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THE CATACLYSMIC VARIABLE V751 CYG AT THE EYE OF THE PELICAN NEBULA: EVIDENCE OF A CIRCUMSTELLAR RING?

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RESUMEN

Se presentan observaciones espectroscópicas echelle de V751 Cygni y su región circundante. Aunque las observaciones de rendija larga muestran la presencia de emisión variable en dicho material, las temperaturas y densidades derivadas de las líneas de [O II], [O III] y [S II] sugieren que el material viene del fondo y no está conectado con la variable cataclísmica. Un análisis de la curva de velocidad radial de la línea de Hα arroja un periodo orbital de 0.144584 días.

ABSTRACT

Spectroscopic echelle observations of V751 Cygni and its nearby surroundings are presented here. Although long-slit observations show the presence of variable emission in the material around the object, the temperature and densities derived from [O II], [O III] and [S II] lines suggest that this material comes from the background and is not connected with the cataclysmic variable. An analysis of the radial velocity of the Hα line gives an orbital period of 0.144584 days.

Key Words: **BINARIES: CLOSE — NOVAE, CATACLYSMIC VARIABLES — STARS: INDIVIDUAL (V751 CYG)**

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1. INTRODUCTION

V751 Cyg was discovered by Martynov (1958) and originally classified as an R CrB star due to its irregular variations (13.5–14.0 mag) and occasional fading down to 16th mag (Martynov & Khopolov 1958). Further observations by Wenzel (1963) revealed prominent fading events, but the absence of absorption line and the presence of a strong blue continuum (Herbig 1958; Herbig & Rao 1972; Downes et al. 1995) were against this classification. The flickering characteristic observed photometricaly its similarity to the VY Scl objects (Robinson et al. 1974) changed its classification as a nova-like object. Walker & Bell (1980) report a semiamplitude variation of Hβ and Hγ of about 75 km s^{-1} in a period of about 6h. Further X-Ray and optical observations by Greiner et al. (1999) revealed the object as a Transient supersoft X-Ray object. V751 Cyg is embedded in the Pelican Nebula and very close to its *eye*. Several narrow emission lines are present and contaminate the broad lines arising from the object. In this contribution we discuss the possibility of whether or not the narrow emission lines are associated with the object and revise the determination of the orbital period.

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2. OBSERVATIONS OF OBJECT AND ITS SURROUNDINGS

Observations of V751 Cyg were obtained with the Echelle Spectrograph attached to the 2.1-m Telescope at the Observatorio Astronómico Nacional during two different observing runs. On the nights of September 25 to 29, 1998, a 15 μm Thompson 2048 $\times$ 2048 detector was used to obtain a spectral resolution of $R = 22\,000$, and to cover orders 57 to 30, corresponding to a spectral coverage from $\lambda\,3850$ Å to $\lambda\,7600$ Å. Fifty-five spectra were taken with an exposure time of 1200 seconds each. Forty-one additional spectra of the object with the same exposure time, and several long slit observations of the nearby surroundings were obtained on the nights of August 20 to 22, 2000 with the same configuration. The long slit positions are shown in Figure 1. The spectrophotometric star BD+28 4211 was observed to derive absolute fluxes.

3. EMISSION FROM THE NEARBY FIELD

V751 Cyg shows the typical spectrum of a Cataclysmic Variable with broad Balmer lines and a blue continuum. Superimposed in this case, however, are narrow H I and He I lines as well as Oxygen, Nitrogen and Sulfur forbidden lines (see Fig. 2 as an example for order 34). Measurements of these narrow components are shown in Table 1. The flux intensities are

