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The peculiar interacting binary V Sagittae: Brightness variations in 1932 – 1994*

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Abstract. — The analysis of the historical light curve revealed several kinds of variations not connected with the orbital modulation: *a)* large outbursts consisting of a primary (amplitude about 2 $mag_{vis.}$) and a fainter secondary peak; *b)* transitions from the high to the low state and vice versa; *c)* small outbursts (amplitude about 0.7 $mag_{vis.}$) on the time scale of 15-20 days in the high state; *d)* year-to-year variations of brightness. It is shown that drastic changes of the photometric activity occurred in the course of the last six decades. An interpretation of this activity in terms of mass transfer events in a strongly interacting binary containing an accreting white dwarf is offered.

Key words: stars: binaries: general — stars: emission-line, Be — novae, cataclysmic variables — stars: variables: other — circumstellar matter — stars: individual: V Sge

1. Introduction

V Sge is a little studied variable star despite of the fact that its large-amplitude variability has been known for several decades. The most extensive study in the visible band was presented by Herbig et al. (1965, hereafter H65). It was found that V Sge is a close binary with the orbital period 0.514195 days long. Several kinds of brightness variations were found: *(a)* Long-term changes (weeks–months) with an amplitude about 2 mag(U). *(b)* Orbital modulation (the depth of the primary eclipse varies from 0.3 mag(U) in the high state to 1.24 mag(U) in the minimum brightness). Secondary minimum is discernible, too, and the light curve is highly variable. *(c)* Rapid variations (0.1 mag(U)) on the time scale of one hour.

The spectra presented by H65 display strong and very broad emission lines of H, HeII, O, C, N and resemble the spectral type WN5. Most emission lines strengthen when the brightness rises. The OIII 3444 line appears double and its components shift sinusoidally with the photometric orbital phase. These variations were supposed to reflect the orbital motion of the stars and allowed for the determination of the orbital elements and the mass ratio $q = 3.8$. The less massive, but more luminous star occulted in the primary eclipse was abbreviated as the primary component.

H65 interpreted the odd nature of V Sge in terms of highly evolved components below the main sequence and stated that the system may represent an advanced stage of the evolution of a binary.

Koch et al. (1986, hereafter K86) analysed the *IUE* spectra and found only strong emission lines which do not follow the orbital motion of any star and don't vary through the eclipses. The γ-velocities of these UV lines are 700 km s^{-1}, quite discordant with the value found in the visible band which is close to zero (H65). The distance of V Sge is 1.2 kpc according to K86. They offered a model of V Sge consisting of a Wolf-Rayet star transferring mass on to a compact object, probably a neutron star.

Both above mentioned analyses supposed the flow of mass from the less massive primary. Nevertheless, the behaviour of HeII 4686 and the Balmer lines in the course of the primary eclipse can be explained only by an occultation of the accretion disk (Williams et al. 1986, hereafter W86). The mass therefore flows in the opposite direction than was thought previously. Moreover, the primary eclipse in these lines is much broader than corresponds to the dimensions of the Roche lobe of the occulting secondary.

Analysis of the orbital period by Smak (1995b) revealed decreasing period but the trend is dependent of the reliability of the old photographic timings. Šimon (1995) showed that the orbital period was stable during the last 31 years with only a very small decrease and pointed out that the period change is much smaller than expected for the accretion rate larger than 3 10^{-8} $M_{\odot}$ yr^{-1} determined

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*This research has made use of the AFOEV database, operated at CDS, France

