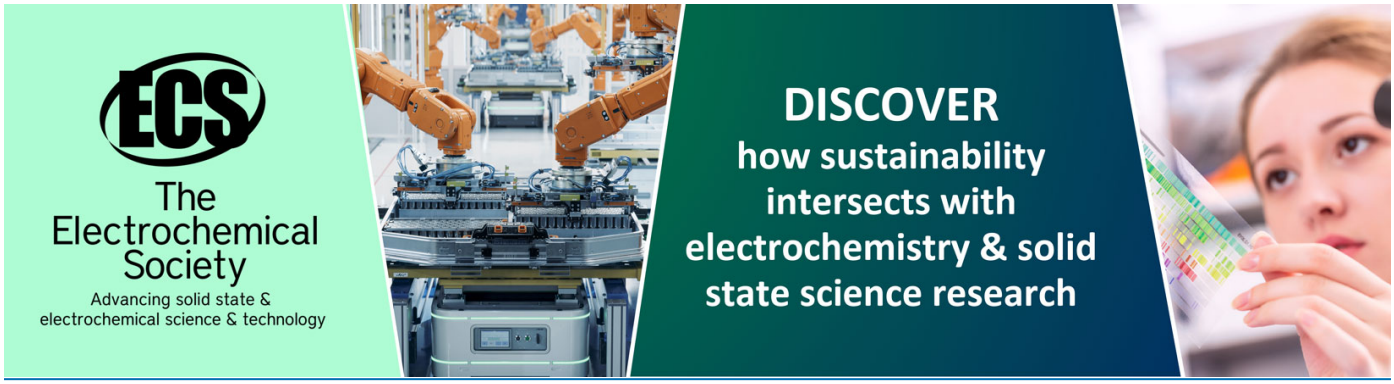
The spectral evolution of nebular phase from Nova V5668 Sgr



The spectral evolution of nebular phase from Nova V5668 Sgr

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Abstract. The spectral evolution of the Nova V5668 Sgr has been observed on 12 June, 23 June, and 15 August 2015 using NEO-R1000 spectrograph attached to the C-11 telescope at Bosscha Observatory, Lembang, Indonesia. The observed spectra indicate that the nova has been entering the nebular phase. The spectra during this phase showed strong forbidden lines of [O I] λ6300, 6364, [O II] λ7320, and [O III] λ5007, [N II] λ5755. The spectra also showed emission line of Fe II λ4924, 5169, 5317, 6149. We classify Nova V5668 Sgr into the Fe II type. We present and discuss the variation of nebular abundance N(X)/N(H) of the Nova V5668 Sgr in the light of its evolutionary stages.

1. Introduction

Nova is an attractive astrophysical object to be comprehensively studied. The instability of the state of the accretion disc will create variability of long or short periods of photometry to reach the minimum apparent brightness [1]. The change in the light curve of nova indicates differences in the physical conditions. This, consequently also has an impact on the variation of its spectral line. When the nova passes peak of maximum luminosity, absorption lines will be weaken, while the emission lines begin to strengthen. This indicates the existence of large and hot region, commonly called the nebulae [3]. The appearance of striking features of forbidden lines [OIII] λ5007 and [NII] λ5755 indicates that the nova is under nebular phase.

Nova Sgr 2015 No. 2 (V5668 Sgr) was first discovered by John Seach (Chatsworth Island, NSW, Australia) on March 2015. Its position is RA (J2000.0) = 18h36m56.84s and Dec (J2000.0) = -28°55′39.8″. Here, we present our spectroscopic study of V5668 Sgr which shows the evolution of spectra from June to August 2015.

2. Optical spectroscopic observations

The observations were allocated during nearly three months since 9 June until 29 August 2015 at Bosscha Observatory, Lembang. Unstable sky conditions prevailing at Bosscha Observatory has hampered monitoring observational mode. Observations were successfully carried out and we obtained 3 spectra of the nova taken on 12 June, 23 June, and 15 August 2015. We used the Celestron-11 Telescope (f/10) combined with a low-resolution spectrograph NEO R-1000 (spectral coverage 3548-7977 Å, and resolution, $R = \lambda/\Delta\lambda = 1000$, slit width 65 μm, and grating 600 groove/mm) and CCD ST-8 XME (1530x1020 pixels, 9 micron/pixel, On-chip Binning 1x1 and 1x2). We used Image Reduction and Analysis Facility (IRAF) to produce wavelength and flux calibrated spectra. For wavelength

calibration we used spectral atlas for FeNeAr, whereas for the flux calibration, spectrophotometric standard stars HR 7001 and HR 7596 were employed [2].

