(　2022) 年度国立天文台滞在型共同研究報告書

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国立天文台長 殿

申請者 （受入責任者）	氏名	守屋尭
	所属・職	科学研究部・助教
研究課題名	Combined study of Type IIn supernovae and their local environmentwith Integral Field Spectrosc	
研究場所	三鷹キャンパス	
台外からの 共同研究者	氏名	Lluis Galbany Gonzalez
	所属・職	Institute of Space Sciences, Spain・Ramón y Cajal Fellow

1. 研究概要

Single-star evolution models predict that massive stars (M > 8 Msun) form a heavy iron core 4-40 Myr after their birth which gravitationally collapses, triggering the explosive ejection of the stellar outer envelope and producing a core-collapse supernovae (CC SNe). Type II SNe, which show H features in the spectra, are the most common CC SNe. Red supergiant (RSG) stars have been found at the locations of ordinary Type II SNe in pre-explosion images and their progenitor mass has been constrained to be between 8.5 and 16.5 Msun (Smartt 2015, PASA, 32, 16).
It is known that Type II SNe have some subtypes. Among them, Type IIn SNe are those showing narrow Balmer emission lines in their spectra. The narrow emission lines are caused by the interaction between SN ejecta and dense circumstellar matter (CSM). This suggests that their progenitors have passed episodes of enhanced mass-loss activity prior to their explosion caused by strong winds or binary interaction induced by a companion star. As suggested by Taddia et al. 2015, A&A, 580, 131, if the mass-loss is only due to canonical stellar winds, we expect to see continuity in the observed properties of Type IIn SNe. However, Type IIn SNe are known to be the SN type with the most heterogenous observational properties, which indicate that the diversity exists not only in the mass-loss mechanisms but also in their progenitors. Indeed, the direct progenitor detections of Type IIn SNe also indicate the multiple progenitor channel leading to Type IIn SNe. Both very massive stars above 50 Msun such as luminous blue variables (LBVs) (e.g., Gal-Yam & Leonard 2009, Nature, 458, 865) and low-mass stars around 10 Msun such as RSGs (Prieto et al. 2008, ApJ, 681, 9) have been identified as progenitors of Type IIn SNe. However, the major progenitor channel of Type IIn SNe is not yet clear.
Studying the environment around Type IIn SNe is another way to investigate the diversity in Type IIn SNe. Taddia et al. 2013, A&A, 558, 143 showed that Type IIn SN environments exhibit a metallicity distribution that closely matches that of ordinary Type II SNe, consistently with what Anderson et al. 2012, MNRAS, 424, 1372 found studying the association of SN types to the distribution of the Halpha emission (proxy for ongoing SFR) in their host galaxies: Type IIn SN distribution was quite similar to that of ordinary Type II SNe, indicating that they may come from progenitors with similar stellar masses. Kangas et al. 2017, A&A, 597, 92 studied the distribution of massive stars and SNe in the LMC and M33 and found no correlation between LBV and Type IIn SN distributions, which favored lower mass progenitors for Type IIn SNe. Moreover, Kuncarayakti et al. 2018, A&A, 613, 35 recently found that Type IIn SNe are less related to ongoing SFR studying the parent clusters with high-resolution narrow-field Integral Field Spectroscopy (IFS).
Galbany et al. 2018, ApJ, 855, 107 studied the stellar populations present at SN locations of all types, using IFS data from the Pmas/PPak Integral-field Supernova hosts Compilation (PISCO). Stellar population synthesis of IFS allows the reconstruction of the star formation history (SFH) at different locations in the galaxy, particularily at SN locations. An interesting result is that SNe IIn have a bimodal behavior, with higher averages than ordinary Type II SNe both in the younger and older bins and lower or similar percentages than ordinary Type II SNe in the central two bins.
All these evidence together would suggest that SNe IIn come from a mixture of progenitors, some fraction from young and massive progenitors (e.g., LBVs) and probably a higher fraction from older progenitor populations (e.g., RSGs). Unfortunately, there was no IFS data available for a larger sample of SNe IIn, and it was not possible to extend the study with the distribution of environmental metallicities compared to Type IIn SNe.
The proposed research aims at extending this work from the 15 Type IIn SNe used in Galbany et al. (2018) to a sample of around 60 Type IIn SNe from other IFS surveys (PISCO, AMUSING, and MANGA). In addition, we will search for correlations among local environmental properties from the IFS data, SN light-curve parameters (for a fraction of objects with data available), and models from Moriya et al. 2013, MNRAS, 435, 1520 as well as Suzuki, Moriya, & Takiwaki 2019, ApJ, 887, 249. This will be the most complete study of Type IIn SNe to date, putting together SN observations, modelling, and IFS of their host galaxies.

２．研究成果　※学会等での発表、学会誌等に掲載するなどされた場合は（別紙）にご記入ください。

ホスト銀河がIFUで観測されており、かつ光度曲線のデータが十分あるIIn型超新星のサンプルをまず作成した。作成したサンプルのIFUデータの再解析をGalbany氏が行い、IIn型超新星の現れた場所とその周辺の金属量や星形成率を見積もった。並行して守屋がIIn型超新星の光度曲線をもとに主に親星の質量放出率を見積もった。最後に両者で見積もった値に相関があるかどうかを調べた。この結果、IIn型超新星の金属量と質量放出率に反相関がある可能性があることが判明した。これはこれまで知られていなかった結果である。質量放出率は金属量と相関する場合が多いが、IIn型超新星爆発の場合は反相関しており、逆センスである。例えばIIn型超新星が爆発直前に行う質量放出が爆発直前の親星の質量に相関する場合、このような逆相関が得られるかもしれない。いずれにせよ、単純な予測に反する面白いインパクトのある結果が得られた。今後論文としてまとめていく。また、HSCで行われている突発天体サーベイのフォローアップ観測で今後協力していくこととなった。国立天文台の談話会でも講演していただき、有意義な議論が行われた。

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なし

５．共同研究者の滞在日程

氏名・所属	Lluis Galbany Gonzalez・Institute of Space Sciences, Spain
滞在日程・日数	2022年　7月　11日　～　2022年　7月　29日　（　19　）日間
滞在日程・日数	年　月　日　～　年　月　日　（　）日間
合計	（　19　）日間

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