An Infrared Search for Dust-Extinguished SNe in ULIRG Galaxies

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Supernova (SN) rates serve as an important probe of star formation models and initial mass functions, particularly at high redshifts due to the SN intrinsic luminosity. Ground-based optical surveys, however, typically discover nearly ten times fewer SNe than predicted, challenging our understanding of massive star formation and evolution. These results are generally attributed to the high dust extinction associated with the nuclei of star forming galaxies, such as Ultra Luminous InfraRed Galaxies (ULIRGs). A successful survey must be conducted at longer wavelengths and with a space-based telescope, which has stable seeing that reduces the necessity for any subtraction algorithms and, therefore, residuals. WFIRST offers an ideal instrument to conduct this experiment. Here we present ongoing work from our 300 hour Spitzer 3.6 micron survey for dust-extinguished SNe in the nuclear regions of ULIRGs within 200 Mpc. The direct product of this study will lay the groundwork for a future survey with WFIRST.

Missing SNe

The observed rate at which stars more massive than 8 M_⊙ explode as core-collapse supernovae (CCSNe) can be used to determine chemical evolution and feedback processes, progenitor mass distributions, star-formation rates, and dust yields. The ability to detect all SNe in a survey limits the completeness of any rate study. This is particularly true in galaxies with high star-formation rates, where gas and dust obscure most of the SNe. In fact, visible-wavelength surveys for SNe in dusty starburst galaxies have established SN rates that are unexpectedly similar to rates observed in more normal galaxies.

The IR, which is about 10 times less affected by extinction than visible light, offers an optimized window for SN searches in these starburst galaxies. In general, the results highlight that S<sub>sim</sub>80% of nearby SNe remain hidden within the innermost nuclear regions of galaxies, with dust extinction A_ν > 25 mag.

The advantage of the infrared (even WFIRST!)

IRAC Channel 1 (3.6 µm) provides an optimal window for detecting SNe embedded in the nuclei of ULIRGs. Increasing extinction (A_ν > 25 mag) shifts the peak of the observed spectrum out beyond the K-band (2.1 µm). Due to the rising thermal background past 2 µm, it is difficult to achieve the same sensitivity with ground-based observations.

A space-based survey offers stable seeing, which reduces the necessity for template subtractions to detect SNe in the galactic nuclei.

We have compiled a list of 41 ULIRGs to be monitored for SNe and other transients over two years. To achieve the desired statistics, we request each galaxy be observed 8 times at t_exposure = 3200 s.

Preliminary Results

Despite the stable seeing from space, the Spitzer PSF itself is not (even close to) symmetric. The telescope rotation throughout the year therefore makes it difficult to search for SNe using standard template subtraction techniques, especially towards the galactic nuclei where most obscured SNe tend to exist.

Instead, we developed a SN detection algorithm using aperture photometry techniques. The noise, however, was dominated by systematics in the data that took significant time to remove and, ultimately, to reduce to the original statistical noise predicted in the proposal.

We present here some preliminary results of the algorithm that will be applied to all the data in the near future. While WFIRST does not extend to the mid-IR, it does offer a much more symmetric and higher-resolution PSF with which to do this project with almost no additional cost.