3. Results

The results of spectra which have been calibrated for each observation date can be seen in figure 1. In spite of low S/N ratio, emission lines appear very strongly and the continuum is also detected. The spectrum shown in green taken on 15 August suggests that the nova envelope became optically thin, since ratios of [N II] λ5755, [O II] λ7320 from continuum light are stronger than the spectrum shown in blue taken on 12 June. The spectrum shown in red taken on 23 June and the spectrum shown in green taken on 15 August, show that these fluxes become weak. The broad emission feature around 4600 Å is Bowen blended band (C III/N II). Bowen band along with CIII, N II lines indicate the existence of the hard UV radiation from the photosphere of V5668 Sgr. On the other hand, [O III] λ5007 and He II λ4686 are not so strong yet but clearly detected.

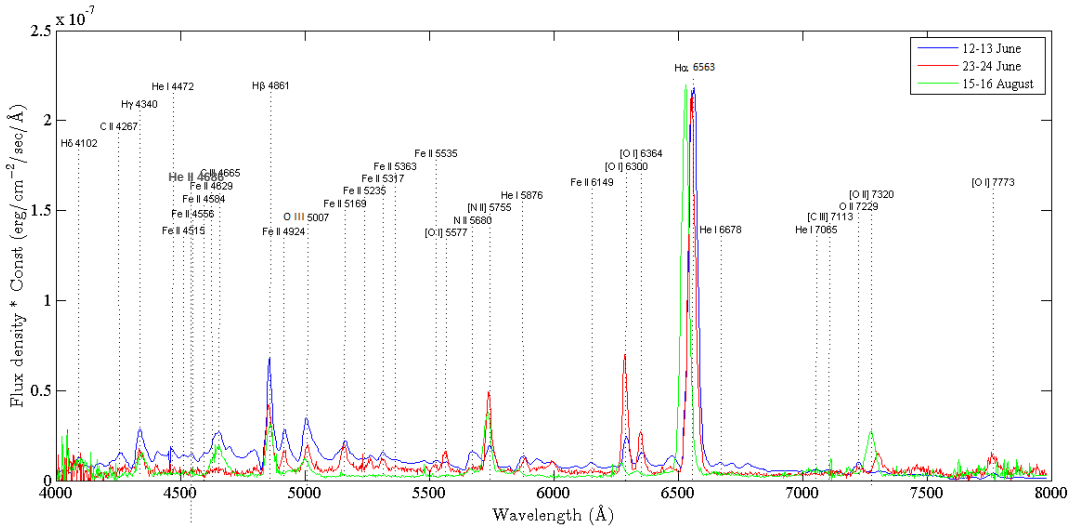

Figure 1. Low-resolution spectra evolution of V5668 Sgr obtained at Bosscha Observatory

Nova classification based on spectrum depends on its own dominant spectrum of chemical elements. According to [5], spectrum of V5668 Sgr is categorized as Fe II type. Expansion velocity of this nova has been measured from its P-Cygni profile in Hß of the blue spectra on 12 June. The expansion velocity was determined to be 2087 ± 179 km/s.

4. Discussion and summary

The changes of light curve and spectral evolution could explain the physical condition of the nova. The changes in physical conditions that occur in V5668 Sgr lead to differences electron temperature and density value of total hydrogen as shown by table 1.

Table 1. The changes of hydrogen density and electron temperature.

Date	6-12-2015	6-23-2015	8-15-2015
N(H) Total Hydrogen density	1.08×10^{11} cm^{-3}	3.15×10^{8} cm^{-3}	4.05×10^{8} cm^{-3}
Electron Temperature (K)	26388 K	15528 K	15528 K

Figure 2 shows the change of light curve for V5668 Sgr from pre-validated AAVSO database . The observations carried out on June 12, 2015 showed a magnitude range of 8-9, while on June 23, 2015 showed a magnitude 11-12. On 12 and 23 June, the V5668 Sgr was in the formation of dust and nebular phase. This is shown by the declining light curve that indicates the formation of a new shell. At this phase there is a significant expansion of shell [4]. From the analysis of P-Cygni profile in Hβ λ4861, it is obtained that the expansion velocity is 2087 ± 179 km/s. The high expansion velocity is capable to carry materials far out along the radial direction. The process of shell expansion which is fast moving make the electron temperature decreases.

