論文の内容の要旨

論文題目

An Integral Field Spectroscopic Study of Nearby Supernova Explosion Sites:Constraints on Progenitor Mass and Metallicity
(近傍超新星の面分光観測による出現環境の研究ー親星の質量と金属量への制限ー)

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The progenitors of supernovae are still not very well characterized. In the recent years, a number of supernova progenitors have been recovered in pre-explosion high resolution archival images. This provides the opportunity to determine the location of the progenitor stars on the Hertzprung-Russell Diagram and compare them to stellar evolutionary tracks to estimate their initial masses. Despite the discoveries, the progenitors of supernovae are still uncertain and theoretical predictions relating the death of certain types of massive stars with a particular type of supernova still need to be confronted with more observational evidences. Thus far only a handful of type II supernova progenitors have been obtained, and there is still no detection of type I supernova progenitors.

In addition to attempting direct detections of the progenitors, investigations on the local environments of the supernovae has proven to be very useful in providing clues about the nature of the progenitors. Association of the supernova with nearby star-forming regions suggests that type Ic supernovae arise from the most massive progenitor stars, followed by supernovae type Ib and type II (Anderson & James, 2008; Anderson et al., 2012). For the hydrogen-poor supernovae Ib and Ic, metallicity is another important parameter of the progenitor star. As the progenitor star needs to be stripped of its hydrogen envelope, metallicity-driven wind has been suggested as one possible mechanism for the removal of the envelope. Indications that Ic supernova progenitors are the most metal rich among the other types have been found (Modjaz et al., 2011; Leloudas et al., 2011; Sanders et al., 2012). A general belief is that Wolf-Rayet stars are the one of the most likely progenitors of type Ib/c supernovae.

In this work, integral field spectroscopy is used to obtain spatial and spectral information of nearby core-collapse supernova sites, providing an insight never obtained before into the immediate environments and the parent stellar populations of the progenitor stars. The observation was carried out with UH88/SNIFS and Gemini/GMOS atop Mauna Kea in 2010-2011. The use of integral field spectroscopy enables the acquisition of both spatial and spectral information of the object simultaneously in a single observation. With this technique the parent stellar populations of the supernovae were detected, and subsequent spectral analysis was performed to constrain their physical properties.

As the spectrum of the parent population was extracted and analysed, its age and metallicity were derived and used to constrain the age, or lifetime, and metallicity of the once coeval supernova progenitor star itself. Metallicity of the stellar population was determined using strong-line method, and age was obtained by comparing age indicators in the spectrum to simple stellar population models. The lifetime of the star corresponds to its initial zero age main sequence (ZAMS) mass. Since the evolution of a star is mainly governed by its initial mass, this provides an strong constraint to the

mass range of stars that can produce a particular type of supernova. This method offers a reliable estimate of the supernova progenitor mass which previously only available for a few type II supernovae, and furthermore, provides metallicity estimates unattainable from imaging observations only.

In this study it was found that supernovae type Ic might have been produced by progenitors which are more massive and metal rich compared to supernova type Ib progenitors. It was also found that possibly some Ib/c supernova progenitors are less massive than the typical Wolf-Rayet stars ($\lesssim 25\ M_\odot$), suggesting that they might have lost their hydrogen envelope via massive binary interaction. This further strengthens the contemporary notion of the existence of both single and binary Ib/c progenitors and the importance of binarity in the evolution of massive stars (Leloudas et al., 2011; Sana et al., 2012). The association of the supernova and the host stellar population in this study was also checked, resulting in an estimate that 50% of them are real association, and the other 50 % are possibly just chance alignments. As it was found in this study that type II supernovae appears to be produced by stars from a wide range of initial mass encompassing supernova Ib/Ic progenitor mass, even if half of them are just chance superpositions the conclusion that some type II progenitors are massive would still hold. This work also demonstrates the power of integral field spectroscopy in investigating supernova environments and active star forming regions.