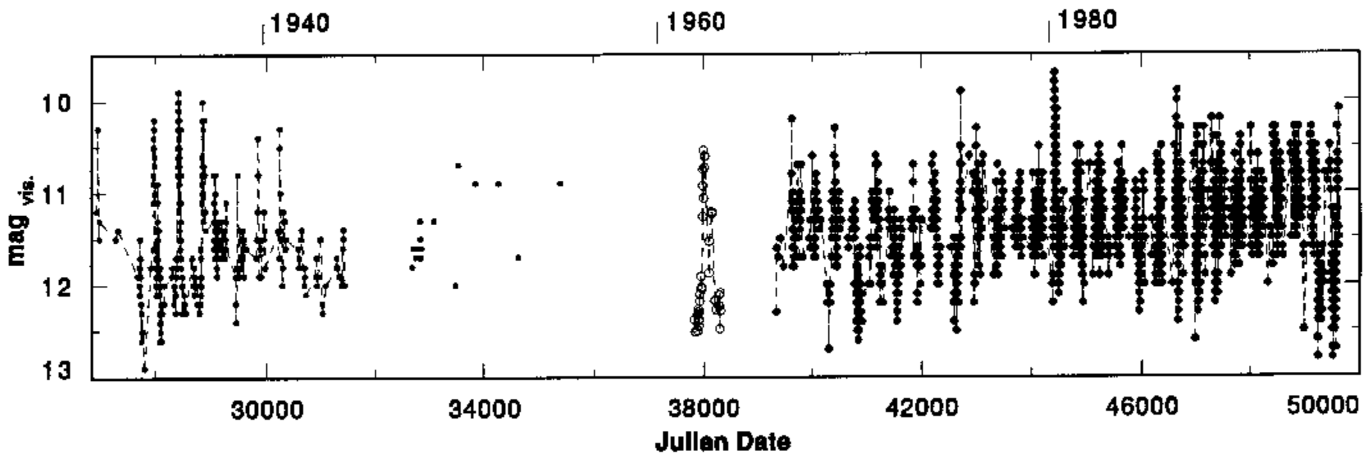

Fig. 1. The whole set of the photometric data of V Sge covering the years 1932 – 1994. The data of AFOEV are marked by solid circles, the empty ones represent the measurements of H65

from the luminosity of the accretion disk. The traditional conservative scheme therefore cannot be applied here.

Nowadays, V Sge is classified as a nova-like cataclysmic variable but it differs largely from most other members of this class namely by the type of the loser and by extremely high absolute magnitude ($M_V \approx 0$, K86).

V Sge was also detected as an X-ray source (Eracleous et al. 1991).

This paper presents the historical light curve in 1932–1994 and gives a description of the variations on the long time scales. The preliminary version of this analysis was presented by Šimon (1996).

2. The source and treatment of the data

Needless to say that long-term light curve of a variable star amounting several decades is very important for its better understanding. However, it is usually difficult to collect such a long series of data since most photoelectric measurements cover only limited time intervals. Photographic monitoring surveys may cover longer intervals but photographic emulsions are being exchanged from time to time and this fact may make these data inhomogeneous. On the other hand, amateur associations organize visual monitoring of many variable stars and long series of visual data are available today. This kind of data may be very useful for an analysis of the long-term brightness changes. Percy et al. (1985) and Richman et al. (1994) discussed the advantages of using visual data and evaluated their accuracy. They found that a typical error of a single visual observation is about 0.2 $\mathrm{mag_{vis.}}$ and an accuracy of 0.02 $\mathrm{mag_{vis.}}$ can be achieved by averaging the data. This accuracy is quite sufficient for analyses of most CVs. More detailed discussion of this topic can be found in the above mentioned papers.

The bulk of the data used in this analysis was obtained from the AFOEV database in Strasbourgh (France). The original file contained 4 600 measurements. The negative and unreliable observations were rejected. The orbital phase of each observation was calculated using the ephemeris of H65 and the data in the phase interval 0.9−1.1 were excluded to diminish the influence of the orbital modulation (namely the eclipses). Most of the data analysed here come from the years 1967 – 1994 and as the analysis by Šimon (1995) showed one can be sure that at least in this interval the ephemeris given by H65 is fully valid. Finally, several largely deviating points were removed. Nevertheless, the remaining variations on the orbital scale (especially the reflection effect) and the rapid variations found by H65 may still contribute to the scatter (see Fig. 7 in H65). It was found that a typical rms error of a mean of five visual observations used here is 0.05−0.07 $\mathrm{mag_{vis.}}$ but one should bear in mind that the error of the mean includes both observational inaccuracies and intrinsic variations (especially the orbital modulation).

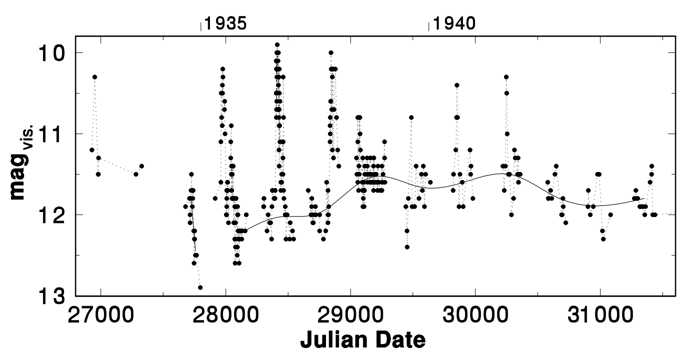

Fig. 2. A part of the light curve with several large doubled outbursts. The smooth curve represents a spline fit of the year means of the brightness in quiescence (outbursts excluded). Note the very low quiescence brightness around the three LOs

3. Description and analysis of the light curve

The whole data set can be seen in Fig. 1. The brightness is variable with a peak amplitude reaching about 3 $\mathrm{mag_{vis.}}$. The observations occupy a belt more than 1 $\mathrm{mag_{vis.}}$ broad and also several large outbursts can be easily distinguished (especially in the first half of this century). A detailed examination of this set revealed several kinds of brightness variations which aren't connected with the orbital modulation: *(a)* large outbursts with amplitude about 2 $\mathrm{mag_{vis.}}$; *(b)* transitions from the high to the low state and vice versa; *(c)* small outbursts (amplitude about 0.7 $\mathrm{mag_{vis.}}$) in the high state; *(d)* year-to-year variations of brightness. In the following sections we will analyse these forms of activity in detail.