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TABLE 1

OBSERVED AND REDDENING-CORRECTED LINE RATIOS AND IDENTIFICATIONS

λ_0 (Å)	Ion	$f(\lambda)$	$\lambda_{\rm obs}$ (Å)	$F(\lambda)$[a]	$I(\lambda)$[b]	$V_{\rm r}$ (km s^{-1})
3726.03	[O II]	0.255	3725.87	38.04	64.01	−12.88
3728.82	[O II]	0.255	3728.63	43.20	72.69	−15.29
4340.47	H I	0.130	4340.19	24.12	31.45	−19.35
4861.33	H I	0.000	4861.06	100.00	100.00	−16.66
4958.91	[O III]	−0.025	4958.71	32.16	30.56	−12.10
5006.84	[O III]	−0.035	5006.49	80.62	75.06	−20.97
5875.67	He I	−0.210	5875.34	20.21	13.17	−16.85
6548.03	[N II]	−0.315	6547.73	40.82	21.46	−13.74
6562.82	H I	−0.320	6562.40	549.48	286.00	−19.20
6583.41	[N II]	−0.325	6582.90	137.11	70.64	−23.24
6716.47	[S II]	−0.345	6717.19	49.28	24.37	−14.71
6730.86	[S II]	−0.345	6730.52	32.99	16.32	−14.71

[a]Normalized to Hβ = 100; $F(\mathrm{H}\beta) = 9.70 \times 10^{-15}$ erg cm^{-2} s^{-1}.

[b]$C(\mathrm{H}\beta) = 0.89$.

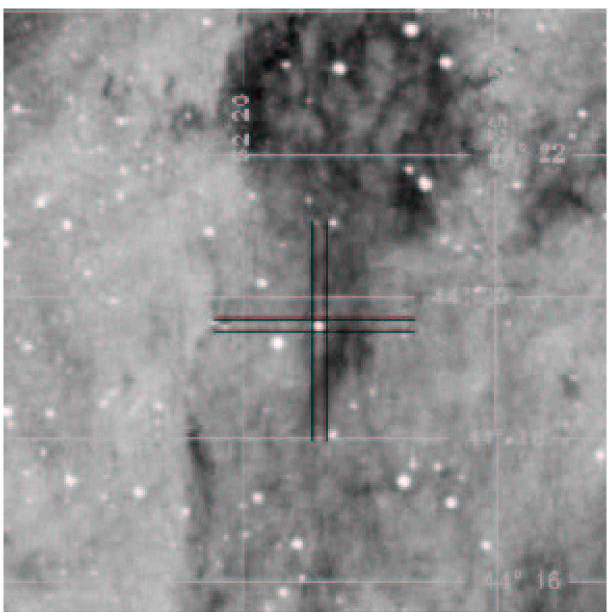

Fig. 1. Long slit positions around V751 Cygni.

the mean of all 41 August spectra of V751 Cyg using Mask 8 (14 arcsec) and correspond only to the adjacent sky at both sides of the star. The line intensities were dereddened according to the expression:

$$\log\left[I_\lambda/I(\mathrm{H}\beta)\right] = \log\left[F_\lambda/F(\mathrm{H}\beta)\right] + C(\mathrm{H}\beta)f(\lambda),$$

where we have adopted a recombination theory case B value: Hα/Hβ = 2.86 (Hummer & Storey 1987) and the Galactic reddening law $f(\lambda)$ by Whitford (1958). Also shown in Table 1 are the measured wavelengths of the lines and their Doppler shifts.

4. LONG SLIT SPECTROSCOPY

The long slit spectroscopy around V751 Cyg is shown in Figure 3. We have selected 8-pixel sums centered on the Hα line for the four exposures and these are plotted (from top to bottom) N, S, E, and W. In the first two spectra coordinates run from West to East and in the last two from South to North. The emission is very patchy and only the north and south observations show a noticeable peak near the object. The rest of the emission is consistent with the changes in obscuration from the eye of the pelican nebula.

5. NEBULAR PARAMETERS

The available diagnostic lines were analyzed by the usual procedures. Values for the electron densities are shown in Table 2. No direct temperature calculations were possible as no [O III] λ4363 or [N II] λ 5755 are detectable. The [O II] and [S II] density indicators suggest that we are observing a very low density region. To have a rough idea of the electronic temperature we have use the diagnostic $\log(R_{23})$ versus $12 + \log(\mathrm{O/H})$ diagram (e.g., McGough 1991).

