Photometric and Spectroscopic Observations of V1280 Sco

Hiroyuki Naito\textsuperscript{1}, Sahori Mizoguchi\textsuperscript{2}, Akira Arai\textsuperscript{3}, Masayuki Yamanaka\textsuperscript{3}, Shin-ya Narusawa\textsuperscript{1}, Kozo Sadakane\textsuperscript{2} and Takashi Iijima\textsuperscript{4}

\textsuperscript{1} Nishi-Harima Astronomical Observatory, Sayo, Hyogo 679-3113, Japan
\textsuperscript{2} Astronomical Institute, Osaka Kyoiku University, Kashiwara, Osaka 582-8582, Japan
\textsuperscript{3} Hiroshima Astrophysical Science Center, Hiroshima University, Higashi-Hiroshima, Hiroshima 739-8526, Japan
\textsuperscript{4} Astronomical Observatory of Padova, Asiago Section, Osservatorio Astrofisico, 36012 Asiago (VI), Italy

ABSTRACT
Photometries of $B$, $V$, $R_c$, $I_c$, $y$, $J$, and $K$s bands and low dispersion optical spectroscopic observations of Nova V1280 Sco, started soon after the outburst, are reported. We show that V1280 Sco is an Fe ii nova and it is going through the historically slowest spectroscopic evolution. The rapid decline observed in the early phase was caused by formation of a dust shell. We estimate the abundances of CNO using the absorption lines on a spectrum at pre-maximum, and find over-abundances by $[\text{C}/\text{Fe}] \sim 1.4$, $[\text{N}/\text{Fe}] > 2.0$ and $[\text{O}/\text{Fe}] \sim 1.1$.

Key words: photometry, spectroscopy, nova: individual (V1280 Sco), nova: dust nova

1 INTRODUCTION
V1280 Sco (Nova Scorpii 2007 No. 1) is a classical nova which was discovered by Y. Nakamura and Y. Sakurai on the same night (Feb. 4, 2007) at 9-th visual magnitude (Yamaoka et al. 2007a). Its early spectra were taken by some observers and it was classified as an Fe ii type nova (e.g. Naito & Narusawa 2007, Munari et al. 2007, Kuncarayakti et al. 2008), where the Fe ii type nova spectrum is described in Williams (1992). Yamaoka et al. (2007b) reported that the spectrum at the pre-maximum stage looked like an early-type supergiant dominated by absorption lines of hydrogen, iron and other metals. It showed a somewhat slow rise to maximum of about 3.7 in the $V$ band on Feb. 16 (12 days after the discovery), and became a naked eye nova since V382 Vul and V1494 Aql recorded in 1999. It is also remarkable in that V1280 Sco formed a dust shell in the early phase. After maximum, it faded slowly for about 12 days, then it declined rapidly in the visual region by the obscuration due to dust shell(s), the formation of which was directly detected by Chesneau et al. (2008) from near-IR and mid-IR observations by the VLTI at ESO. Das et al. (2008) presented near-infrared studies of V1280 Sco and suggested that the dust is in clumpy shells.

2 PHOTOMETRY
We performed $B$, $V$, $R_c$, $I_c$ and $y$ photometries using a 51-cm reflector at Osaka Kyoiku University and $J$ and $K$s photometries using the 1.5-m KANATA telescope at Higashi-Hiroshima Observatory. The light curves in $V$, $J$ and $K$s bands are shown in Fig. 1. Concerning the visual light, within two weeks after maximum, V1280 Sco started a rapid decline until mid-May when a re-brightening started. On the other hand, the brightness in the $K$s band stayed at nearly the same brightness ($K$s $\sim$ 4) through these days. These results imply that V1280 Sco formed thick dust shell(s), which are consistent with the results of Chesneau et al. (2008) and Das et al. (2008). When the first re-brightening in the $V$ band occured in the latter half of May 2007, near IR magnitudes had brightened simultaneously. We guess that another H-burning event had happened on the WD at that time. The light curves in visual show the second re-brightening from

![Figure 1. Light curves in V(open triangle), J(open circle) and K's(open square) bands.](image-url)
can be classified as an Fe II type nova. On Feb. 14, two days before maximum, the spectrum showed a dramatic change. It apparently became an early A-type supergiant. From an analysis of absorption lines observed on this spectrum, we estimate the abundances of CNO contained of this object, and found over-abundances by [C/Fe] ∼ 1.4, [N/Fe] > 2.0 and [O/Fe] ∼ 1.1. The analysis is based on an assumption that the atmospheric parameters of V1280 Sco on Feb. 14 could be approximated by those of Deneb (A2Ia).

The spectral evolution after maximum luminosity was very slow and strong forbidden lines of [O I] λ5577, [O I] λλ6300,6363 were observed on Mar. 7. The ratio of [O I] λ5577 to [O I] λ 6300 is so large that we can infer the electron density in the ejecta was still high because the ejected mass is large and, at the same time, the expansion velocity is low. When the optical decline started by the dust formation from March to mid-May, the continuum flux was too weak to be detected and at the same time the Hβ emission also was not detected. However, during the re-brightening phase, Hβ line reappeared. On the same spectrum a P Cygni absorption line having a velocity of 2,000 km s⁻¹ at Hα was shown. These may have been connected with a new mass ejection on the re-brightening. It is caused by the second large outflow triggered by a new H-burning event on the WD. Until June 10, no emission line of He I, He II, or other highly ionized ions such as C III or N III was observed.

On Feb. 18, 2008, the He I λ6678 appeared and the blue continuum was strong. This indicated that the temperature was higher than in 2007, but the temperature was not so high as to excite the He II lines. A higher S/N spectrum observed on Jul. 8 showed P-Cyg profiles in the Balmer lines, indicating the gas outflow caused by the continuing H burning. Even on our last spectrum taken on Sep. 9, 2008, the forbidden lines of [O I] λλ4959,5007 were not seen, thus V1280 Sco has not entered the nebular phase yet (Fig. 3).

4 SUMMARY

From our observations, it is clear that V1280 Sco is a very unique nova in history. GQ Mus had the H burning turn-off time of about 3,000 days (Hachisu et al. 2008), and V723 Cas took 540 days before entering the nebular phase (Iijima 2006). V1280 Sco takes longer time than V723 Cas to enter the nebular phase, and it may rewrite the record of GQ Mus. Follow-up observations are needed to probe the nature of this very interesting nova.

REFERENCES

Chesneau, O. et al., 2008, A&A, 487, 223
Das, R. K. et al., 2008, astro-ph/0809.4338
Hachisu, I., Kato, M., Cassatella, A., 2008, astro-ph/0806.4253
Iijima, T., 2006, A&A, 451, 563
Kuncarayakti, H., Kristyowati, D., Kunjaya, C., 2008, Ap&SS, 314, 209
Munari, U. et al., 2007, CBET 852
Naito H., Narusawa S., 2007, IAC Circ. 8803
Williams, R. E., 1992, AJ, 104, 725
Yamaoka, H., et al., 2007a, IAU Circ. 8803
Yamaoka, H., Fujii, M., Naito, H., 2007b, IAU Circ. 8807