Nova V5579 Sgr 2008: near-infrared studies during maximum and the early decline phase

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ABSTRACT
We present near-infrared spectroscopic and photometric observations of the nova V5579 Sgr during the maximum and early decline phase. The spectra follow the evolution of the nova from peak brightness when the lines had strong P Cygni profiles to a phase dominated by prominent emission lines. The spectra during the emission phase are dominated by strong H I lines from the Brackett and Paschen series, O I and C I lines. The spectra in the final stages of our observations show a rising continuum towards longer wavelengths, indicating dust formation. Dust formation in V5579 Sgr is consistent with the presence of lines of elements with low-ionization potentials like Na and Mg in the early spectra. The early presence of such lines had been earlier suggested by us to be potential indicators of dust formation later in the nova’s development. We also discuss the possibility of using P Cygni profiles to probe the properties of the erupting white dwarf during the early outburst.

Key words: line: identification – techniques: spectroscopic – stars: individual: V5579 Sgr – novae, cataclysmic variables.

1 INTRODUCTION
Nova V5579 Sgr was discovered on 2008 April 18.784 UT by Nishiyama and Kabashima (Nakano, Nishiyama & Kabashima 2008) at V = 8.4. Munari et al. (2008) reported a rapid and steady brightening of about 0.7 mag d⁻¹ in the initial stages leading to the possibility of V5579 Sgr reaching naked-eye visibility if the trend continued. However, the brightening lasted only for 5 days, and V5579 Sgr reached a maximum brightness of Vₘₐₓ = 6.65 on 2008 April 23.541 UT as seen from its light curve (Fig. 1). The early optical spectrum taken during the pre-maximum phase by Fujii (2008) on 2008 April 19.82 UT showed hydrogen Balmer series absorption lines, with Hα having a prominent P Cygni profile and also several additional broad absorption lines indicating that V5579 Sgr is a classical nova. The infrared (IR) spectra taken by Russell, Rudy & Lynch (2008) on 2008 May 9 showed lines of O I, N I, Ca II and exceptionally strong lines of C I. The full width at half-maximum (FWHM) of the lines are approximately 1600 km s⁻¹. Even though the Fe II features were weak, Russell et al. (2008) classify V5579 Sgr to be a Fe II-type nova. The lines of neutral helium had not yet formed, and the strongest lines were the O I lines that are fluorescently excited by Lyβ. The IR continuum showed strong thermal emission from dust at a temperature of 1370 K. Subsequent IR observations extending to 13.5 μm by Rudy et al.(2008) showed significant spectral changes like substantial decrease in the line strengths and pronounced absorption dip at the line centres. There was an increase in the dust emission and associated cooling of the dust temperature to 1080 K. The formation of dust can also be seen from the light curve. After reaching the maximum, V5579 Sgr followed a smooth and fast decline. This fading was interrupted, about 20 days after discovery, by a sharp decline seen in the American Association of Variable Star Observers (AAVSO) light curve, consistent with the formation of dust in the nova ejecta as reported by Russell et al. (2008). A search in the Digitized Sky Survey (DSS) red image and UK Schmidt red plate by Dvorak (2008) did not reveal any object at the position of V5579 Sgr. With the limiting magnitude of these surveys being close to 20 mag, V5579 Sgr is one of the large-amplitude (∆V = 13 mag) novae observed in recent years.

We present here near-IR spectroscopic and photometric results of V5579 Sgr based on observations between 5 and 26 days after the discovery.

2 OBSERVATIONS
Near-IR observations were obtained using the 1.2-m telescope of Mt Abu Infrared Observatory from 2008 April 23 to May 15. The log of the spectroscopic and photometric observations are given in Tables 1 and 2 and , respectively. The spectra were obtained at a resolution of ~1000 using a near-IR imager/spectrometer with a 256 × 256 HgCdTe NICMOS3 array. In each of the JHK bands, a set of spectra was taken with the nova offset to two different positions along the slit (slit width of 1 arcsec). Spectral calibration was done using the

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Photometry in the $JHK$ bands was done in clear sky conditions using the NICMOS3 array in the imaging mode. Several frames, in four dithered positions, offset by $\sim 30$ arcsec were obtained in all the bands. The sky frames, which are subtracted from the nova frames, were generated by median combining the dithered frames. The star SAO 185779 located close to the nova was used for photometric calibration; the typical errors in the observed magnitudes are $\pm 0.03$. The data are reduced and analysed using the IRAF package.