There is no reason to believe that we are dealing with a high excitation region and there we have chosen the upper value of the diagram to obtain the O/H abundance. Following Alloin et al. (1979) we

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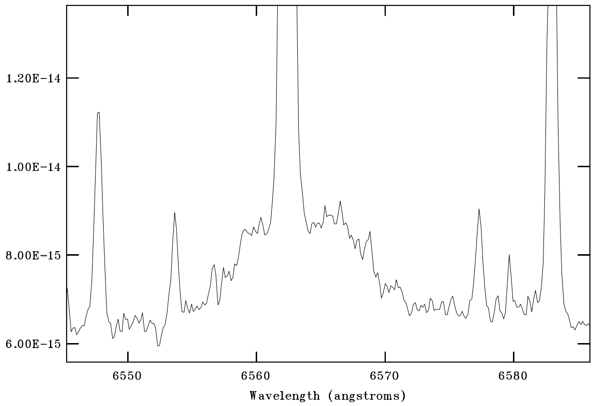

Fig. 2. Summed spectrum of V751 Cyg for the Hα order.

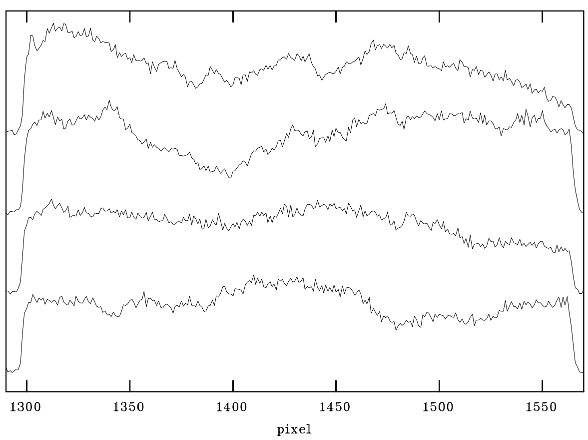

Fig. 3. Long slit spectroscopy around the object.

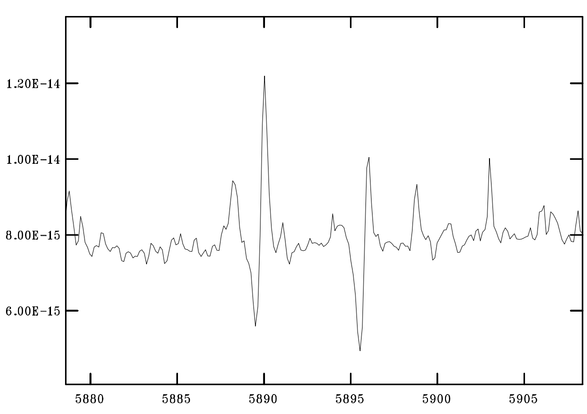

Fig. 4. Complex profile for the Na doublet.

TABLE 2

PHYSICAL CONDITIONS AND IONIC ABUNDANCES

N_e([S II])	< 100 cm^{-3}
N_e([O II])	100 cm^{-3}
$\log R_{23}$	0.38
$12 + \log(\mathrm{O/H})$	9.02
T_e([O III])	6000 K

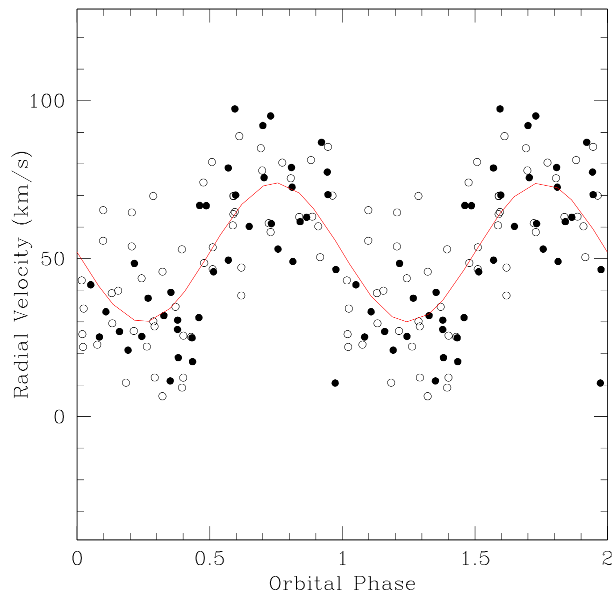

Fig. 5. Radial velocity curve of V751 Cyg. Open circles are the September 1998 data, while filled circles are the August 2000 points.