3.1. *Large outbursts*

One of the most remarkable kinds of activity in V Sge are *the large outbursts* (LOs), which can be characterized as transient brightenings by 2 $\mathrm{mag_{vis.}}$. The AFOEV data set shows four these events, three are well covered. Three LOs occured in thirties when the "quiescence" level of brightness was extremely low (Fig. 2). Another LO occured in 1980. Three well covered LOs are shown in Figs. 3a-c. The V band curve generated from the data of H65 revealed an event which is similar to LOs (Fig. 4). This outburst lasted more than twice longer but the shape of the curve, the amplitude and the surrounding low quiescence level allow an interpretation of this event in terms of LO, too.

The overall shape of the LOs (apart from LO4 observed by H65) was determined by a fit of a smooth curve using the program HEC13 written by Dr. Harmanec at the Ondřejov Observatory. The program is based on the method developed by Vondrák (1969 and 1977) and can fit the data by a smooth curve no matter what is their course. The parameters of the LOs, based on the fit by HEC13, are given in Table 1. The parameters of LO4 observed by H65 are rather crude estimates because of the incomplete covering.

Several common features can be established: *(a)* all LOs with covered descending branch are doubled and consist of a large primary outburst followed by a smaller secondary one; *(b)* the amplitude of the primary peak of LO is about 2 $\mathrm{mag_{vis.}}$ in all observed cases; *(c)* the level of brightness of the system is unusually low (fainter than 11.8 $\mathrm{mag_{vis.}}$) before each LO (and often also after it); *(d)* the final decline is longer than the rise and often a pronounced long "tail" can be seen.

As for the general conditions which give rise to LOs, the inspection of the light curve shows that long-lasting low state ($\mathrm{mag_{vis.}}$ fainter than 11.8–12.0) with a smooth slow decline and rise is needed (the slow rise to HS after LO5 is evident in Fig. 3c).

When the LOs are folded so as the primary peaks coincide a good fit is obtained after slight shifts along

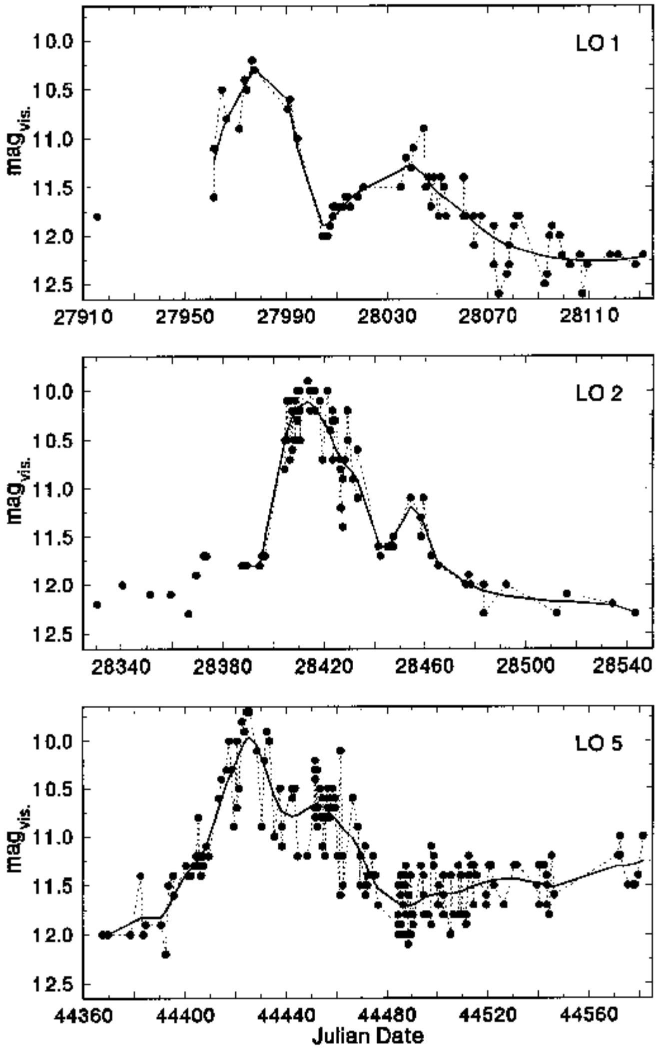

Fig. 3. The light curves of LOs in an expanded time scale. The smooth curves represent the fit by HEC 13 (see the text for details)

