Death of Massive Stars: Supernovae and Gamma-Ray Bursts
Proceedings IAU Symposium No. 279, 2012
P. Roming, N. Kawai & E. Pian, eds.

doi:10.1017/S1743921312013269

Mass and metallicity constraints on supernova progenitors derived from integral field spectroscopy of the environment

Hanindyo Kuncarayakti[1], Mamoru Doi[1], Greg Aldering[2], Nobuo Arimoto[3], Keiichi Maeda[4], Tomoki Morokuma[1], Rui Pereira[5], Tomonori Usuda[6] and Yasuhito Hashiba[1]

[1]Institute of Astronomy, Graduate School of Science, the University of Tokyo
2-21-1 Osawa, Mitaka, Tokyo 181-0015, Japan
email: hanin@ioa.s.u-tokyo.ac.jp

[2]Physics Division, Lawrence Berkeley National Laboratory
1 Cyclotron Road, Berkeley, CA 94720, USA

[3]National Astronomical Observatory of Japan
2-21-1 Osawa, Mitaka, Tokyo 181-0015, Japan

[4]Kavli Institute for the Physics and Mathematics of the Universe, the University of Tokyo
5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8583, Japan

[5]CNRS/IN2P3, Institut de Physique Nucléaire de Lyon
4 Rue Enrico Fermi, 69622 Villeurbanne Cedex, France

[6]Subaru Telescope, National Astronomical Observatory of Japan
650 North A'ohoku Place, Hilo, HI 96720, USA

Abstract. We have obtained optical integral field spectroscopy of the explosion sites of more than 25 nearby type-IIP/IIL/Ib/Ic supernovae using UH88/SNIFS, and additionally Gemini/GMOS IFU. This technique enables us to obtain both spatial and spectral information of the immediate environment of the supernovae. Using strong line method we measured the metallicity of the star cluster present at the explosion site, presumably the coeval parent stellar population of the supernova progenitor, and comparison with simple stellar population models gives age estimate of the cluster. With this method we were able to put constraints on the metallicity and age of the progenitor star. The age, i.e. lifetime, of the progenitor corresponds to the initial mass of the star. By far this is the most direct measurement of supernova progenitor metallicity and, if the cluster-progenitor association is confirmed, provides reliable determination of the initial mass of supernova progenitor stars.

Keywords. stars: supernovae

1. Introduction

Despite the large number of observed events, the current knowledge of supernova progenitors and of the final stages of massive stars still needs refinement. Theoretical predictions have suggested numerous possibilities on how a certain type of star produces which type of supernova. This poses the challenge of answering the question of which kind of star produces which supernova with observational evidences. It has been suggested that progenitor mass and metallicity are the most important parameters which drive the evolution of a massive star into supernova (e.g. Georgy *et al.* 2009). With integral field spectroscopy we were able to determine directly the metallicity of the explosion site, and derive the initial mass of the progenitor star via host cluster study. These constraints of mass and metallicity will give better understanding of the progenitor stars of supernovae.

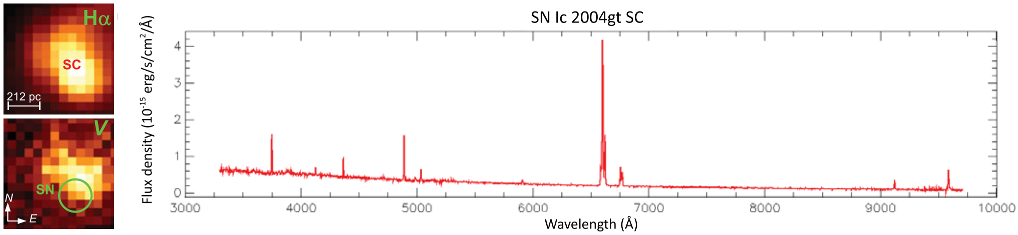

Figure 1. Reconstructed SNIFS IFU focal plane images of SN 2004gt explosion site in Hα and V-band (left panels), and the extracted spectrum of the host cluster (right).

2. Observation and data analysis

Using SNIFS integral field spectrograph (Aldering *et al.* 2002) attached to University of Hawaii 2.2 m telescope (UH88) at Mauna Kea and Gemini-N/GMOS-IFU (Hook *et al.* 2004; Allington-Smith *et al.* 2002), we observed 27 nearby type-IIP/IIL/Ib/Ic supernova sites in 2010–2011. Both SNIFS and GMOS datasets were analysed using IRAF. We performed aperture extraction to the flux-calibrated (x, y, λ) datacubes in the wavelength direction to obtain the spectra of the clusters in the field of view. We then measured the emission lines to determine metallicity using strong line method (Pettini & Pagel 2004). The age of the clusters was determined by comparison of Hα or near-infrared Ca II triplet equivalent widths with simple stellar population (SSP) models from Starburst99 (Leitherer *et al.* 1999) for the respective metallicities. Adopting the age of the parent stellar population as the supernova progenitor lifetime, we derived initial mass of the progenitor star using Padova stellar evolution models (Bressan *et al.* 1993).

3. Results

Figure 1 shows SN 2004gt site, one example of the results. SN 2004gt exploded in the outskirts of a cluster identified as the 5.8 Myr-old knot S in Whitmore *et al.* (2010). We derived the age of this cluster as 5.8 Myr. Metallicity was derived as $12 + \log(\mathrm{O/H}) = 8.72$, consistent with Modjaz *et al.* (2011)'s determination of $12 + \log(\mathrm{O/H}) = 8.70$. The derived age corresponds to the lifetime of a progenitor star with initial mass of 33.5 $M_\odot$.

We carried out our analysis on all of our samples and found that the result is mostly consistent with the currently accepted SN Ic > Ib > II progenitor mass sequence (Anderson & James 2008). Interestingly, we also found that the progenitors of all those types of core-collapse supernovae can appear on the same region in the mass-metallicity space. The full result of this work will be presented in Kuncarayakti *et al.* (2012, in preparation).

References

Aldering, G., *et al.* 2002, *Proc. SPIE*, 4836, 61
Allington-Smith, J., *et al.* 2002, *PASP*, 114, 892
Anderson, J. P. & James, P. A. 2008, *MNRAS*, 390, 1527
Bressan, A., *et al.* 1993, *A&AS*, 100, 647
Georgy, C., *et al.* 2009, *A&A*, 502, 611
Hook, I., *et al.* 2004, *PASP*, 116, 425
Leitherer, C., *et al.* 1999, *ApJS*, 123, 3
Modjaz, M., *et al.* 2011, *ApJ*, 731, 4
Pettini, M. & Pagel, B. E. J. 2004, *MNRAS*, 348, L59
Whitmore, B. C., *et al.* 2010, *AJ*, 140, 75

https://doi.org/10.1017/S1743921312013269 Published online by Cambridge University Press