3 RESULTS

Before presenting the results properly, we estimate some useful parameters for V5579 Sgr.

3.1 The pre-maximum rise, outburst luminosity, reddening and distance

The light curves based on the $V$-band data of AAVSO and $JHK$ magnitudes from Mt Abu are presented in Fig. 1. There is a good photometric coverage of the nova’s rise to maximum, which lasts for almost 5 days, culminating in a peak brightness of $V_{\text{max}} = 6.65$. From a least-squares regression fit to the post-maximum light curve, we estimate $t_2$ to be $8 \pm 0.5$ d, making V5579 Sgr one of the fast Fe II classes of novae in recent years. As mentioned earlier, V5579 Sgr is also one of the large-amplitude novae observed in recent years with $\Delta V = 13$ mag. These observed values of the amplitude and $t_2$ for V5579 Sgr are consistent with its location in the amplitude versus decline rate plot for classical novae presented by Warner (2008). Using the maximum magnitude versus rate of decline (MMRD) relation of della Valle & Livio (1995), we determine the absolute magnitude of the nova to be $M_V = -8.8$. The reddening is derived using the intrinsic colours of novae at peak brightness, namely $(B - V) = 0.23 \pm 0.06$, as derived by van den Bergh & Younger (1987). We have used the optical photometry data from the AAVSO to calculate $E(B - V)$. The observed $(B - V) = 0.95 \pm 0.06$ results in $E(B - V) = 0.72 \pm 0.06$ and $A_V = 2.23 \pm 0.08$ for $R = 3.1$. Russell et al. (2008) estimate $E(B - V) = 1.2$ using the OH lines in the spectra obtained on 2008 May 9 but remark that part of the reddening may be local to the nova as dust had already formed. Our observations, discussed in a later subsection, also clearly show the dust formation in V5579 Sgr. In their study of the spatial distribution of the interstellar extinction, Neckel & Klare (1980) have shown that close to the direction of V5579 Sgr, $A_V$ steadily increases to a value of $\sim 1.8$ mag around 2 kpc and flattens after that. The moderate value of $A_V$ estimated by us appears reasonable even though the nova is located close to the direction of the Galactic Centre. Based on the above, we obtain a value of the distance $d = 4.4 \pm 0.2$ kpc to the nova.

3.2 Line identification, evolution and general characteristics of the $JHK$ spectra

The $JHK$ spectra are presented in Figs 2, 3 and 4, respectively; line identification in graphical and tabular forms are shown in Fig. 5 and Table 3, respectively. The IR observations presented here cover all the phases with the first IR spectra taken on 2008 April 23 very close to the visual maximum. These spectra are dominated by lines of hydrogen, neutral nitrogen and carbon and display deep P Cygni profiles. The emission components of all these lines have become stronger in the spectra taken on 2008 April 26, and by May 3 all the lines are seen in emission. The typical FWHM of the H$_\alpha$ lines is $1500$ km s$^{-1}$. A noticeable feature of these early spectra

![Figure 1](https://example.com/fig1.png)

**Figure 1.** The $V$-band light curve of V5579 Sgr from AAVSO data. The days of spectroscopic observations are indicated by dashes below. The Mt Abu JHK photometric data are also shown.

