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The photometric and spectroscopic characterization of the V Sagittae star V617 Sagittarii*

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Abstract. Photometric and spectroscopic characterization of the V Sge star V617 Sgr (WR 109) is presented. The orbital period, 0.207 day, is the shortest of its class. The optical light curve presents a double wave with minima and maxima of uneven brightness. Strong emission lines of highly ionized species such as HeII, NV and OVI dominate the optical spectrum. High and low photometric states have been observed and the primary eclipse becomes shallower at eruptions. Hα emission becomes stronger and broader at high state when compared to low state. The striking similarities to V Sge are discussed. The photometric and spectroscopic observations suggest that a high and asymmetric rim exists associated with the accretion disk. This star is interpreted as a X-ray quiet galactic counterpart of the supersoft X-ray binaries seen in the Magellanic Clouds.

Key words: stars: novae, cataclysmic variables – stars: individual: V617 Sgr – stars: binaries: eclipsing – stars: Wolf-Rayet – X-rays: stars

1. Introduction

In the course of a photometric and spectroscopic survey of southern and equatorial irregular variables (Steiner et al. 1988; Cieslinski et al. 1997; Cieslinski et al. 1998) we have observed V617 Sgr, a star classified as an irregular variable of type I in the General Catalogue of Variable Stars (Kholopov et al. 1987). It became evident that this star had been misclassified, having a spectrum very similar to V Sge and an orbital period of about 5 hours (Steiner et al. 1988). Later we found that this object was also classified as a Wolf-Rayet star – WR 109 in the catalog of van der Hucht et al. (1981). Van der Hucht et al. (1988) and Conti & Vacca (1990) classified the object as WN3. The later authors suggested a distance of 32.5 kpc under the hypothesis that it is a normal WR star. Such classification was challenged by Lundström & Stenholm (1984, 1989) on the basis of the small observed extinction. Recently, Steiner & Diaz (1998) included this star in a group of 4 objects called the V Sagittae stars and suggested that this class might be the galactic counterpart of the Compact Binary Supersoft Sources seen in the Magellanic Clouds (Kahabka & van den Heuvel 1997).

In the present paper we report on the photometric and spectroscopic characterization of V617 Sgr and discuss its implications and similarities with other stars. A detailed spectroscopic study using Doppler Tomography was presented in a separate paper (Cieslinski et al. 1999 – CDS).

2. Observations and data reduction

2.1. Photometry

V617 Sgr was monitored on various occasions at the Laboratório Nacional de Astrofísica – CNPq/LNA in southeast Brazil. Photoelectric measurements were made with an offset-guided photometer (FOTEX) and with the FOTRAP photometer (Jablonski et al. 1994) on the 1.6-m and 0.6-m telescopes. CCD photometry was obtained at the 0.6-m telescopes using two LNA's CCD and the CCD photometer. Both configurations use Wright Instruments Ltd cameras. The CCD's used were a GEC P8603 front-illuminated chip (CCD 009) and a SITeSI003AB back-illuminated chip (CCD 101), while the CCD photometer is equipped with a EEV CCD-02-06-1-206 back-illuminated chip specially prepared for high time resolution observations. The journal of observations is shown in Table 1.

Absolute photoelectric photometry was obtained on 8 occasions using UBV filters. These measurements are shown in Table 2. Typical errors in these measurements are 0.02 magnitudes in V, 0.03 in $B-V$ and 0.08 in $U-B$. The median values are V=14.72, $B-V=-0.05$ and $U-B=-0.79$. For nights in which no absolute photometric calibration was available, the UBV magnitudes were obtained differentially by measuring a nearby (94″ East and 121″ South) comparison star of magnitude V=12.22 and colors $B-V=0.64$ and $U-B=0.16$.

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* Based on observations made at Laboratório Nacional de Astrofísica/CNPq, Brazil, and Cerro Tololo Interamerican Observatory–CTIO, Chile.