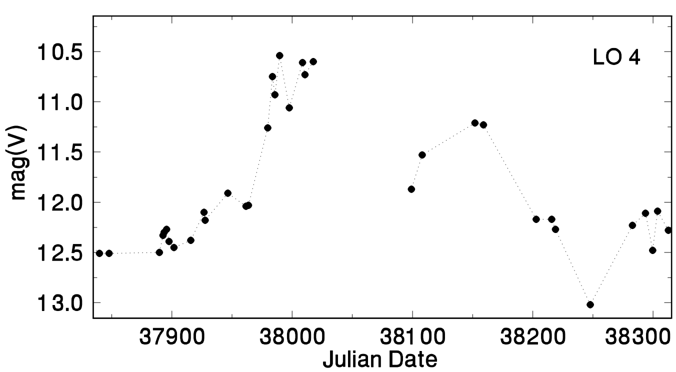

Fig. 4. The V-band curve constructed from the observations of H65. The dashed line represents a possible interpretation in terms of LO

the abscissa (namely LO1 and 2) but the positions of the secondary peaks with respect to the primary ones and their intensities differ appreciably. There is a tendency the sooner the secondary peak occurs the smaller its amplitude.

The occurence of LO1–3 seems to be periodic with the cycle-length of about 440 days. On the other hand, LO5 in 1980 occured in phase 0.4 with respect to LO1–3.

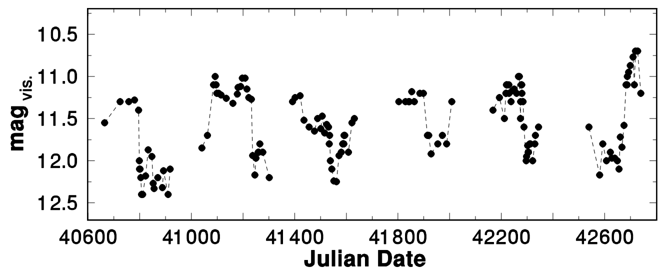

Fig. 5. The extended season of interchanging high and low states of V Sge in 1970-1975. The observations were averaged and a typical rms error of a single bin is $0.05-0.07$ $mag_{vis.}$

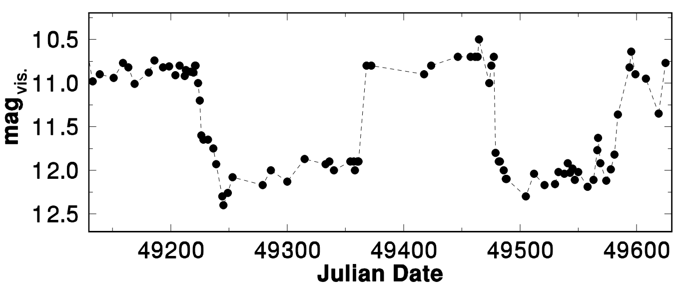

Fig. 6. Two episodes of the low states in 1993-1994. The transitions are very steep and the changes reach several tenths of magnitude per day. Notice that the levels of brightness in the respective LSs and HSs are almost equal. The curve was slightly smoothed and a typical rms error of a single bin is $0.05-0.07$ $mag_{vis.}$

LO5 is the best covered outburst. Striking feature is the different scatter of the ascending and descending branch. While on the rising part of LO5 the observations fall close together large scatter (almost 1 $mag_{vis.}$) is beginning on the top and persists through the decline. It is improbable that it is caused purely by the observational inaccuracies. The statistical distribution of the residuals of the fit of LO5 by HEC 13 is bimodal (separation of the peaks 0.32 $mag_{vis.}$) and much less steep than the Gaussian.

3.2. *High and low states*

The inspection of the light curve revealed occasional episodes of abrupt decrease of the brightness from the high state (HS) to the low state (LS). On the whole, these

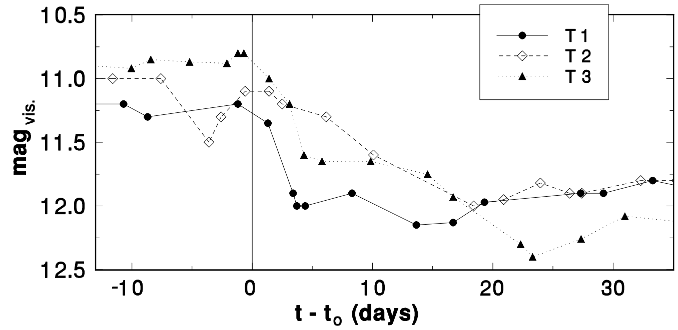

Fig. 7. Examples of transitions from HS to LS. The time scale is expressed in days from the start of the transition and the zero points correspond to JD = 41 232, 42 278, 49 222 for events T1 – 3, respectively. The light curves were smoothed

episodes aren't very frequent and V Sge spends most of the time in the high state (see the histograms in Fig. 10). One extended season of the interchanging high and low states set in 1970–1975 and the corresponding light curve can be seen in Fig. 5. The amplitude of these transitions varies but reaches about 1 $mag_{vis.}$. One may get an impression of a cyclic behaviour of the changes in this season. A period search was undertaken using the PDM analysis (Stellingwerf 1978). Several possible periods were found but their significance is low ($\Theta > 0.7$). The best one seems to be about 250 days long.

