Optical spectroscopy of nova ASASSN-17hx at Bosscha Observatory

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Abstract. We report optical spectroscopic observations in 2017 at Bosscha Observatory on an interesting nova, ASASSN-17hx (Nova Sct 2017). The nova ASASSN-17hx was observed on July 26th, July 29th, July 31st, and August 14th. Based on the light curve, we propose that our spectroscopic observation of ASASSN-17hx was conducted during “iron curtain” phase. The observed spectra showed a strong Hα emission line and multiple emission lines of Fe II multiplets, which is typical for a Fe II type nova. However, since ASASSN-17hx was classified as a He/N type only few days after its outburst, it is suggested that the nova is actually a hybrid type nova. We will discuss the characteristic of ASASSN-17hx by analysing its expansion velocity, electron density, and evolution of the emission lines.

Keywords: Optical Spectroscopy and Nova ASASSN-17hx

1. Introduction

Novae are stellar explosions caused by a thermonuclear runaways on the surface of a white dwarf in a close binary system, which exhibit a sudden rise in optical brightness within a period of time. Since only several novae outbursts reported every year, they are very interesting to be studied. Spectroscopic phases of novae can be explained by examining its light curve and emission lines. The elements of emission lines in the spectra can also be used to classify the nova, which consist of three types: He/N type, Fe II type, and hybrid type. The outburst of nova ASASSN-17hx was discovered with All Sky Automated Survey for SuperNovae (ASASSN) and announced in Astronomer’s Telegram on June 23rd 2017 [8]. We aim to determine the characteristic of ASASSN-17hx by analysing the changes of expansion velocity, electron density, and evolution of the emission lines.

2. Observations

The optical spectroscopic observations were conducted on four nights in July and August 2017 at Bosscha Observatory. We employed two spectrographs. They are a low resolution spectrograph NEO-R1000 (R=1000, grating=600 grooves/mm) attached on Celestron C-11 28-cm Schmidt-Cassegrain telescope (f/10) with SBIG ST-8 CCD camera and a high resolution spectrograph LHIRES III
(R~5000, grating=1200 grooves/mm) attached on Meade 25-cm Schmidt-Cassegrain telescope (f/10) with SBIG ST-402 CCD camera. The nova ASASSN-17hx was observed using NEO-R1000 on July 26\textsuperscript{th}, July 29\textsuperscript{th}, and July 31\textsuperscript{st} and using LHIRES III on August 14\textsuperscript{th}. We used Image Reduction and Analysis Facility (IRAF) to perform image reductions and calibrations. FeNeAr spectral atlas was used to perform wavelength calibration for the low resolution images and Neon-Argon spectral atlas for the high resolution image. We employed HR7001 as a spectrophotometric standard star to conduct flux calibrations. We also used line list provided by Williams [10] to identify the spectral lines of the nova. Although city light lines were detected on the low resolution spectra, we could still identify the lines from the nova.

3. Spectra of ASASSN-17hx

The wavelength calibrated and normalised spectra of ASASSN-17hx can be seen in Figure 1 and Figure 2. We detected emission lines of Fe II, Mg I, H\alpha, and H\beta. An absorption line of Na I was also detected. During three nights of observations, we could see the evolution of intensity of the emission lines. On July 26\textsuperscript{th}, the H\beta line showed a P-Cygni profile, the metal lines were not clearly visible yet, and we could see a strong H\alpha emission. In the next observation on July 29\textsuperscript{th}, the intensity of H\alpha and H\beta were weakened, with P-Cygni profile could be seen on the H\alpha line. The intensity of metal lines were increasing, but still relatively weak. The evolution of the spectra could be distinctly seen on July 31\textsuperscript{st}. The emission lines of metal became opaque, with a significant increase of H\alpha and H\beta intensity. In this spectrum, the P-Cygni profiles were observable in the metal lines. The high resolution spectra of H\alpha obtained on August 14\textsuperscript{th} showed an asymmetric double-peak emission line. After barycentric correction, we measured that the radial velocities corresponding to blue-shifted peaks and central absorption were 485.672 km/s, 23.403 km/s, and 287.131 km/s respectively.