Table 1. Journal of time series photometry of V617 Sgr

Date	Start HJD (2440000+)	Δt(s)	Filter[a]	Length (hrs)	Instrument (detector)
1987 Mar 23	6877.80362	10	C	0.90	FOTEX
1987 Mar 24	6878.71891	10	C	1.51	FOTEX
1987 Jun 01	6947.74183	10	C	2.70	FOTEX
1987 Jun 06	6952.71270	10	C	3.44	FOTEX
1987 Jun 26	6972.53457	31.3	U,B,V	1.11	FOTEX
1987 Jun 26	6972.64055	31.3	U,B,V	1.41	FOTEX
1987 Jun 27	6973.45730	16.3	U,B,V	8.97	FOTEX
1987 Jun 28	6974.42777	16.3	U,B,V	2.16	FOTEX
1987 Jun 30	6976.49277	1	C	0.66	FOTEX
1987 Jun 30	6976.59881	17.3	U,B,V	3.12	FOTEX
1987 Jul 01	6977.53715	1	C	0.64	FOTEX
1989 May 11	7657.75741	180	C	2.36	CCD 009
1989 May 12	7658.72302	180	C	3.05	CCD 009
1989 Jul 07	7721.51408	300	C	6.96	CCD 009
1989 Jul 18	7725.51396	240	C	6.82	CCD 009
1990 May 25	8036.78747	180	R	1.77	CCD 009
1990 Jun 27	8069.64362	180	C	4.50	CCD 009
1997 Jun 03	10602.55213	1	C	3.16	CCD 301
1997 Aug 10	10671.49039	10	R	6.21	CCD 301
1998 Jul 16	11011.53858	10	R	6.76	CCD 301
1998 Jul 17	11012.59656	10	R	3.89	CCD 301
1998 Jul 18	11013.57336	10	R	4.69	CCD 301
1998 Aug 14	11040.47981	40	V	3.60	CCD 101
1998 Aug 15	11041.47752	40	V	4.97	CCD 101
1999 Apr 22	11290.77878	30	V	1.72	CCD 101
1999 Apr 24	11292.63687	20	V	2.83	CCD 301

[a] C = integral light, R = Cousin filter, UBV = Johnson filters

Table 2. UBV photometry of V617 Sgr

JD	V	U−B	B−V
2446650.6023	14.82	−0.82	0.16
2446877.8020	15.15	−0.87	−0.01
2446947.7296	14.68	−0.72	0.05
2446952.7061	14.73	−0.79	−0.01
2446966.5388	14.62	−0.76	0.03
2446966.5445	14.64	−0.84	−0.07
2446966.5514	14.59	−0.80	−0.04
2446966.5648	14.68	−0.89	−0.10
2446966.5697	14.64	−0.82	−0.07
2446966.5747	14.72	−0.92	−0.11
2446966.5790	14.69	−0.78	−0.08
2446966.5835	14.66	−0.72	−0.04
2446966.5944	14.78	−0.78	−0.06
2446966.6280	14.76	−0.74	0.04
2446966.6428	14.68	−0.72	−0.03
2446966.6479	14.76	−0.73	−0.01
2446966.6755	14.58	−0.81	−0.08
2446966.6896	14.77	−0.89	−0.07
2446966.7091	14.73	−0.71	−0.06
2446966.7140	14.72	−0.74	0.01
2446966.7276	14.69	−0.73	−0.04
2446966.7318	14.76	−0.75	−0.09
2446976.4636	14.89	−0.76	−0.05
2446976.5220	14.73	−0.81	−0.07
2446977.5302	14.61	−0.81	−0.04
2447004.4744	14.78	−0.83	−0.12
2447361.4501	14.47	−0.83	−0.03

2.2. Spectroscopy

Spectroscopic observations of V617 Sgr were carried out in 1986 June/July with the 2D Frutti photon-counting detector on the Cassegrain Spectrograph at the 1 meter telescope of Cerro Tololo Interamerican Observatory (CTIO). The observations covered the wavelength range of 3900–6800 Å with 5 Å resolution. Spectrophotometric standard stars were observed, providing an accuracy of about 30% in absolute fluxes. The average spectrum is shown in Fig. 1 while the equivalent widths and fluxes of the most conspicuous emission lines are listed in Table 4.

V617 Sgr was also observed with the 1.6-m telescope at Laboratório Nacional de Astrofísica. On June 30, 1989 (UT) it was observed with a Coudè spectrograph + GEC CCD and a 600 lines/mm grating. A total of 15 spectra with integration times of 10 and 15 minutes were collected. The spectral resolution was 1 Å. On Apr 15, 1997 (UT) we observed V617 Sgr at Hα using the Cassegrain spectrograph, a front-illuminated and UV-coated GEC P88230 CCD (770×1152 pixels) as detector and a 1200 lines/mm grating. The spectral resolution provided by this instrumental configuration is 2 Å. A near infrared 10 Å resolution spectrum was also obtained on Feb 22, 1996 (UT), with a 300 lines/mm grating, the CCD SITe and an order sorting OG550 filter. This filter has a transmission of less than 0.05% at 5300 Å. Another spectrum in the Hα region was obtained on Aug 13, 1998 (UT) with Cassegrain spectrograph. In this case we used a 600 lines/mm grating and the detector CCD SITe, which provided a resolution of 5 Å. The Hα line properties are summarized in Table 5.