**Table 1.** A log of the spectroscopic observations of V5579 Sgr. The date of the outburst has been assumed to be its detection date, namely 2008 April 18.784 UT.

| Date (2008 UT) | Days since outburst | Integration time (s) | J | H | K |
|----------------|---------------------|----------------------|---|---|---|
| April 23.949   | 5.165               | 40                   | 40| 40| 40|
| April 26.966   | 8.182               | 40                   | 40| 40| 20|
| May 3.947      | 15.163              | 40                   | 60| 60| 60|
| May 4.977      | 16.193              | 30                   | 30| 30| 30|
| May 8.972      | 20.188              | 45                   | 45| 60| 60|
| May 13.914     | 25.13               | 200                  | 100| |

**Table 2.** A log of the $JHK$ photometric observations of V5579 Sgr. The date of outburst has been assumed to be its detection date, namely 2008 April 18.784 UT.

| Date (2008 UT) | Days since outburst | $J$ $H$ $K$ |
|----------------|---------------------|-------------|
| April 23.988   | 5.204               | 4.58 4.47 4.16 |
| May 1.894      | 13.11               | 5.58 5.14 4.90 |
| May 8.926      | 20.142              | 6.19 5.96 4.69 |
| May 14.919     | 26.135              | 6.85 5.47 4.09 |

OH sky lines that register with the stellar spectra. The spectra of the comparison star SAO 185320 were taken at similar airmass as that of V5579 Sgr to ensure that the ratioing process (nova spectrum divided by the standard star spectrum) removes the telluric features reliably. To avoid artificially generated emission lines in the ratioed spectrum, the H$_\alpha$ absorption lines in the spectra of standard stars were removed by interpolation before ratioing. The ratioed spectra were then multiplied by a blackbody curve corresponding to the standard star’s effective temperature to yield the final spectra.
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Figure 2. The $J$-band spectra of V5579 Sgr are shown at different epochs. The relative intensity is normalized to unity at 1.25 µm.

is the presence of lines due to Na I and Mg I. In the spectra taken on 2008 May 3, the Na I lines at 1.1381, 1.1404, 2.1452, 2.2056 and 2.2084 µm, and the Mg I lines at 1.1828, 1.5040, 1.5749 and 1.7109 µm are clearly seen. In an earlier study of V1280 Sco, Das et al. (2008) had suggested that the presence of spectral lines of low-ionization species like Na I and Mg I in the early spectra are indicators of low-temperature zones conducive to dust formation in the nova ejecta, and this is very well borne out in the case of V5579 Sgr. We would like to point out the presence of a large number of strong lines of neutral carbon. These are typical of Fe II-type nova as seen in the cases of V1280 Sco (Das et al. 2008) and V2615 Oph (Das, Banerjee & Ashok 2009). The rising continuum is seen in the

spectra taken on 2008 May 8, indicating formation of significant amount of dust in the nova ejecta. The dust continuum has started dominating on 2008 May 13.

From the $K$-band spectra, we do not find CO emission bands in the first overtone. However, it is possible that such emission may be weakly present but below detection levels. It is thus useful to try and set an upper limit on the strength of the CO emission and hence on the CO mass. An upper limit can be set by computing a model spectrum for the CO emission and using the criterion that CO emission should be discernible if the calculated model strengths of the CO bands are at least 3σ times the value of the continuum noise.

Figure 3. The $H$-band spectra of V5579 Sgr are shown at different epochs. The relative intensity is normalized to unity at 1.65 µm.
in the CO-band region (2.29–2.4 µm). The model CO spectrum has been computed along the same lines as done for the nova V2615 Oph, where CO was strongly detected, and which is described in details in Das et al. (2009). The model calculations were done for the temperature range of 2500–4200 K corresponding to the observed values in case of novae where CO has been detected and modelled (first overtone detections have been made in V2274 Cyg: Rudy et al. 2003; NQ Vul: Ferland et al. 1979; V842 Cen: Hyland & McGregor 1989; Wichmann et al. 1990, 1991; V705 Cas: Evans et al. 1996; V1419 Aql: Lynch et al. 1995; V2615 Oph: Das et al. 2009; V496 Sct: Rudy et al. 2009; Raj, Ashok & Banerjee 2009). A value of \(3 \times 10^{-9}\) to \(5 \times 10^{-9}\) M\(_{\odot}\) is obtained for the upper limit of \(M_{\text{CO}}\) using a distance of 4.4 kpc to the nova.

