Low Resolution Spectroscopic Observation of the 2021 Outburst of the Recurrent Nova RS Ophiuchi

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ABSTRACT

RS Oph outbursts were recorded in 1898, 1933, 1958, 1967, 1985, and 2006, with the most recent outburst identified by an Ireland amateur astronomer, Keith Geary on 2021 August. Since its outburst, RS Oph was observed in almost every wavelength range, from hard X-rays to radio wavelength. We report low-resolution spectroscopic observations (R=1000) of Nova RS Oph in the 390-710 nm range. RS Oph was observed on August 16, 2021, using LISA Pack Spectrograph equipped with Atik 314L+ CCD and Ritchey Chretien GSO 10-inch (F/8) telescope. As in most novae, the spectra are dominated by strong hydrogen Balmer lines (Hα, Hβ, Hγ, Hδ, and Hε). In addition, the absence of nebular forbidden lines in the spectra indicate that the nebular phase has not yet occurred, but RS Oph is thought to enter the nebular phase. This is related to the results of intermediate-resolution spectroscopic observations (R = 5000) by Fajrin et al (2021) at Bosscha Observatory which showed the presence of multiple expanding shells with high velocity.

Keywords: *Nova – RS Oph – Spectroscopy*

1 INTRODUCTION

The nova outburst in binary systems is powered by thermonuclear runaway on the white dwarf's surface (e.g., Warner, 1995, 2008; Bode & Evans, 2008). The hydrogen-rich material is accreted from the donor star to the white dwarf over a long period of time, forming an envelope on its surface. The thermonuclear runaway is triggered when the critical pressure at the base of the accreted layer is achieved, leading to a dramatic brightening. If the binary system survives the outburst, and mass accumulates again, causing the nova to recur on a timescale that is dependent on the accretion rate and the mass of the white dwarf. Recurrent novae are objects that have experienced more than one nova outbursts (e.g., Mukai, 2015). All ancient novae are thought to be recurring, with centuries-long periods between outbursts.

The classification of nova spectra shortly after outburst is a promising avenue for the research of nova populations. Based on the emission lines in their spectra, Williams (1992) found that the spectra of Galactic novae may be separated into one of two main spectroscopic categories, FeII and He/N. When compared to novae with strong lines of He and N (the "He/N" novae), novae with notable FeII emission (the "FeII" novae) have P Cygni absorption profiles, evolve more slowly, have lower expansion velocities, and have lower levels of ionization.

K. Geary reported the 2021 nova outburst of RS Oph on August 8, 2021 (AAVSO Alert Notice 752). The presence of significant Balmer lines, as well as HeI, FeII, OI, and NII features with P Cyg profiles, are revealed in the initial spectral follow-up observations (Taguchi, Ueta & Isogai, 2021). Spectral observation by Fajrin et al. (2021) with a $\lambda/\Delta\lambda$~5000 reveals broad emission, with a blue-shifted absorption line of H-alpha (Δv = -40.272 $\pm$ 2.202 kms^{-1} on Aug. 10.5690 UT) fully visible. The broad H emission line's velocity is estimated to be roughly 2800 kms^{-1}. As expected, the profile and velocity imply that this outburst is a nova explosion. The broad emission line suggests the presence of a second shell that is rapidly expanding.

Williams et al. (1991) devised a physical basis to describe the outburst spectral evolution, generally referred to as the Tololo Classification Scheme. The features of the stronger emission lines are used to determine the phases of evolution in this scheme. The spectrum is classified as belonging to either phase coronal, permitted, auroral, or nebular. Through the ionizing radiation filed and mean gas density, these phases are linked to the physical condition of the shell. As a result, the classification gives insight on the physical conditions in the nova ejecta as the outburst progresses.

To complete the information that has been found here we present low-resolution spectroscopic observations of RS Oph on August 16, 2021 and discuss (1) emission line identification of RS Oph low-resolution spectra, (2) nova RS Oph classification and phase determination, and (3) show image of the nova RS Oph to see how the brightness of RS Oph changes over time.

2 OBSERVATIONS

To obtain low-resolution optical spectra of RS Oph we used LISA Pack spectrograph mounted to the 10-inch Ritchey-Chretien GSO telescope *F*/8 located in ITERA Lampung astronomical observatory, Lampung, Indonesia (see Figure 1). For finderscope, we used CMOS ZWO ASI 178mm. The spectra have a resolution of $R = 1000$ and cover 390-710 nm range in wavelength. The object was observed on 2021 Aug 16,746 UT with integration time of 360 seconds. Figure 2 is a finding chart that we use to identify RS Oph. Using IRAF tasks packed in the noao packages, the spectra are reduced in the standard way, including bias and dark removal, flat-fielding, and wavelength calibration. A Neon (Ne) lamp was used to calibrate the wavelengths.

Figure 1. Instrument configuration during observation.

