The Early Spectroscopy of Supernovae

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Summary. The spectroscopy of a supernova (SN) just after its discovery is quite important not only for the spectral type classification but also for the planning further follow-up observations or the target-of-opportunity observations (ToOs). The early spectroscopy is needed also because the information from the outermost envelope of such exploding objects as SNe cannot be obtained in the later phase. In order to obtain the early spectrum, the quick circulation of the discovery information is important. We introduce our contributions with the public astronomical observatories in Japan, including the case of "hypernova" SN 2002ap discovered by a Japanese amateur astronomer. We summarize the time interval between the discoveries, the announcements, and the first spectral classifications of recent SNe, and discuss what would be required for the early spectroscopy.

1 Importance of the Early Spectroscopy

The early spectroscopic observation after the discovery of a SN is very important in many aspects. The early type determination is necessary to trigger the ToOs, and to plan the follow-up observations. For example, type Ia SNe are strong source of the line γ-ray. The maximum light in some line γ-ray is expected to be earlier than the optical one [14], so the prompt type determination and the early γ-ray observation is especially needed. The γ-ray from SN 1991T, a peculiarly luminous SN Ia, was successfully detected [13].

Type II, Ib, and Ic SNe are thought to be core-collapse events of the massive stars whose envelopes had been lost during the evolution, so the interaction of the SN ejecta with the circumstellar matter made up by the lost envelope will cause a strong X-ray and radio emission. When the discovered SN turns out to be of these types, radio telescopes and X-ray satellites are planned to observe them.

The early spectrum contains the information of the outermost part of the ejecta, which cannot be obtained from the later observation. The diversity of type Ia SNe has been reported in the pre-maximum spectra [4].

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Furthermore, we professional astronomers must reward the amateur discoverers by getting the most fruitful output. The bright (nearby, important) SNe have been discovered mainly by the amateur astronomers.

2 Our Contribution

We have been taking early spectra of SNe in order to obtain type determination. In Japan, there are many observatories with 1-m class telescopes, a main part of which are funded by the local self-governing body, such as prefecture, city, town, or even a village whose population is only thousands.

In these five years, we determined the types of over twenty nearby SNe, with the Bisei Astronomical Observatory 1.01-m telescope and the Gunma Astronomical Observatory 0.60-m telescope. Among them, SN Ia 1998bu was at the Virgo distance. After our type determination, the COMPTEL instrument of the CGRO observed it. The line γ-ray could not be detected from it, which constrained the amount of produced ^{56}Ni and the explosion models [3].

SN 2002ap, a type Ic "hypernova", was observed by us on the night of the announcement of the discovery. It turned out to be a hypernova (Kyoku-Cho-Shinsei in Japanese) by us [6] and by the others [2, 12]. The determination of the SN classification led the follow-up observations in the all wavelengths, including by the Subaru telescopes in optical and IR [5], by the VLA in radio [1], by the XMM-Newton in X-UV regions [15], and so on. After the type determination, we continued to take spectra of this object, and revealed the rapid evolution of the spectra. The expansion velocity measured from the Si line was about 25000 km s^{-1} on the first epoch, which rapidly decreased, besides the other hypernovae evolved more slowly [7]. Probably it is because the ejecta mass was quite small [11].

3 Between the Discovery and the Spectroscopy

Typical progress from the discovery of a SN to its spectral type determination would be summarized as:

1. Discovery of the new object,
2. Confirmation of the existence and no proper motion, by the discoverer or his colleague,
3. Report to the Central Bureau of the Astronomical Telegrams (CBAT),
4. Announcement of the discovery on an IAU circular,
5. Following the discovery, the spectroscopic observation and the type determination.

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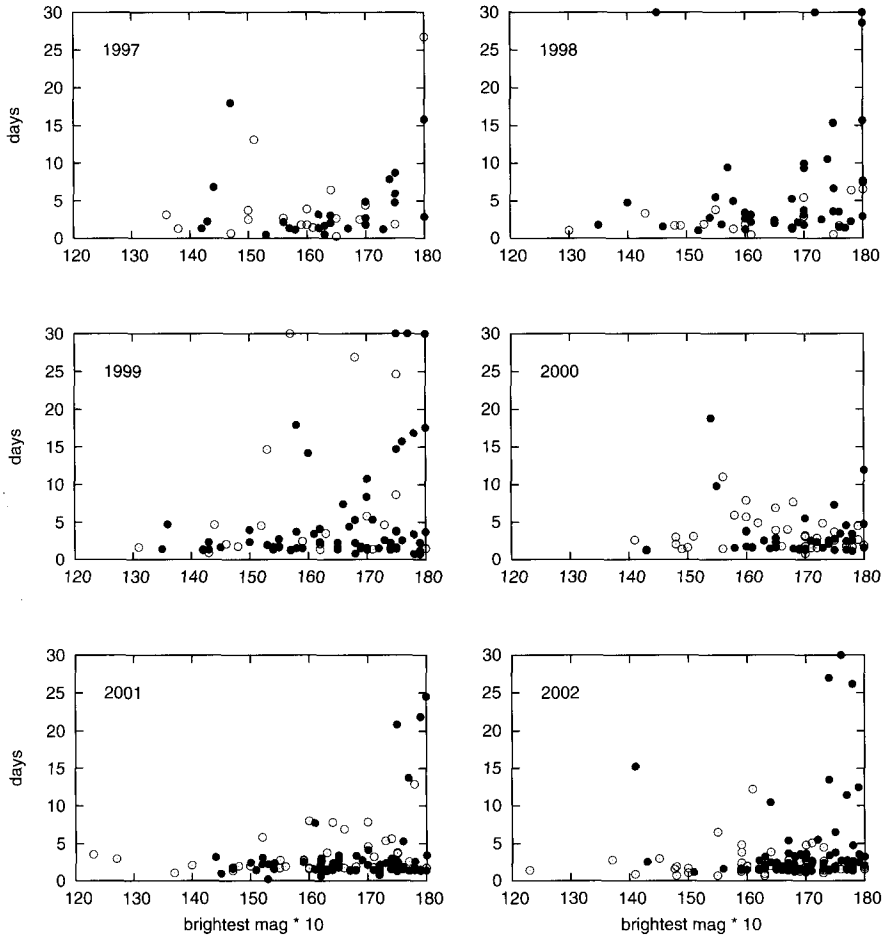