4. Discussion

The chemical elements and characteristics of the spectral lines were used to classify the nova into Fe II type, He/N type, or even hybrid type [10]. Based on our observations of ASASSN-17hx, the Fe II lines were dominating the spectra with visible P-Cygni profiles in every spectrum. These signatures are
usually belongs to the Fe II type nova. However, previous observation a few days after the outburst showed that ASASSN-17hx had the characteristics of He/N type [5]. Similar case was already been seen on the recurrent nova T Pyx [3]. It is suggested that the changing type of nova is common mechanism but rarely observed because lack of data at different phases [10].

![Figure 3](https://example.com/figure3.png)

**Figure 3.** Light curve of ASASSN-17hx from American Association of Variable Star Observers (AAVSO) database.

Based on Figure 4, ASASSN-17hx was observed during its final rise and initial decline phase. In these phases, our observed spectra represented the shell of nova. Physical interpretation of shell can be better understood if we examine the spectral evolution by measuring expansion velocities and electron densities at different times. To determine the expansion velocity, we employed the equation (1), which was previously used by Azaliah et al. [1] to analyse nova spectra.

\[ v_{\text{expansion}} = \frac{\lambda_{\text{absorption}} - \lambda_{\text{emission}}}{\lambda_0} \]  

(1)

After obtaining the expansion velocities, we measured the electron densities. Electron densities were derived using equation (2) by Doroshenko [2]. Since it required the intensity of H$\beta$, electron densities were only measured on the low resolution spectra.

\[ n_e^2 = 0.54 \times 10^{69} \left( \frac{\text{Intensity}_{H\beta}}{(v_{\text{exp}} \times t_{\text{sinceoutburst}})^3} \right) \]  

(2)

To determine the uncertainty of our measurements, we used the method of error propagation. The uncertainty of expansion velocity were derived from the uncertainty of observation parameters, which were the wavelength value of absorption and emission of the P-Cygni profiles. Then, for the uncertainty of electron density, we propagated the uncertainty of H$\beta$ intensity and the mean expansion velocity. The results of our measurements of expansion velocities and electron densities could be seen in Table 1.
Table 1. Expansion velocity and electron density of ASASSN-17hx

| Date          | July 26\textsuperscript{th} 2017 | July 29\textsuperscript{th} 2017 | July 31\textsuperscript{st} 2017 | August 14\textsuperscript{th} 2017 |
|---------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| **Expansion velocity (km/s)** | 867.639 ± 17.041 | 966.361 ± 23.883 | 921.169 ± 28.802 | 226.197 ± 6.687 |
| **Electron density (x10\textsuperscript{16} cm\textsuperscript{-3})** | 12.002 ± 0.285 | 5.350 ± 0.139 | 11.897 ± 0.281 | - |

The values from Table 1 indicated that the shell of nova was expanding with varying velocity and electron density. During the final rise, the shell’s velocity increased until it reached its maximum on July 29\textsuperscript{th}. During this time, the electron density had the lowest value. The less dense medium suggested that the shell was undergoing a cooling stage and therefore allowed the recombination process of metal lines. The process caused metal lines to be more observable on July 31\textsuperscript{st}, during the early initial decline. The emerging metal lines caused the shell to be denser, with lower expansion velocity. This fact suggested that the nova was observed at the spectral “iron curtain” phase [7]. Two weeks after the start of initial decline, the shell was still expanding but with significantly lower velocity. The asymmetric double-peak of H\textalpha implied that the shell had inhomogeneous density at the time, which may be caused by intrinsic nature of the nova or the effect of inclination angle between the ejecta and our line of sight.

5. Summary
Our observations of ASASSN-17hx in July and August 2017 showed a distinct spectral evolution. We could see that the intensities of the emission lines varied between the nova phases. Based on the analysis of expansion velocities and electron densities, the metal lines in the shell of ASASSN-17hx were formed after the peak brightness. It was implied that the low density at the peak brightness trigged the recombination of the metal lines. The appearance of metal lines in the spectra of ASASSN-17hx is also interesting since the nova was classified first as He/N type. Therefore, this nova can be classified as a hybrid type. Since hybrid nova is rarely observed, the case of ASASSN-17hx is important to be studied, particularly about the transition of novae classification and its mechanism.

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