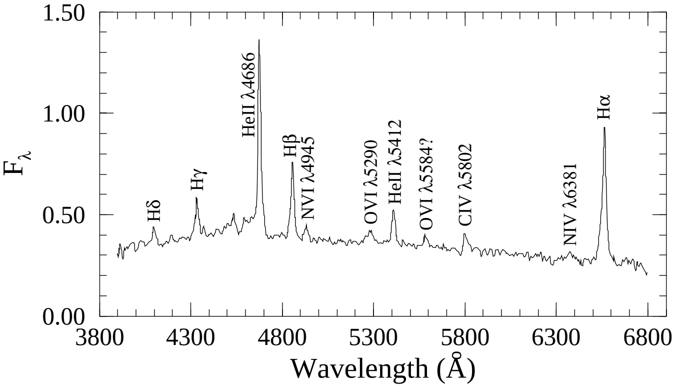

Fig. 1. The CTIO average spectrum of V617 Sgr. The FWHM resolution is 5 Å and flux is in units of 10^{-14} erg cm^{-2} s^{-1} Å^{-1}.

3. Data analysis

3.1. The light curve

The dominant characteristic of the light curve is a strong modulation with two minima of distinct depth per cycle. The

Table 3. Times of minima

Day	Filter	Δm	E	Instrument (detector)
2446878.773(±1)	C	0.5:	0	FOTEX
2446947.758(±1)	C	0.75	333	FOTEX
2446952.731(±4)	C	0.35	357	FOTEX
2446973.655(±1)	B	0.65	458	FOTEX
2446974.483(±1)	B	0.4:	462	FOTEX
2447658.754(±3)	C	0.42	3765	CCD 009
2447721.733(±5)	C	0.10	4069	CCD 009
2447725.670(±2)	C	0.30	4088	CCD 009
2448036.829(±3)	R	0.63	5590	CCD 009
2448069.768(±4)	C	0.46	5749	CCD 009
2450246.685(±6)	Spec[a]	1.0:	16257	CCD 101
2450602.595(±4)	C	0.43	17975	CCD 301
2450671.582(±2)	R	0.39	18308	CCD 301
2451011.754(±1)	R	0.25	19950	CCD 301
2451013.615(±1)	R	0.50	19959	CCD 301
2451040.541(±1)	V	0.36	20089	CCD 101
2451041.577(±1)	V	0.28	20094	CCD 101
2451290.806(±3)	V	0.45	21297	CCD 101
2451292.669(±2)	V	0.65:	21306	CCD 301

[a] Time of minimum obtained from synthetic photometry of spectra

Table 4. Equivalent widths and fluxes of emission lines

Line	W_λ(Å)	F_λ ($\times10^{-14}$ erg cm^{-2} s^{-1})
Hγ	15	5.9
HeII λ4540	21	8.4
HeII λ4686	70	28.5
Hβ	27	11.2
NV λ4933	6	2.3
OVI λ5282	4	1.7
HeII λ5412	9	3.6
OV λ5590	4	1.7
CVI λ5805	6	2.3
Hα	70	22.4

Table 5. Hα properties

Date	W(Hα) (Å)	FWHM (km s^{-1})	FWZI (km s^{-1})	Origin
1986 June/July	70	1030	3700	CTIO[a]
1989 Jun 30	288	2900	5400	LNA/Coudè[a]
1996 Feb 22	85	1300	3500	LNA/NIR[b]
1997 Apr 15	148	1600	6600	LNA[c]
1998 Aug 13	155	1065	4830	LNA[d]

[a] Average spectra
[b] Cassegrain, 300 lines/mm grating
[c] Cassegrain, 1200 lines/mm grating
[d] Cassegrain, 600 lines/mm grating

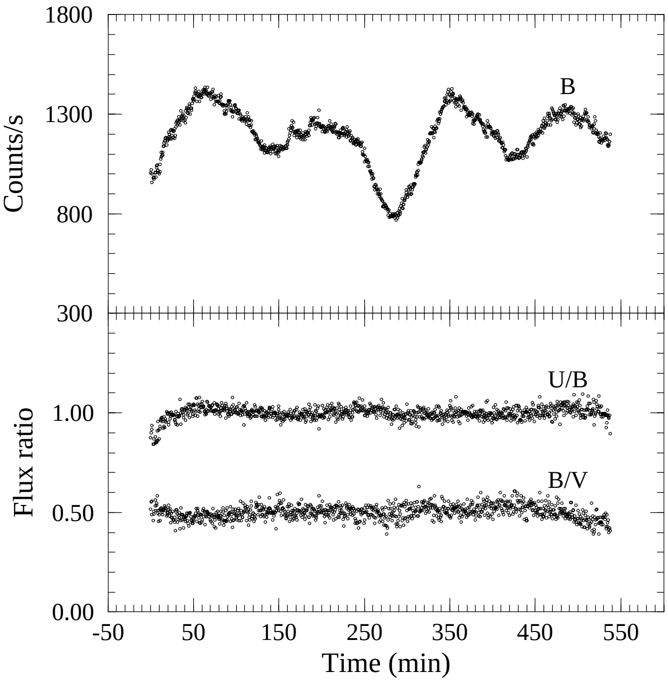

Fig. 2. Light curve of one night showing the eclipse 458.