Two another remarkable transitions occured in 1990's. As can be seen in Fig. 6 these LSs lasted about 130 and 100 days, respectively. The transitions in these two episodes were rather abrupt and the levels of brightness in the HS before LS and after it were almost equal.

A detailed view of three transitions, which can be seen in Fig. 7, reveals that declines from the HS occur in less than twenty days.

3.3. *Small outbursts in the high state*

The brightness of V Sge in the HS isn't constant and the observations show a large scatter (almost 1 $mag_{vis.}$) even when the primary eclipses are excluded. This scatter is significantly larger than the error of visual observations and it may be considered to origin in real fluctuations of brightness but very dense coverage is needed to resolve the course of these variations.

One such season (about 180 days long) is shown in Fig. 8. The changes may have character of small outbursts with the peak amplitude of about 0.7 $mag_{vis.}$. The time scale of these variations may be 15-20 days.

3.4. *Year-to-year variations of brightness*

V Sge is not circumpolar star and there are often seasonal gaps in the data but the number of measurements in every year after 1967 is high (often more than 100). It is possible

Table 1. Parameters of the large outbursts in V Sge. $JD_{max}P$ is the date of the maximum brightness of the primary outburst. The peak brightness of this outburst is in column $mag_{max}P$ and its amplitude is A_P. $JD_{max}S$ is the date of maximum of the secondary outburst while columns $mag_{max}S$ and A_S refer to its peak brightness and amplitude, respectively. Δt is separation of the peaks of the prim. and sec. outbursts in days. Dur. is the total duration of the whole outburst (both peaks). The column $mag_{min}T$ refers to brightness in the transient minimum between the prim. and sec. outburst. mag_q gives the brightness in quiescence before (b) or after (a) the outburst

n	$JD_{max}P$	$mag_{max}P$	A_P	$JD_{max}S$	$mag_{max}S$	A_S	Δt	Dur.	$mag_{min}T$	mag_q
LO1	27 982	10.30	2.00	28 039	11.32	1.0	57	140	11.92	12.30 a
LO2	28 413	10.10	2.10	28 455	11.20	1.0	42	120	11.64	12.20 a
LO3	28 860	10.20	1.80							12.00 b
LO4	38 005	10.65	1.85	38 135	11.2?	1.3	130	320	11.9?	12.50 b
LO5	44 426	10.00	1.80	44 452	10.66	1.2	26	100	10.80	11.70 a

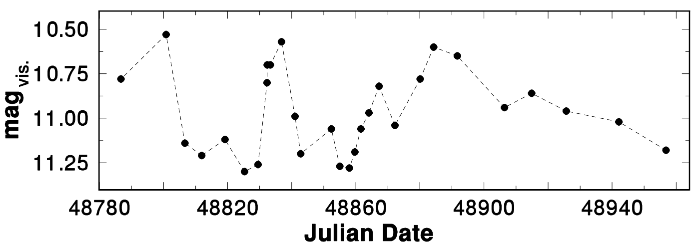

Fig. 8. Variations of V Sge in the high state. These changes reach about 0.7 $mag_{vis.}$ with the time scale of 15-20 days. Means of five observations were used here and a rms error of a single bin is about 0.05 $mag_{vis.}$

to utilize this natural sampling and calculate the mean brightness for every year. These means were calculated separately for HS and LS and the result is shown in Fig. 9. The year 1980 in which LO5 occurred was omitted.

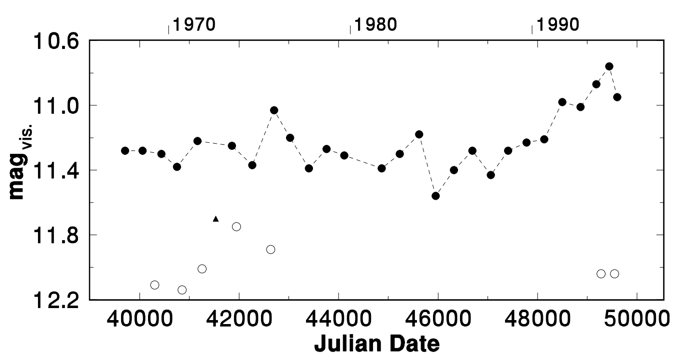

Fig. 9. Year-to-year brightness variations of V Sge. High state is marked by solid circles, low state by empty ones and an unresolved state by a triangle. Note the rapid brightening after JD = 47 000 and almost equal levels of the low states in 1970's and in 1990's. A rms error of a single mean is usually 0.03 $mag_{vis.}$. See the text for details

A rms error of a single mean is usually 0.03 $mag_{vis.}$ therefore it is reasonable to suppose that these long-term variations are real.

