Challenge: Supernovae Iax

Kazmi, N. F.
Dept. of Astronomy, University of Illinois at Urbana Champaign, Urbana, IL 61801

ABSTRACT

We present an analysis of Supernovae (SNe) 2008ge, 2008ha, 2010ae, 2010el. These SNe were observed using the Hubble Space Telescope (HST) in the optical wavebands. These SNe are catagorized as Type Iax, a distinct category from Type Ia or Type II. Iax are notible for their low spectra luminosity and low ejecta velocities. The stellar populations around these four SNe were analyzed to understand the ages of the SNe. There is a correlation between the ages of the four separate SNe. The details of the analysis include an examination of wavebands ; adjusting the spectra for host and Milky Way (MW) reddening; and filtering out sources with respect to their crowding, sharpness, and roundness features. Further study needs to be done to have conclusive results.

Key words: supernovae: general - supernovae: individual (SN 2008ge, SN 2008ha, SN 2010ae, SN 2010el)

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1. Introduction

Type Iax Supernovae (SNe Iax) are a specific class of SNe, separate from Type Ia SNe (Thermonuclear explosions) and Type II SNe (Core-collapse). Type Iax are theorized to be thermonuclear explosions of Carbon-Oxygen White Dwarf (C/O WD) with a partial deflagration (Foley et al. 2014); however, SNe Iax are different from SNe Ia. In the recent decade there has been an increase of SNe Ia analysis. These studies reveal a range of behaviours and spectral features. The behaviors of SNe with peculiar features were cataloged as SNe Iax (SOURCE).

Iax possess a less luminous light curve and a slower decline rate (SOURCE). They have a lower ejecta velocity and do not show hydrogen and helium in their spectra unless the elements were brought in by outside factors, such as circumstellar disks or intermediate mass elements (SOURCE). Iax do not have an observable second maxima in the near-infared (NIR), (e.g., Li et al. 2003). Though, the explosion mechanics of Iax are still unknown, the closest model predicts a partial deflagration from the accretion of a Helium star onto a C/O WD (SOURCE). The unique spectral features and low luminosity lightcurves require a revised class thermonuclear explosions. Therefore, SNe Iax are a separate category from SNe Ia.

Earlier literature called Iax, 'SN2002cx-like'. SN2002cx was examined because of it's peculiar characteristics. The current class of Iax include 25 SNe. These SNe have a range of behaviors but do have low ejecta velocities, low light curve luminosities, and lack the (usual) Ia features.

Four SNe from this class were studied in this analysis, SN2008ge, SN2008ha, SN2010ae, and SN2010el. The focus was on contraining the age limit of the surrounding stellar populations of these four SNe. The stellar population around SN2008ha (08ha) was modeled in Foley et al. (2014), the contrains were recreated for the purpose of applying similar constrains to 08ge, 10ae, and 10el.

In this paper, we will discuss our findings of Iax stellar populations In section 2, we will discuss the Spectroscopy and Photometry of these SNe . We will discuss the methods of our analysis in section 3. In section 4, we will discuss our contraints and results. The summary of this project is in section 5. The World Coordinate System (WCS) is used throughout this analysis.

2. Class Members

The classification of SNe was based off of spectral observations. The increase in SNe data shows the variations in SNe spectra. SN Iax are a result of the new classifications, Iax had a much lower light curve, (exact value), and other stuff. The current list of SNe Type Iax contain 25 SNe, of that list, 4 SNe were chosen to study in depth.

2.1. SN 2008ge

SN 2008ge was first observed by CHASE on 2008 October 8.27 in NGC 1527 (Pignata et al. 2008). [Exact RA and DEC, position details]

2.2. SN 2008ha

SN 2008ha was first observed 2008 November 7.17 in UGC 12862 (Puckett et al. 2008). The classification of Iax was originally called "SN 2002cx-like", SN 2008ha falls on the extreme end of this type. It is less luminous and has one of the smallest ejecta velocity. (Foley et al. 2009, 2010a; Valenti et al. 2009). The remaining criteria (what makes it Iax). [Exact RA and DEC, position details]

2.3. SN 2010ae

SN 2010ae was first observed 2010 February 23 in ESO 162-G017 (Pignata et al. 2010) [direct line from foley 2013]. First observations of it declared it a SN Ia, later it was identified to have a spectra similar to SN 2008ha (Stritzinger et al. 2010b). It was then reclassified as a SN Iax. [Exact RA and DEC, position details]

2.4. SN 2010el

SN 2010el was first observed 2010 June 19 in NGC 1566 (Monard 2010) [direct line from foley 2013] It was identified to have a spectra similar to SN 2008ha and was catagorized as Type Iax (Bessell et al. 2010). [Exact RA and DEC, position details]

3. Spectroscopy & Photometry

This analysis used HST photometric images of SNe 2008ge, 2008ha, 2010ae, and 2010el. These four SNe were observered in the F435W, F555W, F625W, and F814W wavebands. The HST collected these images using (HST Info- exposures, camera lens size and date and time it observed each object. Are these early time or late time spectra, what part of the timeline are we looking at) This data was collected [DATE] using [type of collection method, ccd stuff, how the images were corrected]. From these images we were able to generate a catalog of sources using the DoPHOT photometry package.

Galaxy subtraction info

4. Methods

dim and bright stars crowd ¡= .43 sharpmax ¡= .3 sharpmin ¿= -.45 roundmax ¡= 2.0

radius ¡ = 100 sn ¿ 3 too dim of points sn ¡30 too bright, extended features filtered out bad sources, used ds9 for this

The catalogs generated for this analysis provided us with a selection of stars. The catalog was filtered out to focus on sources, bright and faint stars. The remaining criteria included it's position, the filters included sources within a radius 100 pixels, though the physical distance is dependent on the SNe being discussed. The other criteria was the Signal to Noise (S/N), at minimum, sources had to be above S/N of 3 in at least one waveband. The sources also needed to have particular Crowding values, for example, very clustered sources may included extended sources, which would not be "good" sources. The sharpness and roundness was also taken into account. The sharpness was set to [], and the roundness was set to [].

Using these parameters, we were able to recreate the Color Magnitude Diagram (CMD) of SN 2008ha, figure () from (Foley ...). This study focused on the stars within (15, 30, and 45 pix -¿ turn to pc)

5. Discussion

The stellar populations around SNe 2008ge, 2008ha, 2010ae, and 2010el

6. Results

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