ephemeris for the primary (deepest – see Table 3) minimum is

$$\mathrm{T_{min}(HJD)} = 2446878.772(\pm1) + 0.2071667(\pm3) \times \mathrm{E} \quad (1)$$

Fig. 2 shows a light curve from a single night while Fig. 3 shows the superimposed light curves of distinct nights normalized to the average of each night. We will call the deepest minimum as the primary eclipse and the secondary minimum as the secondary eclipse. By definition of the Eq. (1) the center of the primary eclipse occurs at ϕ=0. This eclipse has a V shape and the minimum light can be determined with an accuracy of ±2 minutes. The secondary eclipse is not centered at phase 0.5 but at $\phi\simeq0.57$. In Fig. 2 it has a flat bottom shape that last for about $\Delta\phi\simeq0.15$. On the average, the primary eclipse is about 0.17 magnitudes deeper than the secondary one. The primary maximum is centered at $\phi\simeq0.28$ while the secondary maximum, at $\phi\simeq0.75$. The primary maximum is about 0.1 magnitudes brighter than the secondary one. An interesting characteristic of the light curve is that both primary minimum *and* maximum show larger scatter of depth and height than secondary ones.

The fact that the secondary eclipse is not centered at phase 0.5 in binary systems is usually considered evidence of an eccentric orbit. For the present star, this is not likely to be the case. As shown from the spectroscopic evidence (CDS), the region of the hot spot has strong emission of HeII and self absorption in Hβ. This suggests the existence of a high asymmetric rim over the disk, similar to the proposed ones for the CBSS (Meyer-Hofmeister et al. 1997). Such a rim + hot spot are likely to be the occultation source for the secondary eclipse. The (optically thick) rim illumination by the central source may also produce a source of optical continuum light brighter at phase 0.25 than at phase 0.75 (see Fig. 6). Evidence for this is also seen in the spectroscopic analysis (CDS). A qualitative inspection of the light curve of V617 Sgr shows a surprising similarity to CAL 87 (Meyer-Hofmeister et al. 1997), V Sge (Patterson et al. 1998) and QR And (Meyer-Hofmeister et al. 1998).

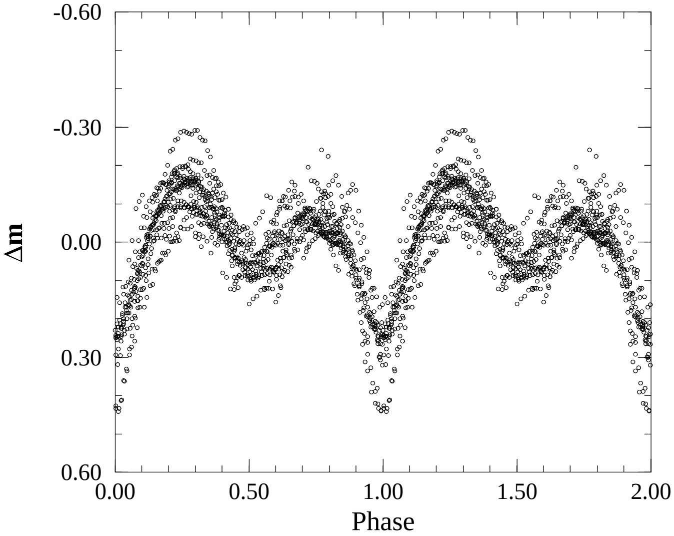

Fig. 3. Composite light curve with distinct nights normalized to the average flux of each night.

The U−B and B−V colors do not show any evidence of systematic variation along the orbit (Fig. 2) suggesting a very high temperature of the primary star. In addition to the periodic modulation, flickering is also present. On the longest run one can clearly see a power excess in the range of 17–27 minutes. Such a flickering with quite long time scale has also been reported for V Sge (Herbig et al. 1965) at low state, where the time scale is 1 hour.