The brightness in HS stayed almost constant at 11.3 $mag_{vis.}$ during JD = 39 500 −46 900 with a possible small decrease. A rapid brightening of HS from 11.45 to 10.77 $mag_{vis.}$ began in JD = 47 000 with a rate of 0.09 mag yr^{-1} if a linear course is assumed. The level of two LSs which occurred in 1993–94 is approximately the same as that of LSs in 1970's but the levels of the HSs in these respective seasons differ appreciably.

3.5. *Statistical brightness distribution*

Analysis of a histogram may help to a better insight to the character of the changes of brightness of V Sge. The large number of measurements enabled to divide the data set into several parts of comparable size and a histogram was constructed for each time interval (Fig. 10). The number of measurements used in a single histogram may exceed one thousand. This approach allows to study the changes of the brightness variations in the course of several decades.

The histograms confirm the overall trend of gradual rise of the mean brightness of V Sge. The brightness in the respective LSs remains rather similar through the covered interval but the episodes of LS become less frequent now. It is worth while to note that LOs contributed significantly to the overall brightness in thirties and the surrounding quiescence brightness in Fig. 10a is not very different from that in LS.

4. Position of V Sge in the colour diagram

V Sge is thought to belong to the class of cataclysmic variables (CV). Let us examine the position of V Sge in the colour diagram and compare it with some well established CVs.

The dereddened indices $(B-V)_0$ were taken from Bruch & Engel (1994) and the absolute visual magnitudes M_V were calculated from the distances given by Patterson (1984) for all CVs apart from V Sge where the value 1.2 kpc derived by K86 from the UV spectra was used. The colour diagram in Fig. 11 clearly reveals the outstanding

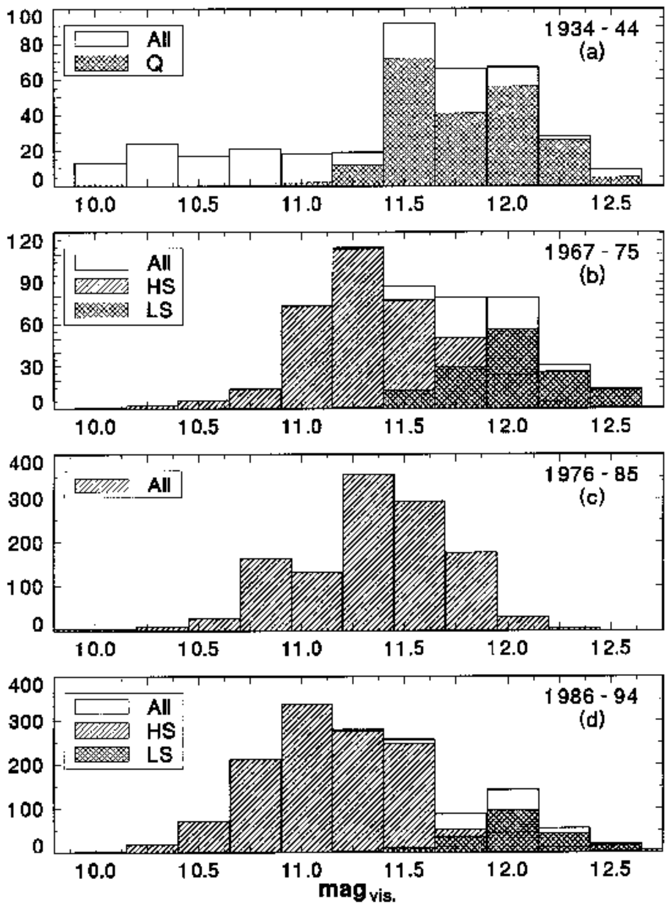

Fig. 10. The statistical distribution of four parts of the data set shown in Fig. 1. **All** denotes the distribution of all data in a given time interval while **HS** and **LS** represent an approximate separation into the high and low states. **Q** marks the quiescence brightness in thirties with excluded LOs