Theoretically, the detailed modelling of Pontefract & Rawlings (2004) for molecule formation and destruction in nova winds predicts that CO should form early after the outburst, remain constant in strength for \(\sim 15\) d thereafter and then get rapidly destroyed. Fairly consistent with this picture, most of the CO detections outlined above have indeed been reported early after the outburst (see Das et al. 2009 for a detailed discussion). Thus, in the present case too, CO emission could have been expected. Its absence indicates that it either is present but below detection levels or that it did not form for reasons which are not clearly understood.

### 3.3 Fireball phase

As noted earlier, V5579 Sgr showed pre-maximum brightening. After its discovery on 2008 April 18.784 UT by Nishiyama & Kabashima (Nakano et al. 2008) at 8.4 mag, it brightened by nearly 1.8 mag over the next 5 days to reach a maximum of \(V = 6.65\) mag on 2008 April 23.541 UT. This pre-maximum rise is well observed at optical wavebands. Our first near-IR photometric observations are available for 2008 April 23.988 UT close to the optical maximum. We have studied the fireball phase by obtaining spectral energy distribution (SED) covering the optical and near-IR regions. The following optical magnitudes \(B = 7.6, V = 6.87, R_C = 6.23\) and \(I_C = 5.55\) at maximum brightness from AA VSO along with the present \(JHK\) magnitudes of 2008 April 23.988 UT were used in deriving the SED. The observed magnitudes were corrected for
Table 3. A list of the lines identified from the JHK spectra shown in Fig. 5. The additional lines contributing to the identified lines are listed and the unidentified lines are mentioned as u.i.

| Wavelength (μm) | Species | Other contributing lines and remarks |
|----------------|---------|--------------------------------------|
| 1.0938         | Pa γ    |                                      |
| 1.1126         | u.i.    |                                      |
| 1.1287         | O i     |                                      |
| 1.1330         | C i     |                                      |
| 1.1381         | Na i    | C i 1.1373                           |
| 1.1404         | Na i    | C i 1.1415                           |
| 1.1600–1.1674  | C i     | Strongest lines at 1.1653, 1.1659, 1.16696 |
| 1.1746–1.1800  | C i     | Strongest lines at 1.1748, 1.1753, 1.1755 |
| 1.1828         | Mg i    |                                      |
| 1.1819–1.2614  | several C i and N i | 1.1896 |
| 1.2461, 1.2469 | N i     | Blended with O i 1.2464              |
| 1.2562, 1.2569 | C i     | Blended with O i 1.2570              |
| 1.2818         | Pa β    |                                      |
| 1.2950         | C i     |                                      |
| 1.3164         | O i     |                                      |
| 1.5040         | Mg i    | Blended with Mg i 1.5025, 1.5048      |
| 1.5256         | Br 19   |                                      |
| 1.5341         | Br 18   |                                      |
| 1.5439         | Br 17   |                                      |
| 1.5557         | Br 16   |                                      |
| 1.5701         | Br 15   |                                      |
| 1.5749         | Mg i    | Blended with Mg i 1.5741, 1.5766, C i 1.5788 |
| 1.5881         | Br 14   | Blended with C i 1.5853              |
| 1.6005         | C i     |                                      |
| 1.6109         | Br 13   |                                      |
| 1.6407         | Br 12   |                                      |
| 1.6806         | Br 11   |                                      |
| 1.6890         | C i     |                                      |
| 1.7045         | C i     |                                      |
| 1.7109         | Mg i    |                                      |
| 1.7234–1.7275  | C i     | Several C i lines                    |
| 1.7362         | Br 10   | Affected by C i 1.7339 line          |
| 1.7449         | C i     |                                      |
| 1.7605–1.7638  | C i     |                                      |
| 1.7675         | u.i.    |                                      |
| 1.7769–1.7814  | C i     |                                      |
| 1.8021         | O i ?   |                                      |
| 1.9445         | H i     |                                      |
| 1.9722         | C i     |                                      |
| 2.0585         | He i    |                                      |
| 2.0870         | u.i.    |                                      |
| 2.1023         | C i     |                                      |
| 2.1156–2.1295  | C i     |                                      |
| 2.1452         | Na i    |                                      |
| 2.1655         | Br γ    |                                      |
| 2.2056, 2.2084 | Na i    |                                      |
| 2.2156–2.2167  | C i     | 2.2520                                |
| 2.2906         | C i     | 2.3130                                |