3.2. The spectrum

The spectrum of V617 Sgr (Fig. 1) is dominated by a number of high excitation lines which we identified with CIV, NIV, NV, OV, OVI in addition to HeII and Balmer lines. Such lines are quite common in Wolf-Rayet stars of the WN sequence and the spectrum is very similar to that described by Herbig et al. (1965) for V Sge, in having a strong HeII λ4686 line together with other high excitation heavy element lines not usually seen in cataclysmic variables. Several of the CNO lines, present in the spectrum, have in common the fact that they share an upper level with a strong resonance line, and therefore can be excited by resonance scattering of an ultraviolet continuum (Williams & Ferguson 1983). Recombination and continuum fluorescence are likely the modes of excitation of the CNO lines. In particular CIV λ5805 and NIV λ6381 are probably excited from scattering of a strong ultraviolet continuum by the CIV λ312 and NIV λ247 resonance lines, respectively. A strong ultraviolet continuum is also indicated by the high level of ionization of the emission lines and may be evidence for a hot white dwarf. The presence of emission lines such as CIV λ5805 and OV λ5590 requires a low density plasma in which radiative scattering and recombination processes dominate over collisions. This is unlikely to occur in an accretion disk, consistent with the absence of these lines in normal cataclysmic variables. The heavy element lines are more likely formed in a low density, extented envelope (probably a wind) which surrounds the white dwarf. The envelope is probably formed from gas which is lost by the secondary star, some of which is certainly accreted onto the white dwarf. The presence of the CNO emission lines suggests, however, that much of the gas escapes from the system.

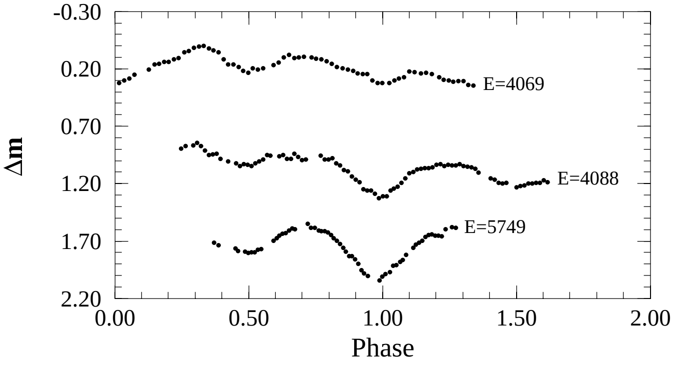

Fig. 4. Ligth curves of three nights showing the effects of different brightness states, in unfiltered light.

3.3. The high/low states

Like V Sge (Herbig et al. 1965; Simon 1996; Robertson et al. 1997), V617 Sgr has also been seen in eruption. An excursion of about 1.7 mag has been observed (Fig. 4). Such eruptions are common in V Sge in which the high/low states have a recurrence time of 240–250 days (Simon 1996; Robertson et al. 1997). Large outbursts (Δm$\sim$2.0) and small outbursts (Δm$\sim$0.7) have been registered (Simon 1996). During the eruptions, the primary eclipse becomes shallower, even disappearing (Robertson et al. 1997; Mader & Shafter 1997; Patterson et al. 1998). This phenomenon is also seen in V617 Sgr (Fig. 4). In this case, at low state the depth of the eclipses is about 0.7 mag while at high state it is only 0.3 mag.

The spectrum also changes significantly between high and low states. While at low state the equivalent width of Hα is W(Hα)$\simeq$70 Å on the CTIO spectra, with FWHM=1030 km s^{-1} and FWZI=3700 km s^{-1}, at eruption it reaches W(Hα)$\simeq$288 Å, FWHM=2900 km s^{-1} and FWZI=5400 km s^{-1} (Table 5). This dramatic change in spectroscopic properties suggests a much stronger and faster wind at high state.

At high state the spectrum displays a red and a blue peak of velocities of about ±1050 km s^{-1} (see Fig. 5). Such a characteristic is also seen in V Sge at high state (Gies et al. 1998).

4. Discussion and conclusions

4.1. The structure of the binary system

The basic photometric and spectroscopic characteristics can be understood by using the schematic model of Fig. 6. The binary system consists of a primary compact object (white dwarf) and a mass-losing secondary star. If the secondary is a Roche lobe filling main sequence star (this case is not obvious!) its mass is $M_2 \simeq 0.55 \pm 0.05 M_\odot$ and the mass of the primary is $M_1 = 0.6 \pm 0.1 M_\odot$ (CDS). Like in the CBSS CAL 87 and QR And

