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THE LIGHT CURVE AND RED SPECTRUM OF NOVA V4643 Sgr IN EARLY DECLINE

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V4643 Sgr (Nova Sgr 2001) was discovered by Liller (2001) on 2001, Feb. 24. The light curve compiled from magnitude estimates published in IAU Circulars and observations of members of the V.S.S. of the R.A.S.N.Z. (Fig. 1) shows it to be a very fast nova. A parametric fit of a second order polynomial to the first part of the light curve (shown as a dashed line in Fig. 1) indicates that it takes $t_2 = 4.8$ days ($t_3 = 8.6$ days) for the nova to decline 2 (3) magnitudes from maximum light, assuming the first point on the light curve corresponding to outburst maximum.

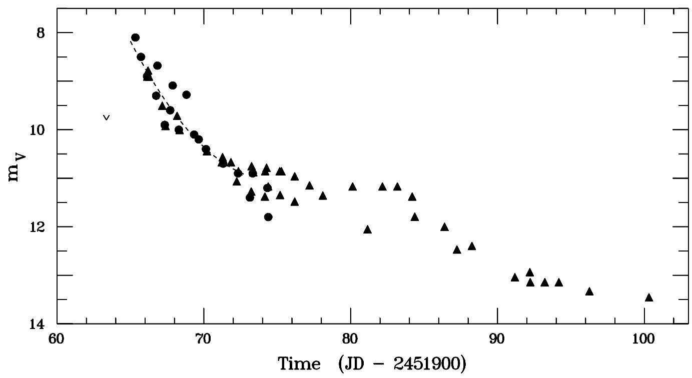

Figure 1. Early decline visual light curve of V4643 Sgr. Dots are magnitude estimates published in IAU Circulars; triangles are observations of members of the V.S.S. of the R.A.S.N.Z. The dashed line is a parametric second order polynomial fit to the data. The chevron indicates the epoch of the last negative observation before discovery

The absolute magnitude of V4643 Sgr during maximum can be estimated using the maximum magnitude–rate of decline (MMRD) relation of which many versions are published in the literature (Schmidt-Kaler 1957, Pfau 1976, de Vaucouleurs 1978, Cohen 1988, Capaccioli et al. 1989, Della Valle 1991). Disregarding the slight dependence on the photometric band, and rejecting a discrepant result based on the Capaccioli et al. relation, all others yield a mean absolute magnitude at maximum of $M = -9\overset{\mathrm{m}}{.}04 \pm 0\overset{\mathrm{m}}{.}08$. The error of the mean is significantly smaller than the error of the individual relations. Thus, there is no point in preferring one relation over the other and I adopt the mean as the best result. Together with the apparent magnitude of the first point in the light curve, $m = 8\overset{m}{.}1$ (to which I arbitrarily assign an error of $0\overset{m}{.}1$), this yields a distance of $d = 2900 \pm 170$ pc. Since the interstellar extinction towards V4643 Sgr is unknown and consequently is not considered here, this distance should be regarded as an upper limit.

The various determinations of the absolute magnitude M_{15} of novae 15 days after maximum (Buscombe & de Vaucouleurs 1955, Schmidt-Kaler 1957, Pfau 1976, de Vaucouleurs 1978, Cohen 1985, van den Bergh & Younger 1987, van den Bergh 1988, Capaccioli et al. 1989) predict $M_{15} = -5\overset{m}{.}53 \pm 0\overset{m}{.}24$. The light curve of V4643 Sgr at this epoch exhibits substantial scatter permitting only to roughly estimate $m_{15} = 11\overset{m}{.}7 \pm 0\overset{m}{.}5$ as the apparent magnitude 15 days after maximum. This is $3\overset{m}{.}6$ fainter than the first point on the light curve which thus corresponds to $M = -9\overset{m}{.}1$, well compatible with the results obtained from the MMRD relation, suggesting that the first observation of V4643 Sgr has been obtained close to maximum light. The error being significantly larger than in the case of the MMRD relation, m_{15} cannot yield an improved distance estimate.

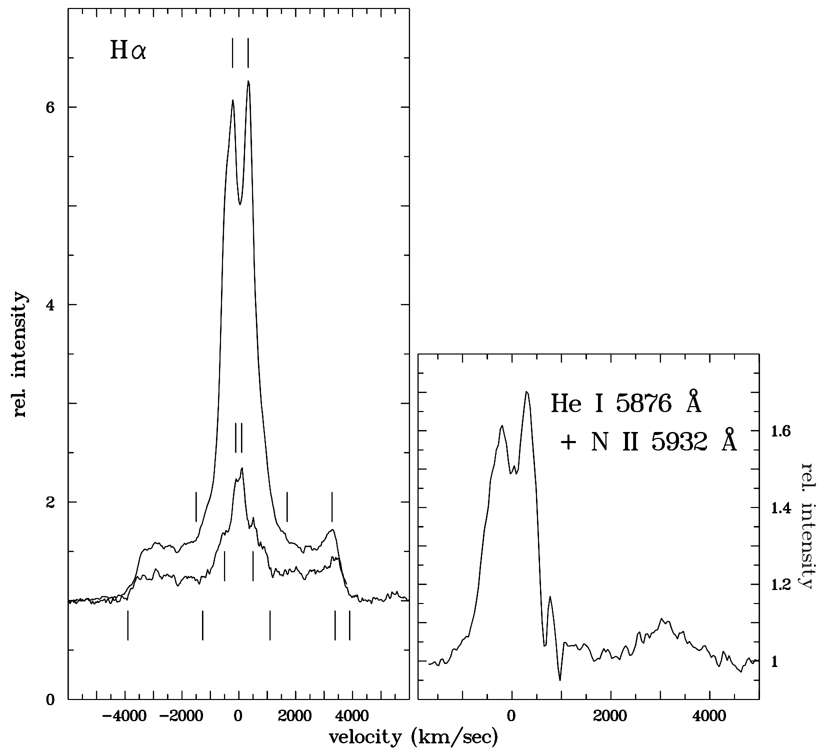

Figure 2. Emission line profiles of Hα (stronger line: 2001, March 16; fainter line: 2001, May 4) and He I λ 5876 Å (plus N II λ 5932 Å; 2001 March 16) in the spectra of V4643 Sgr on a velocity scale. Vertical bars indicate the location of features for which radial velocities are quoted in the text