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Figure 6. The top panel shows SED for the fireball phase data of April 23.988 UT with blackbody temperature fit of 8900 K. The bottom panel shows a similar fit for the data of May 14.919 UT with blackbody temperature fit of 1700 K after dust formation.

displayed by novae at outburst (Gehrz 1988). However, this temperature, $T_{bb}$, estimate is likely to have additional errors as all the observed flux values used in the fit lie on the Rayleigh–Jeans part of the SED. Further, the $\beta$-band flux value is also susceptible to significant errors since it has the largest interstellar extinction correction. The blackbody angular diameter $\theta_{bb}$ in arcsec is calculated using the relation given by Ney & Hatfield (1978), namely

$$\theta_{bb} = 2.0 \times 10^{11} \left(\frac{\lambda F_\lambda}{\lambda_{bb}}\right)^{1/2} \times T_{bb}^{-2},$$

where $(\lambda F_\lambda)_{max}$ is in W cm$^{-2}$ and $T_{bb}$ is in kelvin. From the model blackbody fit of 8900 K shown in Fig. 6 (upper panel), we find $(\lambda F_\lambda)_{max} = 3.64 \times 10^{-14}$ W cm$^{-2}$. We accordingly obtain a value of ~0.5 mas for the angular diameter. This value for the angular diameter can be used to estimate the distance to the nova by invoking constant expansion rate for the ejecta and the relation given by Gehrz (2008), namely

$$d = 1.15 \times 10^{-3} (V_{ej}) t / \theta_{bb},$$

where $d$ is in kpc, $V_{ej}$ in km s$^{-1}$, $t$ in d since outburst began and $\theta_{bb}$ in mas. Taking a value of 1500 km s$^{-1}$ the typical FWHM of H$\alpha$ lines for $V_{ej}$ and $t = 5$ d corresponding to the epoch of optical maximum, we get $d = 17.3$ kpc, which is four times larger than the estimate done in Section 3.1 using the MMRD relation. The reason for this discrepancy is not clear. A likely reason is that the pseudo-photosphere behaves as a grey-body with reduced emissivity in the fireball phase. The estimate of $\theta_{bb}$ will always be a lower limit since it is applicable for a blackbody (Ney & Hatfield 1978; Gehrz et al. 1980). For a grey-body, the observed angular size can be larger, since the right-hand side of equation (1) should be divided by $\epsilon^{1/2}$, where $\epsilon$, the emissivity, has a value less than unity. A similar discrepancy was noted by Das et al. (2008) in the case of V1280 Sco, where the blackbody angular diameters were smaller by a factor of 3 than the values derived from the interferometric measurements. It should be noted that the value of $t$ is likely to have an error due to the uncertainty in the determination of the start of the outburst. For V5579 Sgr, Yamaoka (2008) and Liller (2008) report that no object brighter than 11.5 and 11.0 mag, respectively, was seen on their petal images taken around 2008 April 15.743 UT and April 16.22 UT. Thus our estimate of $t$ is likely to have an error of ~2 d, which worsens slightly more the discrepancy between the distances.
3.4 Dust formation and ejecta mass estimate

The light curve showed a sharp fall about 15 days after the visual maximum, indicating onset of dust formation. The thermal emission from the dust contributes to the near-IR bands and one expects a brightening at these wavelengths. The present near-IR photometric observations presented in Fig. 1 clearly show the onset of dust formation associated with the fall in the visual light curve around 2008 May 8 accompanied simultaneously thereafter by a steady increase in the near-IR magnitudes, especially in the K band. The SED of the dust component in the ejecta is constructed using the observed JHJK magnitudes on 2008 May 14 9:19 UT and shown in the lower panel of Fig. 6. The contribution of the thermal emission from the dust is seen increasing up to the K band, indicating that it may peak at even longer wavelengths. We estimate a value of 1700 ± 200 K for the temperature of the dust shell. However, this estimate of temperature for the dust shell has large uncertainty as observations in only three wavelengths are used in fitting the SED, of which the dust is contributing mostly in the K band. Russell et al. (2008) have estimated the dust shell temperature to be 1370 K based on the observations spanning the wavelength range up to 5.2 µm. The likely reason for the higher value for the dust temperature derived by us is the restricted spectral coverage extending up to K band only that may have emphasized the contribution at shorter wavelengths.