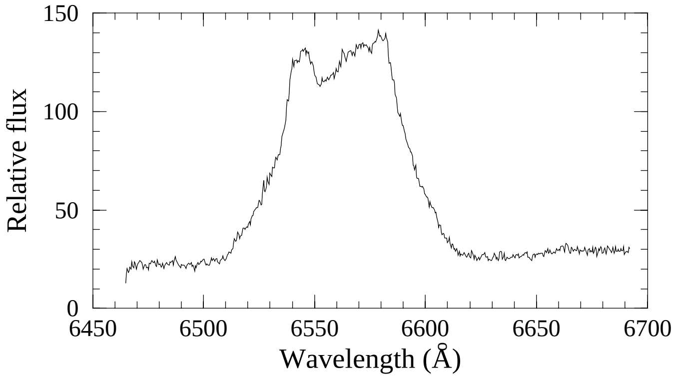

Fig. 5. The 15 co-added spectra at Hα taken with the Coudè spectrograph when V617 Sgr was at high state.

(Meyer-Hofmeister et al. 1997), this object has a high asymmetric rim, near the hot spot. This rim is the source of excess of continuum and HeII emission seen at the phase 0.25–0.30. It is also the location of the strong wind, responsible for the Hβ self absorption. The central source is likely to be the origin of the rim's heating and ionization. The rim also seems to be associated to the secondary eclipse, either because of self obscuration or obscuration of the secondary's heated hemisphere. In addition, from the Greenstein diagram and Doppler tomography shown in CDS, there is evidence for some spill-over of the gas that follows its ballistic trajectories, also shown in Fig. 6.

4.2. *V617 Sgr(≡WR 109) as a Wolf-Rayet star*

V617 Sgr was included in the catalog of WR stars under number WR 109 by van der Hucht et al. (1981) and has been classified as a WN3 WR star by Conti & Vacca (1990) and van der Hutch et al. (1988). On the basis of its photometric and spectroscopic properties it can definitely not be classified as such. The masses (Cieslinski et al. 1999) are far too low for a Population I WR star. The high/low states and their dramatic spectroscopic changes are much better understood in terms of a cataclysmic variable than of a classical WR star. In a cataclysmic variable there is mass transfer that can usually vary significantly with time and in the cases of high accretion rates onto the white dwarf, episodic or stable nuclear burning (van den Heuvel et al. 1992) can produce supersoft X-ray emission as well as large photometric and spectroscopic variations.

The short value for the orbital period is not unique among WR stars. DI Cru (WR 46; WN3p) has an orbital period of 0.311 d (Niemela et al. 1995) and the WN8 star WR 66 has a reported orbital period of 0.145 d (Antokhin et al. 1995; Rauw et al. 1996).

4.3. *V617 Sgr as a supersoft X-ray source*

Could this star be a galactic analogous to the compact binary supersoft X-ray sources – CBSS? From the photometric point of view its behavior is quite similar to CAL 87 and QR And (Meyer-Hofmeister et al. 1998). From the spectroscopic point of view the highly ionized species emission lines (HeII, NV, OVI) are also present in the CBSS basically with the same intensities as in V617 Sgr. High/low states have also been reported for CBSS like QR And (Greiner & Wenzel 1995), RX J0513.9–6951 (Alcock et al. 1996) and CAL 83 (Alcock et al. 1997) while long term variability has also been observed in CAL 87 (Hutchings et al. 1998).

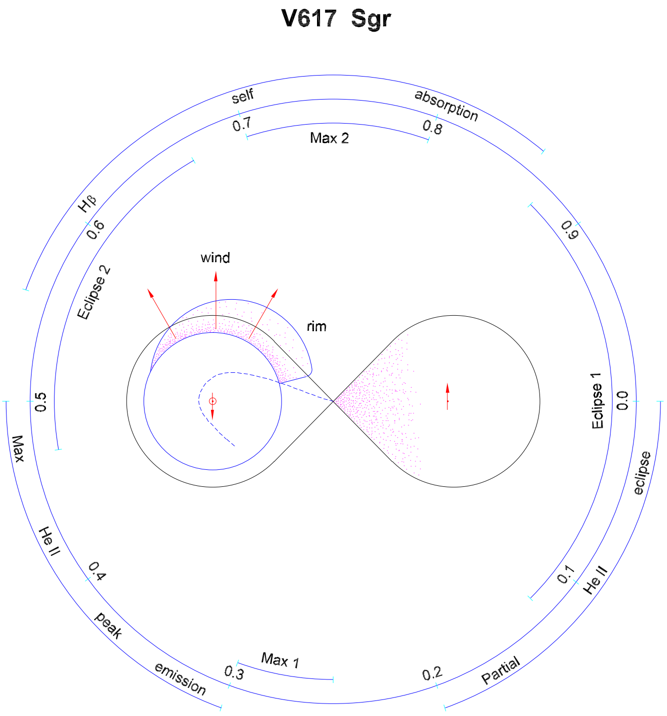

Fig. 6. Binary model for V617 Sgr showing the phase of the main photometric and spectroscopic features. The high rim, wind flow direction and trajectory for spilled-over gas with a ballistic trajectory are indicated.