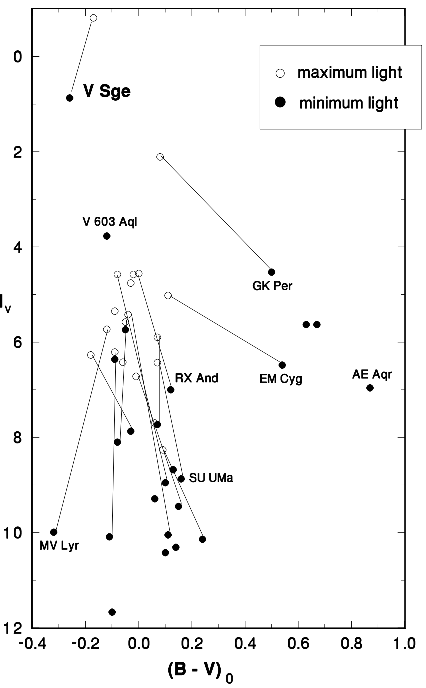

Fig. 11. Comparison of the position of V Sge with several well established CVs in the colour diagram. The positions in the minimum and maximum light were plotted if they were available. Several well-known CVs are marked, too. See the text for details

position of V Sge. This binary is considerably more luminous than all other CVs in this figure. If we used the distance of V Sge 2.7 kpc derived by H65 from the visible band data the value of M_V would be even brighter by almost 1 mag(V).

5. Discussion

5.1. *Configuration of the system*

It is not the aim of this paper to establish a detailed model of V Sge but it is necessary to reevaluate the observations of H65 and K86 in the light of the new findings of W86. Let us resume the observational evidences: *(a)* the mass ratio $q = 3.8$, the more luminous primary star (eclipsed in primary minimum) is the less massive (H65); *(b)* the temperatures of both components are very high (T>20 000 K) (H65); *(c)* both stars contribute to emission in OIII, H and HeII (H65); *(d)* very broad (0.2 phase) primary eclipse is always partial and gets shallow and wide when the system brightens (H65); *(e)* the spectrum is similar to WN5 (H65, K86); *(f)* the accretion disk is occulted in primary eclipse and the velocity of the gas suggests a compact object (W86); *(g)* very high abs. mag. ($M_V \approx 0$) (K86).

The mass flows from the secondary to the less massive primary and the secondary may fill its Roche lobe (W86). Because of the high mass ratio the lobe of the loser is very large with respect to that of the gainer and may be the cause of very broad primary eclipse. The geometric conditions of the partial eclipse of the disk with radius of 0.7 R (L_1) then lead to the inclination angle i close to 65° (but probably not higher than 69°). The semi-amplitudes of radial velocities given by H65 then yield masses of the components $M_1 = 1.0\ M_\odot$, $M_2 = 3.8\ M_\odot$.

Changes of depth and breadth of the primary eclipse during variations of the out-of-eclipse brightness of V Sge are similar to another nova-like variable RW Tri. In case of RW Tri Smak (1995a) offered an explanation in terms of variable radius of the accretion disk. It is possible that a similar mechanism operates in V Sge, too (see below).

V Sge is considerably brighter than other CVs as can be seen in Fig. 11 and this high luminosity of V Sge is namely due to the accretion disk (the eclipses of the disk are deeper than those of the loser) and suggests a very high mass transfer rate (see also Šimon 1995).

Spectrum of the secondary (H65), its high temperature and rather high mass bring an early-type (quasi WR star?)

as a probable type of the loser. As for the gainer, the orbital elements given by H65 lead to a too low inclination angle i with only a grazing occultation of the disk for a neutron star (1.4 $M_\odot$) therefore a white dwarf seems to be a more probable candidate.

5.2. *Large outbursts*

It is reasonable to suppose that the brightness variations have origin in the accretion disk as in other CVs. Nevertheless, the extremely high luminosity of V Sge place it clearly into the area of the nova-like (NL) variables with the stationary disks (see the discussion in Šimon 1995) where the disk instabilities observed in dwarf novae (the limit cycle, e.g. Cannizzo 1993) cannot occur. The variable mass transfer (mass transfer bursts, MTB) may represent an alternative explanation.

Models of MTBs for different courses of variations of $\dot{m}$ can be found in Bath and Pringle (1981, hereafter BP81). A common feature of their generated light curves was a pronounced long "tail" (very slow final decline), nonsensitive to the course of $\dot{m}$. If we accept that the event LO4 observed by H65 is of the same kind as the other LOs we have also the color variations at hand. The changes of the colour indices are very small and as H65 showed they may be fully attributed to the increasing strength of the emission lines as the system brightens. This fact is very close to *model 3* of BP81 where the rise time of the MTB is longer than the diffusion time through the disk. This condition is fulfilled in V Sge if the α parameter is of the order of unity. The disk then can relax to a steady state even during the rise, the spectrum remains very similar to that of a steady disk and large colour changes are avoided. The final "tail" characteristic for the models of BP81 is present in the LOs of V Sge, too. Model 3 of BP81 also shows a significant increase of the surface density and optical depth of the outer parts of the disk in the advanced phase of the outburst leading to the increase of the radius of the disk. It is possible that in V Sge the radius of the disk inflated during MTB reaches the Roche limit and gives rise to almost equal brightness of all LOs.

