2019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

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研究課題名	Effect of dense circumstellar media on early light curves of stripped-envelope supernovae	
研究場所	Mitaka Campus	
台外からの 共同研究者	氏名	Andrea Nagy
	所属・職	University of Szeged ・ Postdoc

1．研究概要

Recent high-cadence transient surveys are starting to catch supernovae (SNe) shortly after their explosions. They are often discovered within a few days after the explosions, and some of them are even discovered within a day after their explosions. The SN information at the very early phases provides us with the information on, e.g., the progenitor’s radius and circumstellar property. In this study, we focus on early SN light curves of stripped-envelope SNe. Stripped-envelope SNe are SNe with little or no hydrogen-rich envelopes left in their progenitors. They need to lose their hydrogen-rich envelope during their evolution, but the exact mass loss mechanism is not well known. When stripped-envelope SNe are observed early enough, they often show a double-peaked light curve. The first peak appears in a few days after the explosion and then the second peak appears in about 10-30 days after the explosion. The second peak is caused by the radioactive decay of 56Ni and 56Co. However, the origin of the first peak is still under debate. We focus on this first peak in this joint research. It has been suggested that the first peak is due to the initial adiabatic cooling of the relatively extended progenitors. However, the early light curves can also be affected by the circumstellar medium surrounding the progenitors. If the circumstellar medium is dense enough, the SN ejecta are decelerated significantly at the beginning. The efficient conversion from kinetic energy to radiation energy occurs in the early phases resulting in the first light curve peak. The effect of the dense circumstellar media on the early light curves on hydrogen-rich SNe has been investigated, but there are not many studies investigating the early effect of the circumstellar interaction in stripped-envelope SNe. In this research project, we investigate the possibility that the first light curve peak in stripped-envelope SNe is powered by the interaction. We numerically model the light curves powered by the interaction between SN ejecta and the circumstellar media by assuming many different circumstellar configurations such as density or radius. We first assume spherically symmetric circumstellar configurations and use the numerical radiation hydrodynamics code STELLA to model the light curves. Then, we move to multi-dimensional circumstellar configurations in order to check how multidimensionality affects the light curves from the interaction. We plan to use the FLASH code for this, for which the joint researcher has experience. Finally, we compare our light curve models with the early observations of stripped-envelope SNe. We plan to make our light curve models public in order for observers to use our models to interpret their observations.

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。

In ordar to obtain a complete picture of stripped-envelope supernovae with dense circumstellar media, we started from calculating stripped-envelope progenitor models using the public stellar evolution code MESA. We succeeded in creating several stripped-envelope supernova progenitor models with different masses to investigate the diversity in double-peaked stripped-envelope supernovae. We calculated light-curve models from the newly obtained progenitor models using the SNEC code. We originally planned to use another light-curve modeling code STELLA, but we have chosen to use SNEC because it is computationally cheaper and faster. We succeeded in obtaining light-curves with and without dense circumstellar matter. We compared our models with several observed double peaked supernova light curves, including SN 2008D, SN 1993J, and SN 2013df. Our initial model was consistent with the double-peaked light curve of SN 2013df and we succeeded in showing that the first peak in the double-peaked stripped-envelope supernovae can be explained by the circumstellar interaction. The other supernovae needs to have other circumstellar and explosion properties from our initial models, but we think they can be easily reproduced soon, confirming that our idea is generally applicable. The visit finished before trying to work on the multi-dimensional interaction modeling. We will keep working together and move to the multi-dimensional model once we are satisfied with the one-dimensional modeling by SNEC. Dr. Nagy also gave a seminar talk at Division of Science. The new results presented by her stimulated discussions among the researchers in Division of Science and resulted in fruitful discussion.

３．本制度に対する意見、要望など【申請者記載欄】

The visitor room was too far from Division of Science. For Division of Sicence to be successful, a dedicated visitor office accepting long term visitors should be made near the Division.

４．本制度に対する意見、要望など【本事業で来訪した共同研究者記載欄】

I have no comments about the visitor program. It was very pleasant to work at NAOJ.

5. 共同研究者の滞在日程										
氏名・所属	University of Szeged ・ Postdoc									
滞在日程・日数	2019年	9月	1日	～	2019年	11月	4日	(	65	)日間
滞在日程・日数	年	月	日	～	年	月	日	(		)日間
合計								(	65	)日間

（記載要領）
※ 記入欄は必要に応じ適宜スペースを拡張して記入のこと。
※ 共同研究者の滞在日程は、必要に応じ行を追加して記入、複数人招へいしている場合には、表をコピーして各人ごとに記載すること。
※ 報告書の公開にあたり支障を生ずるおそれがある場合は、当該部分とその理由を明記すること。

【お願い】
滞在終了2年後、当該共同研究によって出版された論文等の成果の提出を依頼させていただきますので、その際はご協力ください。