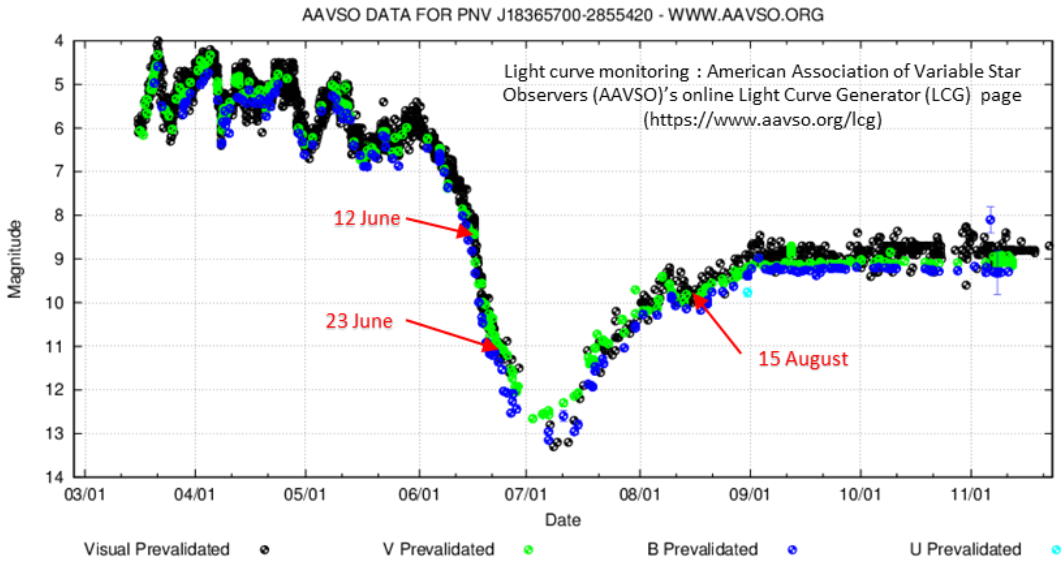

Figure 2. Visual-magnitude light curve of V5668 Sgr from pre-validated AAVSO database

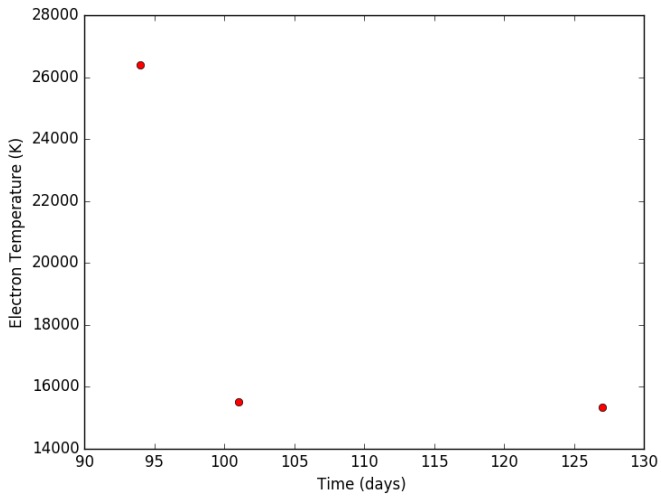

Figure 3. Changes of electron temperature after outburst

Figure 3 shows on 94-days after the outburst, physical condition nova still has a thick shell, so that the intensity is absorbed by the existing material at the shell, heating throughout the region. Thus this increases the electron temperature which cause recombination processes become dominant. There is an

increase of neutral hydrogen in the shell. So that the contribution of neutral hydrogen atoms will produce the forbidden lines by collisional excitation and fluorescence resonance processes. Therefore, this condition allows the V5668 Sgr is in nebular phases and produce a nebular spectra. The increase process of a hydrogen neutral is evidenced by the decline in the ratio of the density profile like [O I] λ6300, 6364 to the total amount of Hydrogen which is getting lower on 101-days and 127-days after the outburst as shown in figure 4.

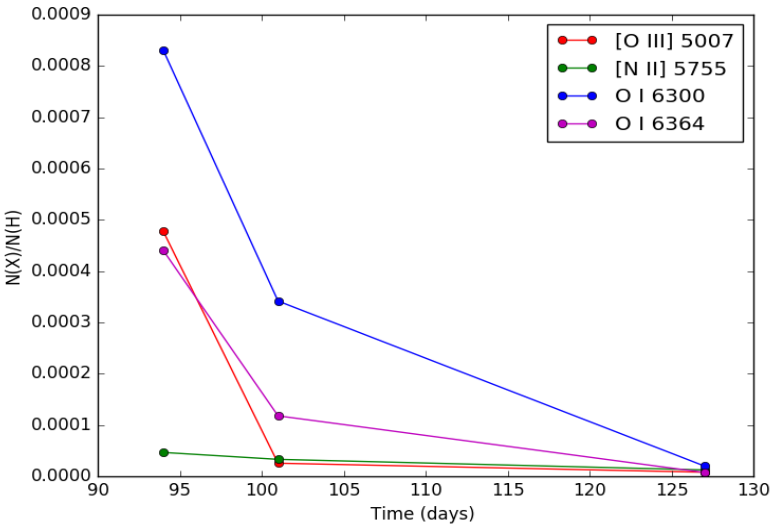

Figure 4. The changes ratio of element nebulae to the total amount of Hydrogen

From this nova spectroscopy observation we can conclude that the spectra during nebular phase showed strong forbidden lines of [O I] λ6300, 6364, [O II] λ7320, and [O III] λ5007, [N II] λ5755. The spectra also showed emission line of Fe II λ4924, 5169, 5317, 6149. Nova clasification based on spectrum depends on its own dominant spectrum of chemical elements. According to [5], the spectrum is included to Fe II type.

Acknowledgments
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