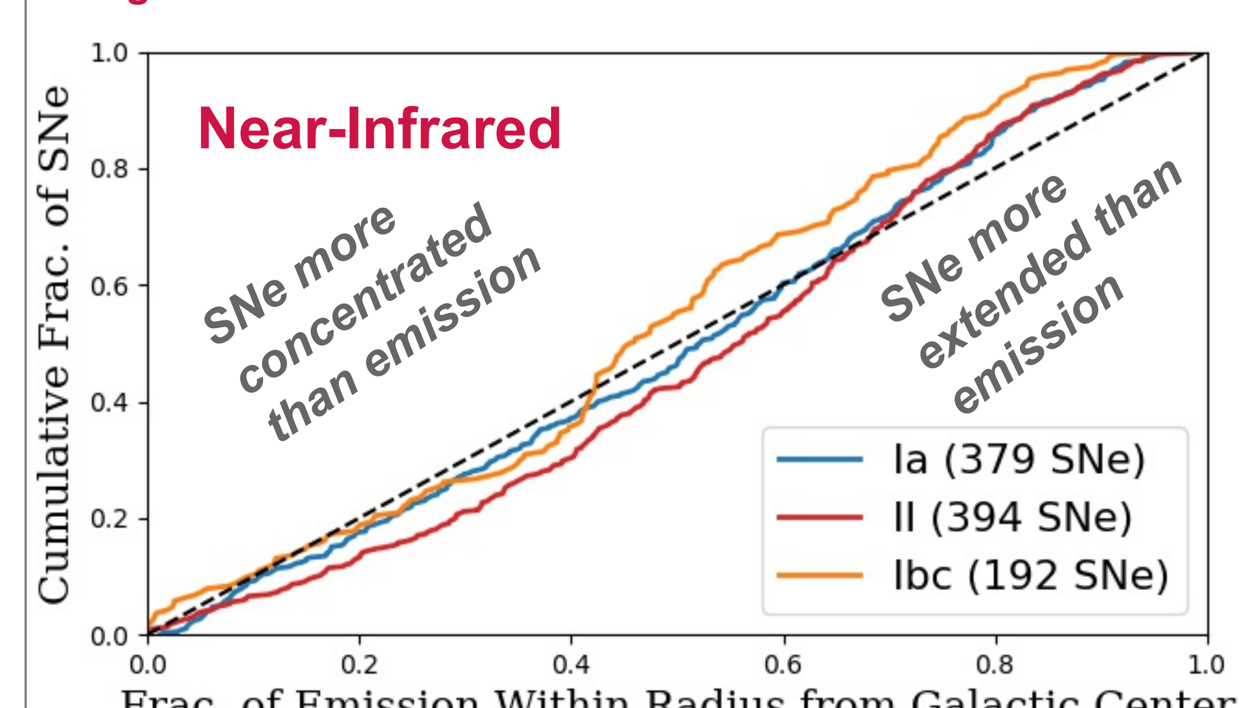



*Figure 2 (above): Cumulative distribution function of all near-infrared emission in NGC 1365. For each supernova in the galaxy, we locate its radius from the galactic center on the x-axis and record the fraction of the galaxy's emission within this radius.*

## RESULTS

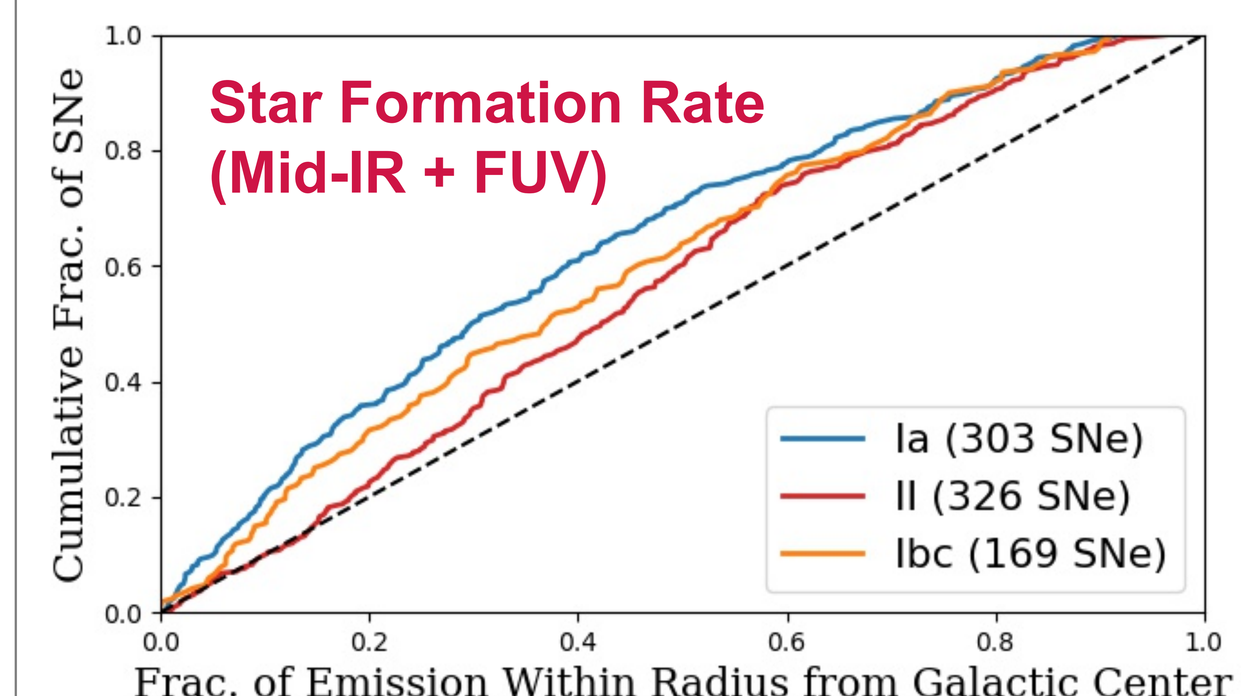
- We repeat the process outlined in the methods section for each near-infrared, mid-infrared, and far-ultraviolet image of a host galaxy (Figures 3 & 4).
- If a supernova population tracks the emitted light, then its distribution will follow the 1:1 line, as shown in each plot.

**Figure 3: Near-infrared CDF**




- The near-infrared plot (above) shows that type Ia supernovae are distributed like that of the total distribution of stars in their host galaxies.
- This is expected because the white dwarfs that give rise to type Ia supernovae are remnants of low-mass stars, and thus should be distributed similarly to that of all low-mass stars, which make up the majority of galaxies.
- We also combine mid-infrared and far-ultraviolet plots to create a star formation rate tracer (below).
- Core-collapse supernovae are more associated with star-forming regions of galaxies than type Ia.
- This is due to core-collapse supernovae having shorter lifetimes, thus exploding in the regions in which they were born.

**Figure 4: Star formation rate CDF**




## CONCLUSIONS & FUTURE WORK

- We have created plots that measure how well type Ia and core-collapse supernovae are distributed like the infrared and ultraviolet light of their host galaxies.
- We conclude that there is a correlation between supernova type and the environments in which they explode.
- We will next investigate the effects that galaxy morphology and inclination may have on the structure of these plots.
- The results of this project will contribute toward an undergraduate thesis and an academic paper.


## BIBLIOGRAPHY

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