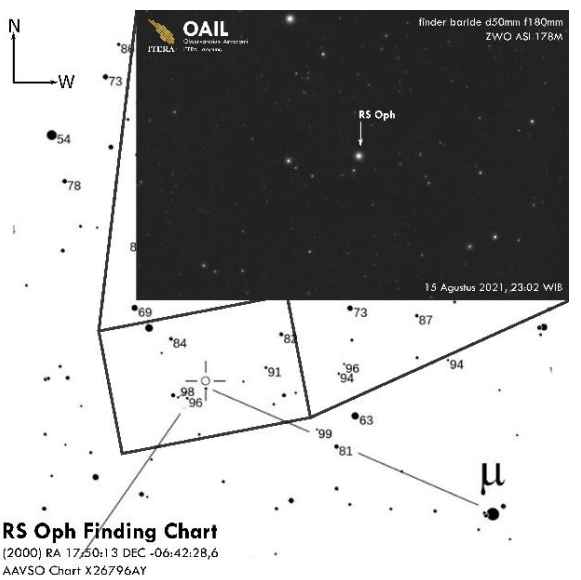

Figure 2. Finding chart and finderscope's field of view.

3 RESULTS

Figure 3 shows the RS Oph spectrum. Strong Balmer emission was found, such as Hα (6563 Å), Hβ (4865 Å), Hγ (4340 Å), Hδ (4100 Å), dan Hε (3917 Å). The strong non-Balmer lines present in the spectrum is FeII and NaI (5892 Å) which correnspond to FeII class novae. These two lines were also found in the spectrum of RS Oph on 2021 Aug 9,44 UT (Figure 4) observed with Fiber-fed IFS at 3.8 m Senmei telescope, Okayama (Taguchi, Ueta & Isogai, 2021).

In addition, we also took image of RS Oph through a finder scope to see how fast the nova is dimming. Figure 5 shows that the brightness of RS Oph decreased within a few weeks which is also correspond to the characteristics of FeII class novae. Therefore, our observations indicate that this nova belongs to the FeII nova class. The absence of nebular forbidden lines in the spectra such as [NII] λ6584 Å or [OIII] λ5007 Å indicate that the nebular phase has not yet occurred, but RS Oph is thought to

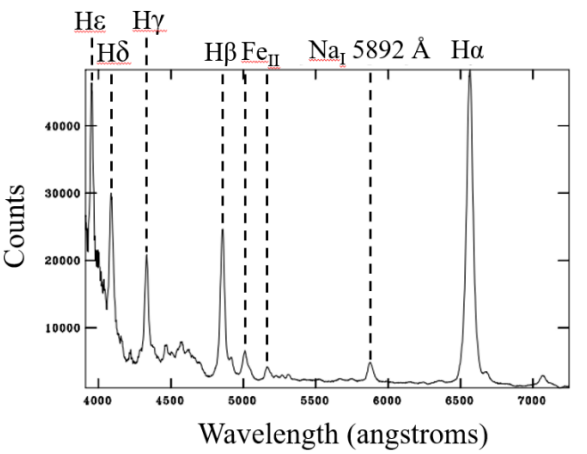

Figure 3. RS Oph low-resolution spectrum observed at ITERA Astronomical Observatory on 2021 Aug 16.746 UT.

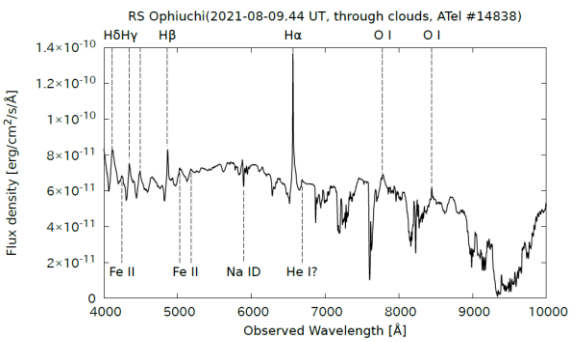

Figure 4. RS Oph low-resolution spectrum observed at Okayama on 2021 Aug 9,44 UT (Taguchi, Ueta & Isogai, 2021)

Figure 5. Image of RS Oph observed with Baride finder scope and CMOS ZWO ASI 178MM from August 15, 2021, to September 27, 2021.

enter the nebular phase. However, to confirm this, it is still necessary to have a spectrum for the following days.

4 CONCLUSIONS

We report spectroscopic observations of the recurrent nova RS Oph obtained after the 2021 nova outburst and obtain the following results:

1. The RS Oph spectrum is dominated by Hydrogen-Balmer lines.
2. The characteristics of the RS Oph spectrum are in correspond to FeII nova class.
3. RS Oph is thought to enter nebular phase
4. The brightness decrease on the RS Oph image shows a scale of several weeks, however a light curve from the RS Oph is highly suggested to verify this information.

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