According to population modeling for the galactic CBSS (Rappaport et al. 1994) such sources should have orbital periods between 0.25 day and 4 days. V617 Sgr is slightly bellow the lower limit of this distribution. The models also predict that the white dwarf should have masses above 0.65$M_\odot$ and the secondary, above 1.2$M_\odot$. In Sect. 4.6 we will see that (stable?) nuclear burning can still be accommodated.

4.4. *V617 Sgr as a SMC 13 object*

SMC 13 (also known as 1E0035.4–7230) is a supersoft X-ray binary with a very short orbital period (4.1 hours compared to 4.97 hours of V617 Sgr). With such a period, SMC 13 is closer of being a typical cataclysmic variable than to a CBSS. By having similar orbital periods these two stars may share some other common characteristics.

SMC 13 has been proposed to be a cataclysmic variable in a post-nova stage (Kahabka & Ergma 1997). Such a model requires that the white dwarf has low mass ($\sim$0.6$M_\odot$) and that it has suffered a nova eruption. Currently it would be in a post-nova stage, burning residual hydrogen. This model, however, requires low CNO abundance in the accreted matter (consistent with being a SMC object) and it is not clear whether it is adequate for stars in the Galaxy.

4.5. V617 Sgr as a V Sge star

Due to the strong similarities with V Sge, Steiner & Diaz (1998) proposed that V617 Sgr belongs to a small group of 4 objects denominated the V Sagittae stars and suggested that they are the galactic counterpart of the Compact Binary Supersoft Sources (CBSS) seen in the Magellanic Clouds (Kahabka & van den Heuvel 1997).

The other proposed V Sge stars are WX Cen (Diaz & Steiner 1995) and DI Cru(≡WR 46). They all have similar spectral characteristics. DI Cru is somewhat discrepant, considering its broad line widths and weak (or absent) Hydrogen. DI Cru also does not display Carbon lines but very strong Nitrogen lines.

V Sge and V617 Sgr have quite similar double eclipses light curves while WX Cen and DI Cru have low amplitude sinewave due certainly to low orbital inclination.

V Sge was shown to be a supersoft X-ray source by Greiner & van Teeseling (1998). However, as pointed out by those authors, the optical and X-ray properties that are described by an expanding and contracting atmosphere model in the case of CBSS, do not describe the date of V Sge. The two classes seem to have some distinct properties, perhaps due to stronger wind and/or metallicity (Steiner & Diaz 1998).

4.6. Stable nuclear burning?

Assuming that the secondary is a main sequence star filling its Roche lobe, its mass is $M_2 \simeq 0.55 \pm 0.05 M_\odot$ (CDS). If, for hypothesis, the primary (WD) is less massive, mass transfer would occur on a thermal time scale, given by (Kahabka & van den Heuvel 1997)

$$\dot{M} = 3 \times 10^{-8} (M_2/M_\odot)^3 M_\odot/\mathrm{yr}. \tag{2}$$

This gives $\dot{M}=3.5\times10^{-9} M_\odot$/yr. However the magnetic braking theory predicts a similar accretion rate (Patterson 1984; Warner 1995),

$$\dot{M}_2 = 2 \times 10^{-11} P^{3.2}(\mathrm{hr}) M_\odot/\mathrm{yr} \tag{3}$$

which, in the case of V617 sgr, is $\dot{M}_2=3.4\times10^{-9} M_\odot$/yr. This means that for a main sequence secondary the mass transfer rate is completely independent of the mass ratio and the mass of the WD.

In fact, assuming that the white dwarf has a mass of $0.6 M_\odot$ (CDS), the minimum accretion rate for stable nuclear burning is (Hachisu et al. 1996)

$$\dot{M}_{\mathrm{low}} \simeq 0.4 \dot{M}_{\mathrm{up}} \tag{4}$$

where $\dot{M}_{\mathrm{up}} \simeq 9.0\times10^{-7}(M_1/M_\odot - 0.50) M_\odot$/yr is the upper limit of $\dot{M}$ for stable nuclear burning.

In this case, $\dot{M}_{\mathrm{low}} \simeq 3\times10^{-9} M_\odot$/yr which is in good agreement with the mass transfer rates derived above.