For a comparison we may mention another NL variable RW Tri in which MTBs were supposed to be responsible for the episodes of transient brightening, too (Smak 1995a). The mass transfer rate $\dot{m}$ and radius of the disk in RW Tri increased considerably during the outburst and significantly affected the shape of the eclipse. The behaviour of the variations of the eclipse in V Sge described by H65 is similar to that of RW Tri and speaks in favour of MTB as a cause of the large outbursts in V Sge, too.

It is very difficult to interpret the secondary peak of LO. At present, we may only offer a speculation that the loser responses by a subsequent smaller MTB to the enhanced irradiation or wind from the disk which occurs during the primary outburst (strongly irradiated loser is implied by the fact that the shoulders of the secondary eclipse are brighter than those of the primary one (K86)). Similar secondary peaks were also observed in two after-events in GRO J0422+32 following its large outburst in 1992 (Chevalier & Ilovaisky 1995). The nature of these after-events in GRO J0422+32 remains unclear but Callanan et al. (1995) favoured mass transfer events as a probable mechanism. There is a possibility that the nature of the unique double-peaked LOs in V Sge and after-events in GRO J0422+32 is similar.

5.3. *The other kinds of brightness changes*

The HS/LS transitions displayed by V Sge are commonly observed both in NL binaries with disk (Hudec et al. 1984; Richman et al. 1994) and those with accretion column (AM Her-type, e.g. Hudec & Meinunger 1977) but they were also detected in some X-ray binaries (HZ Her/Her X-1) (e.g. Hudec & Wenzel 1986) These transitions are attributed to a temporary decrease of the mass outflow $\dot{m}$ from the loser through the L_1 point (Robinson et al. 1981) and are common both in late-type (TT Ari, Hudec et al. 1984) and early-type losers (HZ Her). Although the combined findings of H65 and W86 yield that the loser in V Sge is significantly hotter and more massive than in the above listed examples the light curves of the HS/LS events in V Sge are similar to them. The abrupt transitions in V Sge are very reminiscent of those in HZ Her reported by Hudec & Wenzel (1986). A kind of transient disturbance affecting $\dot{m}$ probably operates in these binaries because the brightness returns to its previous value after recovering from LS. Livio & Pringle (1994) offered explanation in terms of star spots on the late-type loser near the L_1 point. Nevertheless, this mechanism is hardly applicable to the early-type secondary in V Sge. Instead, transient underfilling of the Roche lobe may play a role here.

The brightness of V Sge in LSs detected in the AFOEV data set is comparable to the minimum brightness reported by H65. Deep primary eclipses in the corresponding light curves given by H65 point to the evidence that the primary is still more luminous than the mass losing secondary even when the level of the out-of-eclipse brightness is low ($12-12.5$ mag$_{\rm vis.}$). If we assume that the luminosity of the primary as dominated by the accretion disk around a compact object (proposed by W86) we can infer that the disk is far from a complete disappearing in LS.

Mass transfer variable on the time scale not longer than 15-20 days may be the cause of fluctuations of brightness in the high state (small outbursts) but large α is needed to allow for such rapid responses of the disk. Similar events observed in the old nova V 446 Her by Honeycutt et al. (1995) had character of outbursts with an amplitude of $1-1.5$ mag(V) and the cycle-length of 21 days. The authors stated that MTB is more probable than the limit cycle there.

The activity of V Sge has significantly changed in the course of the last sixty years as can be seen in Figs. 1, 9, 10. If the variable mass transfer is the dominant mechanism of the brightness variations discussed above then also an increase of $\dot{m}$ on the time scale comparable or longer than the covered interval may represent a possible explanation for the overall increase of brightness. This increase of $\dot{m}$ would be transiently intermitted from time to time by episodes of LS.

6. Concluding remarks

The analysis presented here developed the findings of H65, revealed large changes in the behaviour of V Sge and showed that four kinds of intrinsic photometric activity may be traced in V Sge in the last sixty years. Of course, the multi-wavelength detailed investigation of the respective kinds of activity is desirable and should namely check to what extent the MTB model is valid for V Sge. Eclipse mapping and Doppler tomography can be very helpful here. The continuous monitoring, preferably in phases out of eclipses, can help to catch the changes of activity in the early stage (especially LOs and HS/LS transitions). Also the computer simulations of the disk fed by an exceptionally large $\dot{m}$ and affected by a massive companion can help to clarify the processes in V Sge. Determination of the evolutionary status of V Sge would be of interest, too.

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