Supernovae Hunter: Spot the Difference of Night Sky to Solve Mysteries of the Universe

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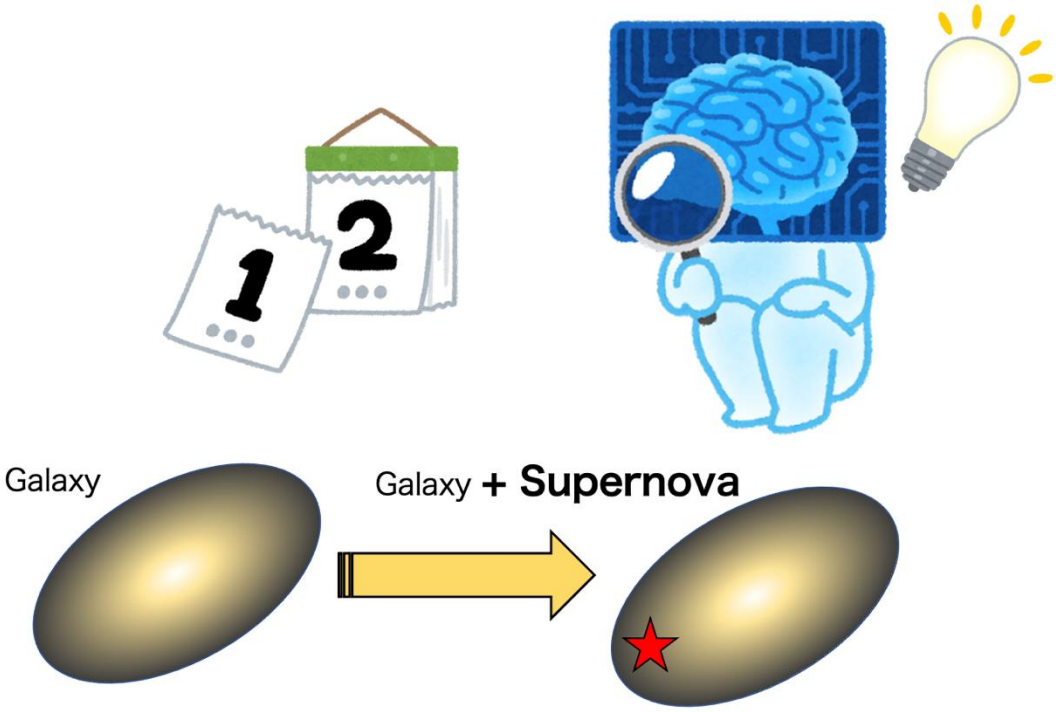

What do you think about the relationship between a star and a galaxy? You may imagine many sun-like stars coming together and forming one galaxy. In that sense, a star is just a particle that makes up a galaxy. However, once a star ends its life in a galaxy, its appearance will drastically change. Some (usually heavier) stars end their lives with a big explosion called a “Supernova.” Even if its origin is a single star, it emits so much energy that it gets as bright as its host galaxy in several weeks, and then it will get darker and darker. This phenomenon is already recorded in the diary of a Japanese poet about 1000 years ago and called a “guest star.” It is a rare event that a supernova happens close enough to be seen by the naked eye like in this case, but there are so many galaxies in the universe, and such an explosion is thought to happen somewhere every day.

However, it is impossible to predict when and where they happen precisely, and it is difficult to observe a supernova a few days after the explosion. Astrophysicists work hard to make models and predictions for mechanisms of explosions and materials formed soon after explosions, but what happens in real is still a mystery. For example, type Ia supernovae, one type of supernovae show similar evolution of brightness to each other. However, it has been recently discovered that some of them get brighter than typical ones for several days after the explosion. Such an observational variation comes to be revealed, but it is not yet understood in detail because the sample size is too small to discuss the fraction of type Ia supernovae showing variation in their early time. Now let me tell you when I became fascinated by supernova explosions.

As a new junior high school student, I thought the universe had hardly changed. All I knew then was that the age of the universe is 13.7 billion years old, the age of the Sun and the Earth is 4.6 billion years old, and the Earth repeatedly spins around the Sun over one year. That “unchanging” universe fascinated me, and I came to read books about the universe. One day, I found an explanation of supernovae. It said that supernovae are large explosions that change their brightness drastically in a few days, and they happen somewhere in the universe every day. This radically changed my impression of the universe. While we are going about our daily lives, surprisingly large explosions happen somewhere in the universe every day! That is why I was fascinated by the “spot the difference of night sky,” which the universe gives us new questions every day. Then I started to look into supernovae, and I learned that the explosion mechanisms of some types of them are not known in detail. “I’ll find supernovae earlier than anybody else and solve the mystery of the evolution of stars!” This inspired me to be a scientist. What do we need to “spot the difference of night sky”? The first is the telescope’s eyesight,

and the second is the telescope's field of view. These two enable us to search vaster and further areas. The third is the computer as a judge. It compares newly taken images during a daily patrol to "usual sky" images and judges if there are any changes in a new image. The use of machine learning in this process has resulted in a significant increase in the number of supernova discoveries in recent years. We use the latest knowledge in optics, engineering, and informatics to discover supernovae. It is also the attraction of this field that we challenge the universe with a combination of various scientific techniques.

Trying to deeply understand the end of a star's life seems to be a pure intellectual desire, whereas the technology for this research will affect people in the next 10-20 years. I noted above that machine learning is used to search for supernovae. There are two approaches to discover supernova candidates. One is anomaly detection in images, just like we do in the spot the difference. This corresponds almost entirely to our visual information. The other is a classification based on many parameters. It calculates the likelihood that a supernova candidate is real by gathering a variety of information, such as how far away it is from Earth, how far away it is from the nearest galaxy to it, how much its brightness has changed, etc. This method is, so to speak, trends inferred by our experiences. With these techniques, we immediately notice changes in things that we cannot or do not see by the naked eye. At present, object detection by AI has already been introduced in some cars and assists in driving. To realize self-driving shortly, real-time and precise anomaly detection and probability prediction of collision are essential. Not only self-driving but also security cameras, etc., if they have a function that alerts us when there is a change from usual, we can "notice" in a moment even if we cannot or do not see. Of course, even when we can get information several hours after supernova

explosions, the universe will continue to show us new mysteries. In that sense, this research will change the way we think and/or behave in the next 10-20 years, and yet continue to show us the fascination of the universe as it does today.

I used Grammarly to correct grammar. I would like to thank Prof. Mark Vagins and Mr. Xinye Guan for their advice on this essay.