obtain a low value for the electronic temperature. These results coupled with the previous discussion about the long slit spectroscopy leads us to believe that V751 Cyg is only in front of the pelican nebula and no circumstellar or ejecta is connected with the object. However, there is some evidence that a wind might be present as shown by a complex P Cygni type profile in the Na doublet as shown in Figure 4. Still, the three components might be unrelated and this will be discussed elsewhere.

6. THE RADIAL VELOCITY OF V751 CYGNI

We have subtracted the narrow Hα emission line due to the nebular contribution and measured the broad line using the standard method of fitting a double Gaussian (e.g., Schneider & Young 1980). A CLEAN power spectrum using the DFT (Discrete Fourier Transform) was applied to the data to calculate the Power Spectrum and the Spectral Window, after a convolution of them to depress spectral peaks originating from the temporal distribution of data. The resulting period is $P_{\rm orb} = 0.1445252$ days. Based on this period we performed a standard sinusoidal fit to the data. We found that the system velocity of the system for the first season has a value 35 km s^{-1} less than the August 2000 run. We found no problems in the calibration in both runs and they were reduced in the same way. For more accurate calculation of the ephemeris we have added 35 km s^{-1} to the radial velocities to the first run to avoid this problem. The final results are: $\gamma = 52 \pm 2$ km s^{-1}; $K_1 = 22 \pm 3$ km s^{-1}; HJD$_{\odot} = 2451081.74310 \pm 0.0006$; $P_{\rm orb} = 0.144584 \pm 0.00002$ days; $\sigma = 17.34$. The radial velocity curve derived using this ephemeris is shown in Figure 5.

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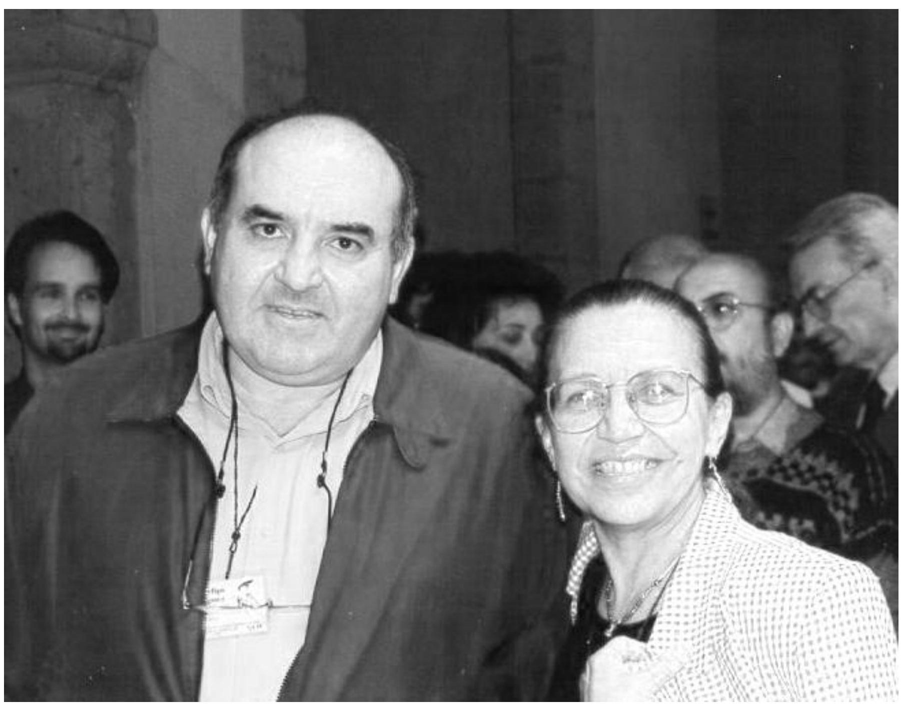

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