The mass of the dust shell can be calculated from the thermal component of the SED of 2008 May 14 UT shown in Fig. 6. Woodward et al. (1993) have given the expression for the mass of the dust shell as \( M_{\text{dust}} = 1.1 \times 10^6 \left( \lambda F_{\lambda} \right)_{\text{max}}^1 \left( \frac{d}{r} \right)^2 T_{\text{dust}}^4 \). In the expression above, mass of the dust shell \( M_{\text{dust}} \) is in units of \( M_\odot \), \( (\lambda F_{\lambda})_{\text{max}} \) is in W cm\(^{-2}\), measured at peak of the SED, the blackbody temperature of the dust shell \( T_{\text{dust}} \) is in units of 10\(^3\) K and the distance to the nova \( d \) is in kpc. It is assumed that the dust is composed of carbon particles of size less than 1 µm with a density of 2.25 g cm\(^{-3}\). The early dust formation, high dust temperature and SED in the near-IR that resembles blackbody in the case of V5579 Sgr are indicative of the presence of carbon grains in the dust shell (Clayton & Wickramasinghe 1976). In addition, the occurrence of carbon spectral features in the observed spectra indicates that our assumption that the dust is made up of carbon/graphite is reasonable. We obtain \( M_{\text{dust}} = 2.12 \times 10^5 M_\odot \) for 2008 May 14, taking the observed parameters of \( (\lambda F_{\lambda})_{\text{max}} = 2.42 \times 10^{-15} \text{ W cm}^{-2} \), \( T_{\text{dust}} = 1.7 \times 10^3 \text{ K} \) and \( d = 4.4 \) kpc. The observed ratio for the mass of gas to mass dust range from 1.8 \times 10\(^2\) for LW Ser that formed optically thick dust shell (Gehrz et al. 1980) to 2.5 \times 10\(^2\) for V1425 Aql that formed optically thin dust shell (Mason et al. 1996). Taking a canonical value of 200 for the gas-to-dust ratio, we get \( \sim 4.2 \times 10^{-7} M_\odot \) for the gaseous component of the ejecta. This value is smaller than the typically observed value of 10\(^{-4}\) to 10\(^{-6}\) \( M_\odot \) in novae. One definite reason for the dust mass being underestimated is that our SED is based on data extending up to only 2.2 µm and certainly neglects contribution from dust emission at longer wavelengths. In this process, we are overestimating the derived dust temperature considerably as is evident from Russell et al. (2008) who get \( T_{\text{dust}} = 1370 \) K on 2008 May 9, 5 days before the date being considered in this analysis, which further cools down quickly to 1070 K by 2008 May 22 (Rudy et al. 2008). The formulation used for the dust mass estimate is very sensitive to \( T_{\text{dust}} \). Further, since the Rudy et al. (2008) and Russell et al. (2008) reports show that the dust emission peaks at longer wavelengths, we are also underestimating \( (\lambda F_{\lambda})_{\text{max}} \). Correct use of both \( T_{\text{dust}} \) and \( (\lambda F_{\lambda})_{\text{max}} \) values should considerably enhance the dust mass estimate made here.

We have alternatively explored the possibility of estimating the ejecta mass using recombination line analysis of H\textsc{i}. However, we find that the strengths of these lines, relative to each other, deviate considerably from Case B values on all epochs, indicating that the lines are optically thick. Hence, we are unable to estimate the ejecta mass from recombination analysis.