It is important to mention that in the case of V617 Sgr, stable nuclear burning can only occur if the mass of the WD is low ($M_1 \simeq 0.6 M_\odot$). For such a situation, the contraction time scale for the WD after an eruption, is given by (Southwell et al. 1996)

$$\tau \simeq 51 (M_1/M_C)^{-1} [(M_1/M_C)^{-2/3} - (M_1/M_C)^{2/3}]^{3/2} \text{ days}, \tag{5}$$

where $M_C=1.4 M_\odot$.

We predict that the transition from high to low states occurs on a time scale (3 months) quite long when compared to RX J0513.9-6951 (1 week) and V Sge (3 weeks – Simon 1996). This is in fact an interesting test to the theoretical picture and also to the mass of the WD.

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References

Alcock C., Allsman R.A., Alves D., et al., 1996, MNRAS 280, L49
Alcock C., Allsman R.A., Alves D., et al., 1997, MNRAS 291, L13
Antokhin I., Bertrand J.-F., Lamontagne R., Moffat A.F.J., 1995, AJ 109, 817
Cieslinski D., Jablonski F.J., Steiner J.E., 1997, A&AS 124, 55
Cieslinski D., Steiner J.E., Jablonski F.J., 1998, A&AS 131, 119
Cieslinski D., Diaz M.P., Steiner J.E., 1999, AJ 117, 534 (CDS)
Conti P.S., Vacca W.D., 1990, AJ 100, 431
Diaz M.P., Steiner J.E., 1995, AJ 110, 1816
Gies D.R., Shafter A.W., Wiggs M.S., 1998, AJ 115, 2566
Greiner J., Wenzel W., 1995, A&A 294, L5
Greiner J., van Teeseling A., 1998, A&A 339, L21
Hachisu I., Kato M., Nomoto K., 1996, ApJ 470, L97
Herbig G.H., Preston G.W., Smak J., Paczyński B., 1965, ApJ 141, 617
van den Heuvel E.P.J., Bhattacharya D., Nomoto K., Rappaport S.A., 1992, A&A 262, 97
van der Hucht K.A., Conti P.S., Lundström I., Stenholm B., 1981, Space Sci. Rev. 28, 227
van der Hucht K.A., Hidayat B., Admiranto A.G., Supelli K.R., Doom C., 1988, A&A 199, 217
Hutchings J.B., Crampton D., Cowley A.P., Schmidtke P.C., 1998, ApJ 502, 408
Jablonski F.J., Baptista R., Barroso Jr. J., Gneiding C.D., Rodrigues F., Campos R.P., 1994, PASP 106, 1172
Kahabka P., van den Heuvel E.P.J., 1997, ARA&A 35, 69
Kahabka P., Ergma E., 1997, A&A 318, 108
Kholopov P.N., Samus N.N., Frolov M.S., et al., 1987, General Catalogue of Variable Stars, Nauka Publishing House, Moscow
Lundström I., Stenholm B., 1984, A&A 138, 311
Lundström I., Stenholm B., 1989, A&A 218, 199
Mader J.A., Shafter A.W., 1997, PASP 109, 1351
Meyer-Hofmeister E., Schandl S., Meyer F., 1997, A&A 321, 245
Meyer-Hofmeister E., Schandl S., Deufel B., Barwig H., Meyer F., 1998, A&A 331, 612
Niemela V.S., Barbá R.H., Shara M.M., 1995, In: van der Hucht K.A., Williams D.M. (eds.) Wolf-Rayet stars: Binaries, Colliding Winds, Evolution. IAU Symp. 163, Kluwer, p. 45

Patterson J., 1984, ApJS 54, 443
Patterson J., Kemp J., Shambrook A., et al., 1998, PASP 110, 380
Rappaport S.D., Di Stefano R., Smith J.D., 1994, ApJ 426, 692
Rauw G., Gosset E., Manfroid J., Vreux J.-M., Claeskens J.F., 1996, A&A 306, 783
Robertson J.W., Honeycutt K.R., Pier J.R., 1997, AJ 113, 787
Simon V., 1996, A&AS 118, 421
Southwell K.A., Livio M., Charles P.A., O'Donoghue D., Sutherland W.J., 1996, ApJ 470, 1065
Steiner J.E., Cieslinski D., Jablonski F.J., 1988, In: Blanco V.M., Phillips M.M. (eds.) Progress and Opportunities in Southern Hemisphere Optical Astronomy. ASP Conf. Ser. 1, 67
Steiner J.E., Diaz M.P., 1998, PASP 110, 276
Warner B., 1995, In: Cataclysmic Variable Stars. Cambridge University Press, Cambridge
Williams R.E., Ferguson D.H., 1983, In: Livio M., Shaviv G. (eds.) Cataclysmic Variables and Related Objects. IAU Coll. 72, Reidel, Dordrecht, p. 97