Spectra of V4643 Sgr in the range of Hα were obtained at the 1.6-m telescope of the Laboratório Nacional de Astrofísica, Brazil on 2001, March 16 (JD 2451984.80; day 19 after maximum; two exposures; 20 min total integration time) when the visual magnitude had dropped to $m_{\rm v} \sim 11.5$, and on 2001 May 4 (JD 2452033.75; day 68; three exposures; 45 min total integration time; visual magnitude unknown, probably $\sim 14^m$). A Cassegrain spectrograph equipped with a thin, back-illuminated SITeSI003AB CCD was used to record the spectra. The instrumental setup yielded a resolution (FWHM) of 2.1 Å. The spectral coverage ranged from 5843 Å to 6624 Å on March 16, and from 5924 Å to 6664 Å on May 4.

The spectra are dominated by strong and complex Hα emission which exhibits appreciable differences between the two observing epochs. The profiles, normalized to the continuum, are shown on a velocity scale in Fig. 2 (left). During both nights Hα consists of a very broad, almost flat component underlying a much narrower strong central emission. The most obvious difference between the observing epochs is the line strength (with respect to the continuum) which is much stronger earlier in the outburst than later on. On March 16 the narrow component exhibits two peaks which, however, at -220 km sec^{-1} and $+330$ km sec^{-1} (these and the subsequently quoted velocities are marked by small vertical bars in Fig. 2) are not symmetrical to the rest wavelength. The full width of the central emission is about 3200 km sec^{-1} (ranging from -1500 km sec^{-1} to 1700 km sec^{-1}). The broad component reaches out to ±3900 km sec^{-1} from the rest wavelength. It appears to be essentially flat with some low scale structure, in particular a red peak at 3280 km sec^{-1}. The overall line profile resembles very much the profile of emission lines of Nova Ophiuchi 1998 a few days after outburst (Lynch et al. 2000).

On May 4 the total width of the broad component is practically unchanged but the equivalent width has decreased by a factor of more than 2. Details of its structure are largely preserved, with the red peak now appearing at a slightly higher radial velocity: 3390 km sec^{-1}. The equivalent width of the narrow component has decreased by a factor of more than five, much more than the broad component. It exhibits more fine-structure than during the earlier epoch: there are peaks (or shoulders) at -110 km sec^{-1}, $+100$ km sec^{-1} and ±500 km sec^{-1}. Furthermore, the total width of the narrow component has decreased to 2370 km sec^{-1} (ranging from -1270 km sec^{-1} to 1100 km sec^{-1}).

The only other spectral features unambiguously present in the spectrum of March 16 are emissions of He I λ 5876 Å and N II λ 5932 Å as well as absorption lines of Na I $\lambda\lambda$ 5890, 5896 Å, shown in the right frame of Fig. 2 on a velocity scale centered on the rest wavelength of the helium line (note the different intensity scale as compared to the left frame of the figure). This spectral range was only observed on March 16. Just as in Hα the structure of the He I λ 5876 Å emission is double-peaked with a peak separation consistent with that seen in Hα. The broad, flat component is not discernible, probably because its blue edge is beyond the observed spectral range and the red edge is beneath the N II λ 5932 Å emission. This makes it difficult to properly define the continuum level in this wavelength range. The nitrogen line is faint and thus noisy, but it is probably safe to say that it does not show a double peak. Therefore, its place of origin is not the same as that of the hydrogen and helium lines. Sharp Na I $\lambda\lambda$ 5890, 5896 Å lines cut into the red flank of the He I line. They are clearly of interstellar origin. They radial velocity is -48 km sec^{-1}. The spectrum of May 4 shows (in a range not covered on March 16) a faint emission of He I λ 6678 Å, seen as a small hump at the extreme right of the left frame of Fig. 2.

The equivalent widths (EWs) of the emission lines were measured and are listed in Table 1. In the case of Hα the EW of the entire line as well as of the broad and narrow components are listed. The EW of the sodium absorption lines cannot reliably be measured because they are superposed upon the steep red flank of the helium emission.

Qualitatively, the morphology of the Hα emission can be explained if the mass was not ejected spherically during the nova outburst but mainly in the equatorial plane of the white dwarf and in the polar regions. Such an outburst geometry is suggested by the nebular remnants of numerous other novae (although Slavin et al. (1995) found this type of morphology preferable in slower novae). If the inclination of the rotation axis to the

Table 1: Equivalent width (in Å) of emission lines observed in V4643 Sgr

Line	2001, March 16	2001, May 4
Hα (entire line)	219	68
Hα (broad component)	95	45
Hα (narrow component)	123	23
He I λ 5876 Å	15	–
He I λ 6678 Å	–	0.8
N II λ 5932 Å	1.9	–

line of sight is high (but not high enough for the approaching part of the matter ejected in the equatorial plane to prevent the view of the receding part) the broad component should be interpreted as being emitted by an equatorial ring. The narrow component is then due to matter ejected along the polar axis which (even if the true velocity is comparable to that of the equatorially ejected matter) has a smaller radial velocity due to the higher angle with respect to the line of sight. The two peaks in the narrow component which are clearly present early on in the outburst then indicate emission from opposite polar ejecta.

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