Fig. 1. Time intervals from the discovery of a SN and its announcement on the IAU Circular. The horizontal axis represents the observed brightest magnitude of the SN. Open circles represent the SNe discovered by the amateur astronomers, and filled circles are by the professionals (the KAIT, the NEAT and so on).

There are some bypasses on this course. If the CBAT thinks the confirmation by others is needed, it will be done within the closed members (skip Item 2). The discovery information is relayed also to the closed members to do spectroscopy (skip Item 3). Occasionally, the discovery information is posted to some mailing lists (skip Item 3 and/or Item 4). In such situations, the first spectroscopy is possibly reported on the same number of the IAU Circular as the discovery announcement.

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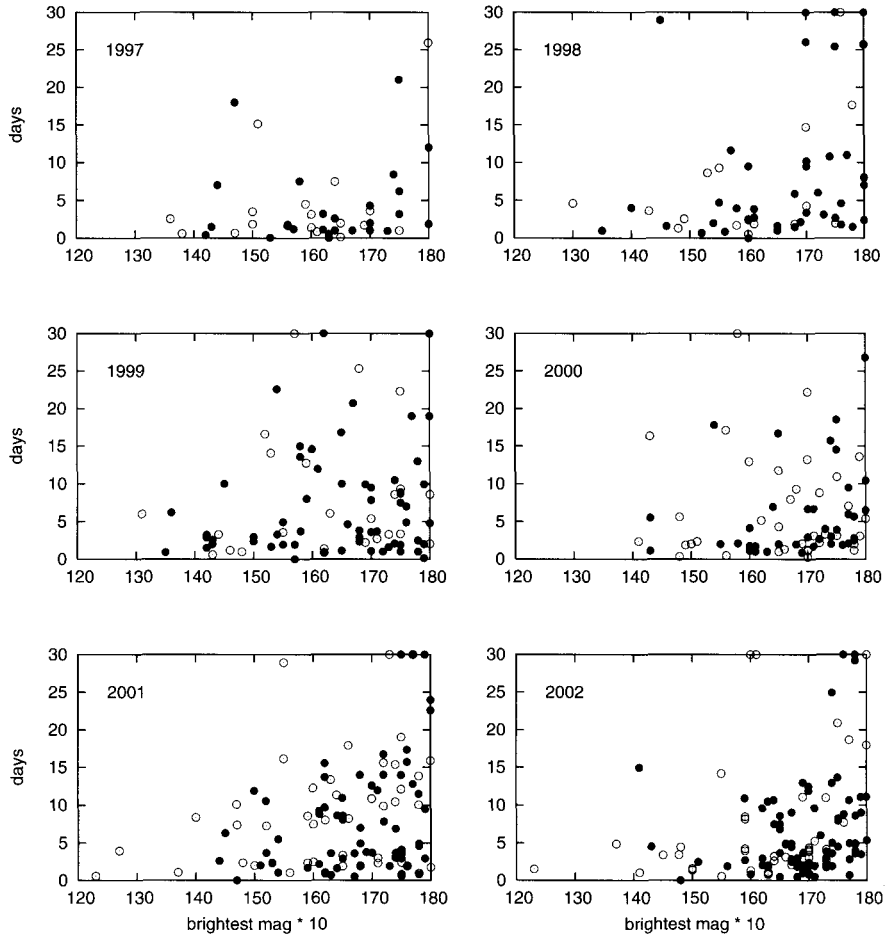

Fig. 2. Time intervals from the discovery of a SN and its spectroscopic type determination. The horizontal axis and the marks are same as Fig. 1.

4 Time Interval from the Discovery to the Announcement and the Spectroscopy

As shown in the previous section, there must be some time interval between the discovery of the new object and the announcement of it, or the spectroscopic observation. Fig. 1 shows the time duration from the discoveries to their announcement on the IAU circulars, year by year from 1997 to 2002. It is clearly shown that this interval has been much improved in recent years. There are, however, only small numbers of SNe being announced within one day after discovery. This "one day problem" is mainly caused by the CBAT

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requirement for the discoverer to confirm the object on the second night before he/she reports it to the CBAT [8, 9, 10]. Indeed, SN 2002ap was left unobserved spectroscopically on the night of the discovery.

Figure 2 shows the time duration from the discovery to the first spectroscopy. This interval is slightly improved during recent years, but compared with Fig. 1, the improvement is rather slow.

5 Proposals and Most Recent Improvements

For the early spectroscopy, the "one day problem" should be avoided, at least for the nearby SNe. The SN hunter should report an SN discovery in the nearby galaxies, and it should be confirmed with the worldwide process. Open policy for the discovery information would help for the contribution by the potential observers. Such open policy can be seen on our web site[1].

On 2002 December, the CBAT began to issue the Central Bureau Electronic Telegram (CBET), which announces the discovery before the formal IAU Circular will be issued. And, as informed at the meeting of Commission 6 (Astronomical Telegrams) in the XXVth general assembly of the IAU at Sydney, the confirmation process is gradually opened. In the same assembly, the Division VIII (Galaxies and the Universe) established a working group on SNe, which will discuss the circulation of the information of SNe. We would like to be working together with these improvements.

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