3.5 A discussion of the P Cygni phase

We qualitatively discuss the P Cygni profiles seen around maximum light as they can help estimate the radius of the white dwarf (WD) photosphere (\( r_{ph} \)) at this epoch. Kato & Hachisu (1994) have shown from theoretical considerations of the photospheric optical depth that \( r_{ph} \geq 100 R_\odot \) at maximum. This is a substantial increase by a factor of almost 10\(^4\) in the WD’s radius between quiescence and maximum. Subsequent refinements in their modelling of nova light curves reaffirm that after the thermonuclear runaway sets in on a mass-accreting WD, its envelope expands greatly to \( r_{ph} \geq 100 \)–1000 R\(_\odot\) (Hachisu & Kato 2001; Hachisu & Kato 2006); the evolution of \( r_{ph} \) with time is illustrated diagrammatically in the above works. It is desirable to have observational confirmation for such estimates of \( r_{ph} \), and P Cygni profiles may provide an assessment of this physical parameter.

The generic formation of P Cygni profiles, following Lamers & Cassinelli (1999), can be understood by considering a spherical symmetric outflowing wind (in our case the mass-loss from the nova outburst) in which the velocity necessarily increases outwards, i.e. the wind is accelerated outwards till it reaches a terminal velocity. To the outside observer, it is the matter in the form of a tube in front of the stellar disc which scatters light from the continuum of the star that is responsible for the absorption component of the P Cygni profile (see fig. 2.4 in Lamers & Cassinelli 1999). The ratio of the strength of the emission to absorption components of the P Cygni profile depends on the size \( r_w \) of the wind region (i.e. size of the ejected material) relative to the size of the star. If the star is large compared to the size of the wind region, then the emission will be smaller than the absorption. When the wind region is large compared to the star’s size, we expect emission to dominate – this can be seen geometrically as the volume of the emitting gas becomes much larger than the volume causing the absorption component. Observationally consistent with this scenario, it is known that prominent P Cygni profiles in a nova outburst are inevitably seen and reported at maximum light and 1 or 2 days following it. At such an epoch, it is therefore reasonable to use an approximation that the wind region size, \( r_w \), is of the order of the stellar size, \( r_{ph} \). Since the wind region size, \( r_w \), can be approximated kinematically (\( r_w \sim v_{\text{mean}} \times t \), where \( v_{\text{mean}} \) = mean velocity of ejecta and \( t = \) time after outburst), a qualitative estimate can be made of \( r_{ph} \). This could be used as the rationale in estimating \( r_{ph} \). As the ejected matter (the wind region) keeps expanding to larger sizes at later times following the maximum, the emission component strengthens and finally begins to dominate. This expected behaviour is reasonably in accordance with the early P Cygni profiles seen in V5579 Sgr as shown in Fig. 7.

A simplistic order-of-magnitude estimate for \( r_{ph} \) may be obtained in the following way. Let a typical velocity of \( v_{\text{mean}} \sim 1000 \text{ km s}^{-1} \) for the nova ejecta be assumed. Velocities in nova ejecta can range from few hundreds to few thousands of km s\(^{-1}\), and \( v_{\text{mean}} = 1000 \text{ km s}^{-1} \) is a fairly representative value. For our choice of \( v_{\text{mean}} \), and taking \( t = 1 \) d as the typical time-scale when
prominent P Cygni profiles are generally seen, the value of $r_w \sim 120 R_\odot$ encouragingly matches that expected for $r_{ph}$. However, we emphasize that this is purely a qualitative estimate. We hope to undertake a detailed modelling, which takes into account a realistic wind-velocity law in the ejecta, to try and reproduce observed P Cygni profiles in novae and their evolution with time.

4 SUMMARY

We have presented near-IR spectroscopy and photometry of nova V5579 Sgr which erupted on 2008 April 19. From the optical light curve, the distance to the nova is estimated to be $4.4 \pm 0.2$ kpc. The IR spectra indicate that the nova is of the Fe II class. Evidence is seen from the $JHK$ photometry and spectra for the formation of dust in the nova in mid-May 2008. In this context, the presence of emission lines from low-ionization species like Na and Mg in the early spectra and subsequent formation of the dust support the predictive property of these lines as indicators of dust formation as proposed by Das et al (2008). It may be noted that V5579 Sgr is one of the few fast Fe II classes of novae ($t_2 = 8$ d) that formed dust. We have indicated the possible usefulness of the P Cygni profiles seen in the nova spectra around maximum brightness to study the physical parameters related to the central WD.

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